



The Congress logo, commissioned from local aboriginal artist Laurie Nilsen, incorporates cross hatching which represents an indigenous presence on the land. The two leaves represent the northern and southern hemispheres, and reflect the element of balance. The motif under the leaves is representational of communication and the flow between the water and land elements on a stylised Australia. The logo aligns with the Congress Theme "Forests in the Balance: Linking Tradition and Technology".

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**XXII IUFRO World Congress**



# The International Forestry Review



Forests in the Balance: Linking Tradition and Technology  
XXII IUFRO World Congress, 8-13 August 2005, Brisbane, Australia

ABSTRACTS



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*The  
International  
Forestry Review*



**Forests in the Balance:  
Linking Tradition and Technology**

**XXII IUFRO World Congress, 8-13 August 2005, Brisbane, Australia**

**Abstracts**

EDITORS

JOHN L. INNES, IVOR K. EDWARDS and DAVID J. WILFORD



## Preface

On behalf of the Congress Scientific Committee, I am pleased to provide an introduction to this volume of abstracts. The abstracts represent the scientific contributions to the XXII World Congress of the International Union of Forest Research Organizations, a Congress that has as its theme 'Forests in the Balance: Linking Tradition and Technology'. This title was deliberately ambiguous, and was intended to mean different things to different people. At its most basic, the future of many forests around the world really is in the balance, as conversion of forests to other forms of land use continues. For the forests that remain, and for the increasing area of forests in some countries, pressures are mounting on the goods and services that they provide. Some of these goods and services are mutually exclusive, and making trade-offs between them is all about achieving the right balance. On a more abstract note, the future of forestry as a profession is also in the balance. Major changes are occurring in the way forestry is practiced, and these changes seem to be occurring globally, although not always in the same direction. For example, in Europe and some parts of North America, we are seeing pressure to practise forms of forestry that are 'closer to nature'. In areas that still have natural forests, the pressure is there to make forestry less intrusive, and techniques such as reduced impact logging are becoming mainstream. We are also seeing changes in the skills needed by those working within the forest sector. Forest management skills are evolving rapidly to be much more focused on the relationship between people and their forests, yet our university curricula are having difficulty adjusting to this change in demand. The forest sciences are increasingly dominated by biotechnology and tensions have developed between, for example, traditional forms of tree breeding and improvement and those that involve techniques such as bioengineering. We are also seeing major changes in the ways that we utilize the products derived from forests, including both timber and non-timber products. Wood processing techniques are becoming increasingly sophisticated, requiring new skills and expertise. All of these changes are reflected in the sub-themes and sessions of the Congress.

The sub-title 'Linking Tradition and Technology' reflects the efforts that are needed to ensure that the changes engendered by the rapid introduction of technology do not completely mask more traditional forms of knowledge, particularly the traditional knowledge of aboriginal peoples and forestry communities. This is no more evident than in Queensland 'The Smart State', where the government has a vision that 'knowledge, creativity and innovation drive economic growth to improve prosperity and quality of life for all Queenslanders', yet there is a significant aboriginal legacy. The vision of the Queensland Government could equally be applied to forest sectors around the world; the move by forest-dependent communities around the world to gain greater control of their resources reflects their desires to see forests provide a greater contribution to their livelihoods, whether in the form of economic, social or spiritual aspects of their quality of life.

The 2005 Congress has seen the introduction of a number of changes to the way the Congress is organized and structured. The sessions were the result of a call for proposals for sessions made in 2003. Some fields of research are less well-represented than others, but this reflects the willingness of scientists within those areas to organize sessions. In making the selection of sessions a competitive process, we have tried to ensure not only a consistent quality across all sessions, but also to encourage external groups into the IUFRO sphere. I am particularly pleased to see the presence of so many sessions dealing with the social and economic aspects of the forest sector. The forest sector could, and should, be the epitome of sustainable resource management, and we must always remember that sustainability represents a balance between environmental, social and economic values. In response to views expressed after the 2000 Congress, we have attempted to reduce the

number of parallel sessions, and ensure minimal overlap between these. This has meant that much information will be presented in the form of posters, and I strongly encourage you to make effective use of this form of communication. You will find that we have placed the posters in prominent positions throughout the Convention Centre, reflecting the belief of the Congress Scientific Committee that they are a highly effective means of communication.

I hope that you will take the opportunity to browse through abstracts not directly related to your own field of interest. A Congress is intended to be an opportunity for people from diverse disciplines to get together to discuss issues of common concern. Even if you were unable to attend the Congress itself, the abstracts presented here represent an important snapshot of the state of the art of forest science in 2005, and well worth any time that you can devote to them.

**Professor John Innes**  
**Chair, Congress Scientific Committee**

## Sub-themes and sessions

<b>Sub-theme: Integrating Approaches to Achieve Multiple Goals: Intensive Management, Extensive Management or Conservation?</b> .....	<b>1</b>
Integrating approaches to achieve multiple goals: Intensive management, extensive management or conservation? .....	1
Biodiversity and plantations – oxymoron or opportunity? Integrating approaches to achieve multiple goals: intensive management, extensive management or conservation .....	2
Wood quality from intensive management .....	5
Integrating wood production within sustainable forest management .....	10
Designing policies for the protection of biodiversity in forested environments .....	14
Economics of forest multi-functionality .....	17
Environmental planning for harmonizing forest biodiversity conservation and sustainable development .....	21
Uneven-aged silviculture: from temperate to tropical forests .....	22
Harmonizing commercial utilization, social, and conservation values through intensive tropical forest management (ITFM) .....	26
Properties and utilization of plantation timbers: Plantation wood as a substitute for native forest resources .....	31
Modelling multi-dimensional forest dynamics for multiple-purpose management objectives .....	34
Monitoring and indicators of forest biodiversity: Towards a harmonized system at country, landscape and stand scale .....	36
Managing forest landscape mosaics for production and conservation .....	36
The expanding international role of agroforestry in the establishment and management of planted forests: Impediments and success stories .....	42
Research demonstration: Long-term multi-purpose experiments in the forest sector .....	46
<b>Sub-theme: Utilizing Genetic Resources to Further Sustainable Forestry</b> .....	<b>49</b>
Utilizing genetic resources to further sustainable forestry .....	49
Threats to forest genetic resources and approaches for gene conservation .....	50
Forest biotechnology .....	52
Using genetics and silviculture to manage multiple stress complexes in planted forests .....	56
Genomics: Present status and progress .....	59
Interspecific hybridization for sustainable forestry: Breeding and deployment .....	61
Genomics and tree breeding for sustainable forestry .....	62
Progress in tree breeding for tropics and subtropics .....	65
Recent advances in Eucalyptus breeding .....	67
Management and conservation of forest genetic resources .....	67
<b>Sub-theme: Meeting the Challenge of Climate Change.</b> .....	<b>72</b>
Meeting the challenge of climate change .....	72
Tree rings as indicators of the impact of environmental changes on forest growth .....	73
Global fire trends and climate change .....	77
Experimental manipulations of forest ecosystems: hints on global change .....	78
Climate change and tree resistance to insects and pathogens .....	80
Forest insect effects on forest productivity, management decisions, and carbon sequestration .....	83
Forests between air pollution and climate change .....	87
Understanding linkages between climate and forest fire .....	91
The contributions of tree physiology to understanding the effects of climate change .....	91
Impacts of drought and heat on forests .....	98
Forestry in climate change mitigation .....	102
Managing and conserving genetic resources in a changing climate .....	103
<b>Sub-theme: Promoting Development Through Improvements to the Forest – Wood and Products Chain</b> .....	<b>105</b>
Promoting development through improvements to the forest – wood and products chain .....	105
Wood production in agroforestry and in short-rotation forestry systems – synergies for rural development (A) .....	106

Finishing and surfacing .....	108
Cross-sectoral policy linkages in forestry sector .....	111
Agroforestry for economic, social and environmental prosperity in rural areas: Current highlights from Australia's Joint Venture Agroforestry Program .....	114
Small-scale private forestry and its role in producing multiple benefits for society: Enhancing management for multiple objectives and challenges of forest fragmentation and parcelisation .....	115
The role of the International Energy Agency in creating a carbohydrate-based economy: bioenergy, biofuels and bioproducts .....	118
The role of wood chains in the social and economic development of tropical countries .....	120
Utilization of plantation teak .....	121
Application of newly-developed technologies in mechanical wood processing towards sustainable utilization of forest products in the 21 <sup>st</sup> century .....	124
Using wood composites as a tool for sustainable forestry .....	126
Links between supply chain management and value recovery .....	130
Promoting economic development through forest products marketing and business management .....	131
The small get smaller: Fragmentation in small-scale forestry .....	135
Forests and the livelihoods of rural people .....	137
Wood production in agroforestry and in short-rotation forestry systems—synergies for rural development (B) .....	139
Current issues in forest products marketing and business management .....	140
<b>Sub-theme: Involving Indigenous Groups in Forest Science and Forestry .....</b>	<b>142</b>
Involving indigenous groups in forest science and forestry .....	142
The state of scientific and indigenous knowledge and dissemination of non-timber forest product classification and utilization .....	142
Indigenous peoples and commercial enterprises in forestry .....	146
'Forestry' for indigenous peoples: Learning from experiences with forest industries .....	147
Indigenous knowledge and biodiversity conservation .....	148
Co-management agreements between indigenous peoples and others .....	150
<b>Sub-theme: Increasing the Value of Forests Through Innovative Products and Technologies .....</b>	<b>151</b>
Increasing the value of forests through innovative products and technologies .....	151
Utilizing small-diameter trees and solving forest resource problems .....	152
Role of genetics in manipulating wood quality .....	156
Strengthening collective innovation capacity of forest stakeholders in research and development .....	157
Linking research, development and implementation in forestry .....	159
Innovation and entrepreneurship – rural development and forest sector competitiveness .....	161
Fire safety of wood structures .....	165
Remote Sensing in Forestry: Recent developments of forest remote sensing .....	166
Integration of wood utilization with intensive forest management .....	169
Optimal matching of species to sites: impacts on growth and wood quality .....	171
Understanding and managing wood quality to improve product value .....	172
Recent developments in biodegradation and protection of wood materials .....	175
Site specific management and precision forestry .....	179
Detecting, monitoring and modeling deforestation and forest degradation using remote sensing and GIS .....	183
Agroforestry: taking stock of recent developments .....	187
<b>Sub-theme: Demonstrating Sustainable Forest Management .....</b>	<b>191</b>
Demonstrating sustainable forest management .....	191
Research: A critical partner in forest certification .....	192
National forest inventories to support sustainable forestry: Research for linking practices to emerging challenges .....	194
International research to monitor sustainable forest spatial patterns .....	198
The certification of fast-grown plantation forests: Issues, costs and benefits .....	200
Economics of sustainable forest management .....	201
Long term experiments, inventories and observations in irregular (complex) forests .....	204
Sustainable harvest planning and scheduling .....	208

Do we need new management paradigms to achieve sustainability in tropical forests? .....	209
Evaluating new modes of governance for sustainable forestry .....	213
Attempts to measure sustainable forest management .....	215
Evaluation of sustainable forest management .....	216
<b>Sub-theme: Sustaining Forests: A Duty for Forestry and Society? .....</b>	<b>218</b>
Sustaining forests: A duty for forestry and society? .....	218
Conditions for the transition to sustainable forestry .....	219
The changing roles of stakeholders in sustainable forest management .....	223
What future for community forestry? The case of Nepal .....	226
Boreal Zone forests in the balance: Regional and global factors in Boreal forest management .....	228
Emerging issues for sustainable forest management .....	231
Changes in forest ecosystems and their implications on human health .....	235
Natural and anthropogenic disturbances – rehabilitation of forests .....	238
Towards sustainable forestry – The living soil: Soil biodiversity and ecosystem function .....	243
Social and cultural values of forests: benefit for today’s society .....	250
Alien pests threatening biodiversity of forest ecosystems .....	252
Linking experience with disciplinary science to address sustainable forest management’s greatest need—reliable prediction .....	256
Impact of exotic invasive plant species on the forest ecosystems .....	258
Forests in the global balance: Changing paradigms .....	262
Forests, trees and human health and well-being .....	267
Forest landscapes for locals and tourists .....	268
Forest policy research: New methodological and empirical developments in the last decade and priorities for the future .....	271
Setting conservation targets in managed forest landscapes: Theory and practice .....	273
Sustainable management of high-value timber species of the Meliaceae: A global perspective .....	275
Environmental concerns of forest products utilization .....	277
Building synergies between institutions and conventions dealing with Non-Wood Forest Products .....	280
Ozone exposures and effects on forest vegetation: A global overview .....	282
Remote sensing in forestry: Modern technology supporting sustainable development .....	285
Silviculture and management of rare, threatened and endangered tree species .....	286
Social and cultural values of forests: Benefits-based management .....	288
Mangroves and the protection of coastal areas .....	289
Forests, trees, and human health and well-being (B) .....	290
<b>Sub-theme: Realizing the Environmental Benefits of Forests .....</b>	<b>293</b>
Realizing the environmental benefits of forests .....	293
The role of forests in carbon sequestration: Considerations for the carbon market .....	294
Innovations in forestry accounting: Integration of forest assets and non-market environmental benefits into management and national accounting and reporting .....	297
Decisions with long-term effects in forest management: how to deal with uncertainty? .....	300
Forestry for urban development: Urban forestry as a tool for industrializing countries .....	301
An overview of national forest greenhouse gas accounting systems: Progress and scientific challenges .....	304
Improving the functional benefits and ecological services from forest rehabilitation .....	307
Stem and shoot fungal pathogens and parasitic plants: The values of biological diversity .....	309
Protection forests: Recognizing and maintaining the forest influence with regards to hydrogeomorphic processes .....	310
Managing forests for biodiversity conservation .....	314
Net environmental benefits of plantation forests in degraded agricultural landscapes .....	317
Carbon balances in planted forests established in agricultural landscapes .....	319
Planted forests and water .....	321
Field experiments in the conservation of forest biodiversity .....	324
Forests and people: Valuation of the forest ecosystems’ outputs .....	327
The role of forests in carbon sequestration: Accounting for ecosystem dynamics .....	328
Environmental goods, institutions and markets .....	333
Stem and shoot fungal pathogens and parasitic plants: The values of biological diversity (B) .....	334



<b>Sub-theme: Advancing The Role of Communication, Education and Capacity Building in the Future of Forestry</b> .....	<b>338</b>
Advancing the role of communication, education and capacity building in the future of forestry .....	338
Horizontal communication: Combining traditional expressions in communication strategies .....	339
Technology and tradition at the desktop: effective use of global forest information resources .....	340
Added value of terminology work for forestry stakeholders .....	342
Communicating forest science to the public: From theory to practice .....	345
Crossing borders: International perspectives on interdisciplinary research .....	346
International networking in forest education .....	350
Effective teaching with technology in higher forestry education: Foundations for success .....	353
Expanding the knowledge base by improving non-timber forest products (NTFP) educational opportunities .....	356
From needs to solutions: A dialogue on core business and institutional models for effective development, marketing and implementation of science .....	357
Capacity building as an objective of international development projects: Case studies from ACIAR's Asia-Pacific forestry program .....	359
Interactions between science and practice .....	360
Linking science and practice through the Landcare approach .....	362
Dissemination of forest restoration and regeneration knowledge into management .....	367
<b>General Sessions</b> .....	<b>368</b>
General Posters: Silviculture .....	368
General posters: Physiology and genetics .....	369
General posters: Forest operations .....	373
General posters: Forest assessment, modeling and management .....	377
General Posters: Forest products .....	378
General posters: Social, economic, information and policy sciences .....	383
General posters: Forest health .....	389
General Posters: Forest environment .....	394

## Sub-theme: Integrating Approaches to Achieve Multiple Goals: Intensive Management, Extensive Management or Conservation?

### Integrating approaches to achieve multiple goals: Intensive management, extensive management or conservation?

Organizer: Klaus von Gadow *University of Göttingen, Germany; kgadow@gwdg.de*

#### **Forest Stewardship Council certification of industrial plantation forests.** Goulding, C.J. (*Ensis; Chris.Goulding@Ensisjv.com*).

Retailers in North America and Europe are demanding forest products that have been certified as supplied from 'well managed' forests. There are many certification schemes; that of the Forest Stewardship Council (FSC) is one of the most widespread, worldwide. Although proffering an ideal of timber and non-timber products from uneven aged, natural forests, FSC is also applicable to intensively managed exotic forest plantations. New Zealand has 670,000 ha of its 1.8 million hectares of plantations certified, and predictably, the most frequently issued corrective action requests concern environmental issues. Recently, social issues increased in prominence when an industry downturn impacted on employment in communities dependent on forestry. New Zealand's indigenous people are expected to become the major owners of plantation forest land, raising the profile of those criteria concerned with the rights of indigenous people to benefit from their forests. Certified logs rarely command a financial premium, but certification compliance costs can be significant. Research could assist by designing modifications to plantation management systems that maintain profitability but enhance the social and environmental non-timber benefits, and by defining methods to more correctly value those benefits.

#### **Impacts of forest management on the carbon budget of European forests.** Mund, M., Schulze, E.-D. (*Max Planck Institute for Biogeochemistry, Germany; mmund@bgc-jena.mpg.de*).

Forests and woodlands cover about 40% of European land area. Except for some protected or inaccessible areas all of these forests are used by human beings. The influence of different silvicultural treatments on timber production and quality is well documented for all European merchantable tree species. But data on the carbon budget of different silvicultural systems in comparison to natural, unmanaged forests are rare, particularly in regard to soil organic carbon stocks. In this paper, the carbon budgets of different silvicultural systems will be presented. The carbon budget of a forest ecosystem is strongly affected by the removal of tree biomass, soil preparation and the size and duration of canopy openings. The impacts of shelterwood cuttings and selection cuttings on forest carbon budgets are lower than those of clear cuttings. The high spatial variability of soil-specific properties and long-term impacts of land use history are the strongest restrictions to detect significant effects of current forest management on soil organic carbon pools. A sustainable increase of carbon storage in forest soils will be a long-term, continuous process. In contrast, the loss of carbon due to disturbances is a very rapid process. Optimization of carbon storage will be discussed.

#### **Balancing between set-aside and forest management activities of stands using integrated stand and forest level optimization.** Nuutinen, T., Anola-Pukkila, A., Lempinen, R., Redsvén, V., Siitonen, M. (*Finnish Forest Research Institute, Finland; tuula.nuutinen@metla.fi; aimo.anola-pukkila@metla.fi; reetta.lempinen@metla.fi; visa.redsvén@metla.fi; markku.siitonen@metla.fi*).

Conventionally, there are two major conservation strategies in forestry: 1) to set areas aside from timber production and 2) to change forest management strategy. Typically, in land-use planning, set-asides are designed separately from forest management planning. Decisions on forest management strategies are usually made at regional and national level by forest policy makers. These decisions are then implemented into forest practice as recommendations, such as rotation periods and thinning rules. In practice, production potentials of different forest products and services depend on forest resources and their management. Both forest resources and the multiple goals set for products and services vary between ownerships. Therefore, the effective combination of set-asides and management activities of stands varies between ownerships. The aim of this paper is to introduce a method for balancing between set-aside and forest management activities of stands to achieve multiple goals set for a particular forest area. The method is implemented in the Finnish MELA system based on integrated stand and forest level optimization. In addition, a case study is presented to illustrate the method 1) in the analysis of production potentials and 2) in the simultaneous location of set-asides and management activities for a forest area in Finland.

**Balancing ecosystem values: Innovative experiments for sustainably managing forests.** Szaro, R.C., Peterson, C.E. (*USDA Forest Service, USA; rszaro@fs.fed.us*).

Historically, applied manipulative studies of forests have tested the ability of specific silvicultural treatments to address regeneration and wood production objectives. Changing societal values now demand expanded approaches to forest management that also integrate social, ecological and economic goals. As a result, many recent (past decade) experimental manipulations have become multi-disciplinary in scope and approach and involve restorative treatments, novel silvicultural approaches or variants of more traditional approaches that are relevant to operational scales. We examine a wide range of manipulative forest ecological experiments that have addressed a variety of responses to changes in forest structure or function. The silvicultural treatments employed in these experiments were oftentimes designed by interdisciplinary teams (e.g., forest ecologists, sociologists, biologists, economists and silviculturists) with wood production and additional ecological, social or economic objectives as joint outcomes. Individually and collectively, these studies represent major investments by research and land management organizations to meet increasing public demands for forests that provide healthy environments for people (clean air and water), support biological diversity (e.g., habitat), and sustain economic productivity (wood or other forest products and jobs).

**Human dimensions in forest management decision-making.** Torres-Rojo, J.M. (*Centre for Research and Teaching of Economics, Mexico; juanmanuel.torres@cide.edu*).

Many countries, especially developing ones, face the problem of incorporating basic forest management principles into traditional management practices. However, the interaction and variety of social, economic and physical conditions in forest areas makes it difficult to find options relating optimal forest management strategies with social and economic goals such as poverty alleviation, improvement of income distribution and forest conservation. Nevertheless, this topic is highly relevant to define public policy measures that effectively mitigate natural resource and welfare degradation. In addition, the topic is highly relevant to identify appropriate forest management practices in time and space that can meet this variety of goals. This paper summarizes the results from different research projects embedded in the idea of the simultaneous analysis of social, economic and physical conditions which identify successful forest management strategies under environments characterized by common property forest lands. The analysis is limited to common property forestlands, although it can be extended to situations where there are several small non-industrial forest producers. The paper shows that forest production has little impact on poverty alleviation and economic development in such forest communities unless some particular physical, social and economic characteristics, including locally accumulated social capital, are present.

**Biodiversity and plantations – oxymoron or opportunity? Integrating approaches to achieve multiple goals: intensive management, extensive management or conservation**

Organizers: Jeff Sayer *WWF International, Switzerland; JSayer@wwfint.org*, and John Parrotta *USDA Forest Service, USA; jparrotta@fs.fed.us*

**Vegetation exclusion under monoculture plantations of exotic trees: role of allelopathy.** Batish, D.R., Singh, H.P., Kaur, S., Kohli, R.K. (*Panjab University, India; daizybatish@yahoo.com*).

Due to increasing population and already dwindling natural forests, there has been a great deal of impetus on raising monoculture plantations of exotic trees. In this context, fast growing exotics, primarily *Eucalyptus tereticornis* and *Leucaena leucocephala*, are being raised on large scale without any consideration of their ecological impacts on the vegetation and soil health. A study to determine ecological status of the vegetation (in terms of diversity, evenness, dominance and richness) under these exotic plantations indicated that the vegetation diversity was significantly reduced under these trees. The reasons for depleted vegetation were explored in terms of the impact on soil nutrient status and the allelopathic interference, if any. Both the trees were found to release a significant amount of phenolics into the soil. The phenolics interfered with the nutrient availability of the soil, thereby interfering with the growth and establishment of the vegetation under these trees. The present paper discusses all aspects of vegetation exclusion under *E. tereticornis* and *L. leucocephala*.

**Contributions of plantation forests to biodiversity conservation and the importance of ‘context’.** Brockerhoff, E. (*Forest Research, New Zealand; eckehard.brockerhoff@forestresearch.co.nz*).

The primary purpose of plantation forests includes the efficient production of wood, fibre or other forest products as well as soil and water protection. The contribution of plantation forests to the conservation of biodiversity is often overlooked or even seen as negative. Several case studies on various taxa from different countries will be used to

illustrate how such forests may or may not provide conservation benefits. An analysis will be provided to demonstrate the role of context when conservation outcomes are being assessed. Relevant context issues include factors such as land use prior to afforestation (e.g., natural vs. intensive agricultural), historical vegetation patterns and percentage of remaining natural vegetation, origin of planted tree species (indigenous vs. exotic), and intensity of management. For example, in regions or countries that have lost much of their natural forest cover, even exotic plantation forests can provide important 'substitute' forest habitat, unless plantation establishment occurred at the direct expense of natural vegetation. On the other hand, afforestation of non-forest sites is usually detrimental for conservation. Where possible, examples will be shown that involve rare or threatened species because such cases have more weight than 'biodiversity' *per se*. Suggestions will be provided for enhancing the conservation value of plantations.

**Enhancing biodiversity in eucalypt plantations.** Cummings, J., Reid, N. (*Center for Rainforest Studies, Yungaburra, Australia; jcummings@fieldstudies.org*).

As conservation reserves expand, the likelihood that they will capture areas degraded by previous land uses increases. Ecological restoration will therefore play an increasing role in biodiversity conservation. On the New South Wales North Coast, recent expansion in the conservation estate has captured over 300 softwood or hardwood plantations, many with understoreys dominated by exotic weeds. Here we present the principles and practices adopted in managing these plantations to enhance their biodiversity value. By initiating experiments designed to overcome potential barriers limiting regeneration of natural forests, we have gained insights into the management of former timber plantations for biodiversity. Thinning and burning markedly improved understorey species richness, with retained canopy cover proportional to richness or abundance of native woody shrubs, understorey trees and potential canopy trees. Abiotic indicators were not degraded by management, indicating that one-off thinning and burning treatments are sustainable options. This is the first time plantations have been managed solely for biodiversity. Revenue from salvage logging means the restoration techniques are almost unique in ecological restoration in being cost-neutral. We present key results from management experiments and outline the future for management of plantations for biodiversity across the north coast bioregion reserve estate.

**Plantation forestry and opportunities for restoring and conserving biodiversity in Southeastern Brazil.** Engel, V.L. (*São Paulo State University, Brazil; veralex@fca.unesp.br*); Onofre, F.F. (*jatobadocerrado@bol.com.br*); Almeida Jr., A.C. (*Aracruz Celulose; aca@aracruz.com.br*); Sartori, M.S. (*mssartori@estadao.com.br*).

Industrial plantations with fast growing exotic species cover more than 4.8 million hectares in Brazil, with 62% of this area in *Eucalyptus* species. Plantation forestry is responsible for creating more than 500,000 jobs. The forest sector represents 4.0% of Brazil's GIP and 10% of total national exports. However, large scale monoculture plantations are often considered as potentially hazardous to biodiversity conservation. To attend Brazilian forest legislation, many commercial stands are being managed or suppressed to restore local native vegetation. By providing adequate distribution of native forest remnants in the landscape, plantations may act as sinks for species accumulation, increasing their role in biodiversity conservation. Plantations can also be managed as an intermediate step for native forest restoration in degraded areas. To enhance their potential role in biodiversity conservation, management strategies can include the maintenance of understory, changes in harvesting techniques and the design of buffer zones and corridors with native species. Case studies are discussed with data from different sites in south-eastern Brazil showing that many short rotation eucalyptus plantations have woody species richness comparable to native forest fragments. Including multiple benefit goals in commercial plantation can be an additional strategy to increase rotation cycle, benefiting natural regeneration.

**Integrating biodiversity and multiple use assessment in forested landscapes.** Gillison, A.N. (*Center for Biodiversity Management, Australia; andy.gillison@austarnet.com.au*).

Biodiversity is emerging as an increasingly significant factor in the sustainable management of forested lands. Yet the absence of cost-effective and scientifically acceptable methods of assessing biodiversity and its interaction with commercial productivity severely hinders the management process. Global, ecoregional case studies conducted using a standardized low-input, high-return, rapid survey method, illustrate how plant-based biodiversity can vary predictably across natural oldgrowth, secondary and enriched secondary, agroforestry forest management systems, as well as monospecific and mixed-species plantation forests. Intensive baseline studies along forested land use intensity gradients in Asia and Latin America reveal common linkages between plant and animal biodiversity, soil, above-ground carbon and potential productivity. These provide a scientific framework for constructing adaptive management guidelines that incorporate simple field indicators. 'Best-bet' management long-term is likely to come from carefully planned, multiple-use, systems across forested landscape mosaics that maximize overall biodiversity, carbon and nutrient stocks while maintaining ecosystem processes and an acceptable economic return. Successful training workshops in Africa, Southeast and mainland Asia, Oceania and Latin America confirm the utility of the rapid survey method as a low-cost, high-return investment.

**Biodiversity and plantation forests: An overview.** Jactel, H., Franc, A. (*Institut National de la Recherche Agronomique/IEFC, France; herve.jactel@pierroton.inra.fr*), Sayer, J.A. (*WWF International, Switzerland; JSayer@wwfint.org*), Parrotta, J.A. (*USDA Forest Service, USA; jparrotta@fs.fed.us*).

Plantation forests range from intensively managed short-rotation crops to agro-forests and areas of enriched secondary forests. They are expanding rapidly in many parts of the world and are providing an increasing share of forest products. While economic competitiveness will inevitably lead to a continuation of this trend, the expansion of plantations is often resisted by civil society because of the popular perception that they harm environmental functions and especially that they are 'sterile' and lack biodiversity. These concerns have been justified in situations where exotic plantations have replaced biodiverse natural forests. The paper will present empirical studies of the biodiversity values of different types of plantation forests in temperate and tropical countries and ways in which plantation management can be adapted to favour biodiversity outcomes. The paper will argue that biodiversity considerations should be given more attention in planning and managing plantation forestry, both within plantation management units and in the broader landscapes within which plantations are located. The costs and benefits of biodiversity to plantation owners and managers, the application of 'ecosystem approaches', the co-benefits of carbon sequestration schemes under the CDM, and recent initiatives related to the certification of plantations will also be discussed.

**Coniferous monocultures diversification in space and species.** Kupka, I. (*Czech University of Agriculture in Prague, Czech Republic; kupka@fle.czu.cz*).

Coniferous monocultures, especially Norway spruce forests, extend beyond their natural range in Central Europe. The second generations of coniferous monocultures are susceptible to storm, snow, drought, insect and fungal damage. They have low biodiversity, different nutrient cycling and other environmental impacts at the site and landscape levels. There is a vigorous discussion on coniferous monoculture conversion but the question should be taken in a broader sense than only the species changes. Gaps in mature spruce stands with natural regeneration of beech and other species provides an opportunity to analyze the diversification of monocultures into vertically and horizontally structured stands. Detailed analysis of seedling and sapling growth in the gaps provides an opportunity to determine basic silvicultural rules for this type of diversification. Different variables are used to test whether the nutrient and climatic stresses in gaps, to which seedlings and saplings are exposed, could serve as indicators to plant vigor and therefore the success of natural regeneration and diversification of coniferous monocultures.

**Assessing the genetic variability of commercial seeds in Europe: An example in Norway Spruce.** La Porta, N., Muccinelli, I., Passerotti, S. (*IASMA, Italy; nicola.laporta@iasma.it; ivan.muccinelli@libero.it; passer8@yahoo.com*), Melnikova, M. (*Moscow State University, Russian Federation; mmarina\_2002@yahoo.com*).

In recent years, increasing importance has been given to the maintenance of biodiversity and protection of genetic resources. As a consequence, the biodiversity of the seeds used for plantations has gained more attention in several European countries. Commercial samples of Norway spruce (*Picea abies* Karst.) seeds from 25 provenances in Europe, originating from eight European countries, were tested using three different mitochondrial STRs primer sets. All three primer sets gave reliable and polymorphic patterns of amplification. The primer nad1-a/b was the most informative for assessing the level of genetic variability of the mother plants seeds within provenances. A wide range of genetic variability values throughout single provenances was observed. However, provenances coming from the same country show a significant, similar within-variability. The value of genetic variability within-provenance of seed batch, therefore, could be useful in order to monitor the efficacy of seed collecting procedures for each country. Seed collecting procedures are analyzed and discussed.

**A coarse filter approach to conserving arthropod biodiversity in Canadian forests.** Langor, D.W., Hammond, J., Pohl, G. (*Natural Resources Canada, Canada; dlangor@nrca.gc.ca; jhammond@nrca.gc.ca; gpohl@nrca.gc.ca*).

Terrestrial arthropods are hyper-diverse and sensitive to environmental disturbances. However, utilization of arthropods as ecological indicators in forests and their incorporation in bio-monitoring is hampered by limited ecological knowledge for interpretation of human-caused changes in abundance and distribution of taxa in space and time, against a background of natural variation. This poses a challenge for a 'fine-filter' approach to arthropod conservation in managed forests. Can arthropod conservation objectives be better incorporated into operational forest planning using a 'coarse-filter' approach? This question was addressed by investigation of the utility of the Canadian Forest Ecosystem Classification (FEC) system as an ecological surrogate for arthropod assemblage structure. FEC integrates knowledge of vegetation communities in relation to environmental gradients, such as regional climate and site-specific moisture and nutrient regimes. We hypothesized that epigeic arthropods inhabiting soil and litter would respond to some of the same environmental factors incorporated into the FEC, and that the FEC would be a reasonable surrogate for arthropod assemblage structure. Epigeic assemblages were characterized in 15 eco-sites in Upper Cordilleran forests. Partial congruence of eco-site classification with arthropod assemblage structure, especially at the extremes of soil nutrient and moisture gradients, suggests that the FEC may be used as a biodiversity conservation tool.

**Biodiversity management in industrial tree plantations in West Kalimantan, Indonesia.** Otsamo, R., Marjokorpi, A., Otsamo, A., Tyynelä, T. (*University of Helsinki, Finland; riikka.otsamo@helsinki.fi*).

We studied biodiversity management in an industrial tropical tree plantation context. The study area included forest fallows, *Acacia mangium* tree plantations established on deforested and degraded forest lands, dry- and wetland rice fields, rubber gardens, forest gardens and remainders of natural forests (sacred forests, riverine forests, swamp forests). The work was done in cooperation with an industrial plantation project and the indigenous Dayak-people in West Kalimantan, Indonesia. The study methods included literature reviews, interviews, vegetation inventories, economic analyses and GIS-simulation. Mature forest remnants harboured tree species diversity and functional characteristics close to those of undisturbed rainforests. As these forests are an important part of the local culture, their expansion for rehabilitation of surrounding degraded lands could be a viable option. Even small expansion of these areas could have positive effects to rehabilitation. Living conditions of the local population can be improved by their participation in plantation forestry projects. Tree plantations can be combined with other land-use practices. They can improve the economic return on land, without further degradation of the environment. This requires agricultural intensification and support from the plantation company. At the same time, biodiversity can be conserved and even enhanced with careful planning and integration of different land use forms within the context of plantation forestry.

**Forest plantations and biodiversity: A WWF view.** Pollard, D. (*WWF International, Switzerland; DPollard@wwfint.org*).

Forest plantations are a highly politicized issue globally. For some people, plantations are the future direction of the global forest products industry, a solution for carbon sequestration, or an answer to the abandonment of huge areas of unwanted low grade agriculture land. For other people, plantations (and intensive forestry in general) go fundamentally against the objectives of sustainable forestry management, where the aim is to make every forest stand more natural. On top of this philosophical issue there are a range of criticisms about plantations – some well founded. The criticisms range from social issues to biodiversity and freshwater. This paper will discuss these and provide a WWF view on the positive role that a landscape approach to planning can bring to plantations, the contribution that plantations can play in conserving and enhancing associated biodiversity, and how plantations do not have to compromise freshwater supplies. It will also describe the current FSC review of its principles and criteria on plantations, a process that is designed to reduce the conflict on the philosophical issue and achieve a better global consensus amongst a wide variety of stakeholders.

**An application of spatially structured population viability analysis modeling to forest planning: a multi-species perspective.** Nicholson, E. (*The University of Queensland, Australia; e.nicholson@uq.edu.au*), Regan, T.J. (*University of Queensland, Australia*), Fox, J.C. (*Department of Sustainability and Environment, Melbourne, Australia*), Bekessy, S.A. (*MIT University, Australia*), Possingham, H.P. (*University of Queensland, Australia*), Burgman, M.A. (*The University of Melbourne, Australia*).

The use of Australia's forests for competing demands of timber production and the conservation of biological diversity raises questions regarding the impact of anthropogenic disturbance on species persistence. Such activities have the potential to reduce the habitat available to sensitive species, and may decrease probabilities of dispersal and persistence through habitat fragmentation. We develop spatially structured population viability models for eleven forest sensitive species that describe the population dynamics for each species and incorporate spatial dynamics by modeling habitat suitability, dispersal and habitat dynamics. The aim is to investigate the impact of plantation expansion on the persistence of multiple forest-dependant species and to investigate the impact of alternative management options on species persistence. This research provides timely feedback to managers about the sustainability of current and alternative forest management options, and supports the development of better-targeted and more relevant forest planning.

## Wood quality from intensive management

Organizer: Dave Cown *Forest Research New Zealand; Dave.Cown@ensisjv.com*

**Effect of extractives and wood structure on tangential compression strength of mahogany wood.** Arévalo, R. (*Universidad del Tolima, Colombia; rlareval@ut.edu.co*), Hernández, R. (*Université Laval, Canada; roger.hernandez@sbfulaval.ca*).

The influence of density, extractives, and anatomical structure on the tangential compression strength of mahogany (*Swietenia macrophylla* King) wood from Peru was evaluated at 25°C and at different equilibrium moisture contents.

Matched flakes were used to assess the amount of extractive components by successive extraction with cyclohexane, dichloromethane, acetone, methanol and hot water solvents. Additionally, fourteen anatomical parameters were determined by image analysis. A stepwise regression analysis showed that the anatomical features, mainly the rays and vessels, affect more significantly the mechanical behaviour of mahogany than wood extractives. These findings are in agreement with earlier results showing a negative effect of large and multiseriate rays on the mechanical properties of wood when loaded perpendicular to their long axis. The influence of lumen-located extracts soluble in dichloromethane might prevent deformations. Finally, it is postulated that hot water extracts may play a plasticizing role in this species.

**Old growth quality from intensively managed stands? The central European experience** Becker, G. (*Albert-Ludwigs-University Freiburg, Germany; fobawi@fobawi.uni-freiburg.de*).

The term Intensive Management is closely linked to Plantation Forestry, where pure, uniform stands, short rotation and fast growth are the management objectives. The resulting wood quality is different from the typical wood quality for trees from old growth mature forests, which are characterized by old age, slow growth (i.e., narrow rings), natural pruning and big dimensions. Because the remaining natural old growth stands are protected, in most cases it can be foreseen that old growth quality will completely disappear from the markets of the future. In Central Europe, conifers (spruce, fir, pine) and broadleaves (oak, beech) are traditionally managed in a different way. Close-to-natural forest management aims at imitating old growth conditions by intensive management. The target product is mature big trees with excellent wood quality features. This paper describes the management objectives and prescriptions, and presents the analysis of the resulting wood quality, as well as its suitability for selected premium products (veneer, appearance grade timber, high grade construction timber).

**Wood quality in a Danish provenance trial of European beech.** Bergstedt, A. (*Royal Veterinary and Agricultural University, Denmark; abe@kvl.dk*).

In Denmark, many foreign provenances of European beech (*Fagus sylvatica* L.) have been grown in search of better yield and stem form than offered by the indigenous provenance. Large variations are found regarding vigour, form and growth habit, but little attention has been paid to wood quality of foreign provenances. From a 56-year old provenance trial, 78 trees were selected, representing 10 different provenances from a wide range of sites in Europe. Wood properties such as basic density, shrinkage from green to oven dry condition and spiral grain, were analyzed on stem discs. Two bolts from each tree were processed into live sawn boards, and evaluated for splitting, twisting and cupping during drying. Statistically significant provenance effects could be demonstrated for several of the wood properties, but in general the differences were small and hardly affected wood utilization. Bolts from the middle of the stem (2.8–5.5 m) were more prone to checking than bolts from the lower stem. In general, the fibre angle increased with increasing distance from the pith, but in most trees spiral growth was modest. In conclusion, provenances can safely be selected and evaluated from external qualities such as height growth, yield, stem form and branching habit, without risk of producing wood of inferior quality.

**Managing for quality in developing stands.** Briggs, D., Turnblom, E., Bare, B.B. (*University of Washington, USA; dbriggs@u.washington.edu*).

A variety of simple, widely accepted field tools, sampling procedures, summarization software and projection models are available to assist managers in making cultural decisions and monitoring effects on stand growth and yield, and tree size. However, counterparts for tree and wood quality lag far behind. Consequently, quality is poorly integrated into the decision and monitoring process. Inability of managers to integrate quality information into their cultural decisions and monitor effects on quality as stands develop may lead to choice of treatments with detrimental effects on future quality and product value. Lack of quality management during stand development and at harvest can lead to expensive misallocation of timber to processing facilities. Techniques are emerging to permit routine assessment of some quality characteristics. These data, combined with simple quality control techniques, provide managers with opportunities to manage quality of stands and to assess quality of stands at harvest to better matched mills. This paper discusses techniques for gathering quality data from conifer plantations. Correlations of these measures with log and product properties are presented along with the use of statistical quality control procedures to evaluate conformance to desired specifications. The potential for integration into silviculture and harvest scheduling decisions will be discussed. Examples for Douglas-fir from the US Pacific Northwest illustrate these concepts.

**Compositional analysis of selected tree species by thermogravimetry.** Fantu, W., Nuruddin, A.A. (*Universiti Putra Malaysia, Malaysia; woldeyohanes@yahoo.com*).

Burning profiles of biomass fuels give detailed information about the fuel during the process of combustion and are useful for predicting the relative combustion characteristics of fuels to establish relative quality of biomass fuels. Therefore, three component parts, viz. stem wood, branch, and foliage of *Eucalyptus globulus*, *Eucalyptus saligna*,

*Eucalyptus grandis*, *Acacia abyssinica*, *Acacia seyal*, and *Acacia tortilis* were analyzed by thermogravimetry (TG) and derivative thermogravimetry (DTG). Fuels which have burning profile peaks at higher temperatures are more difficult to burn and those with similar burning profiles are expected to have comparable burning characteristics. Stem wood and branch components in all species have similar burning profiles, hence, have comparable burning characteristics. Generally, ignition temperature of burning samples increased with an increasing volatile matter content. It was also observed that an ignition requirement for foliage was lower compared to stem wood branch.

**Results of thinning effects after 8 years on maple plantations in Amol, northern Iran.** Hassani, M., Amani, M. (*Forest and Rangelands Research Institute, Iran; hassani@rifr-ac.ir; amani@rifr-ac.ir*).

This research was started in 1995, in order to study the effect of thinning on a pole stand plantation of maple (*Acer velutinum* Boiss.). The silvicultural interventions included three treatments (medium thinning, heavy thinning, and control) with three replications. Before thinning, the mean and dominant heights of the initial 10-year old plantation were 10.86 m and 12.14 m, respectively. Results derived from treatments demonstrated the positive effects of thinning on the future trees diameter (1.3 cm/yr), and a reduction of the slenderness factor ( $h/d = 84$ ) in the year 2002. The mean annual basal area increment between two measurements (1995 and 1998) was 3 m<sup>2</sup>/yr/ha. Moreover, the mean annual volume increment (remaining stand) was 15.43 m<sup>3</sup>/ha/yr, and mean annual volume increment (remaining stand plus removed trees) was 29.07 m<sup>3</sup>/ha/yr.

**Timber quality assessment in softwood plantations: the modeling approach.** Leban, J.-M. (*INRA, France*).

This paper presents recent results and trends in timber quality assessment of the present and future softwood plantations. Wood quality assessments have two contexts: Timber quality at the stand level or at a regional level, and log value at the sawmill. In the first context, models to determine timber value were based upon the usual forest inventory measurements made on standing trees, and simulate (i) the stem geometry, (ii) the wood property variations inside the stems, and (iii) the conversion of the stems into logs and boards, described in terms of visual and mechanical grades. Expected timber value is evaluated by the simulation of the available grading rules. In the second context, models to determine log value were developed to simulate the expected internal log structure (wood properties) using external shape measurements only. Data for these models were generated by X-ray log scanners that allowed for direct observation of internal log structure. For each context, recent results and informatic tools obtained and built by several research teams, are presented for Norway spruce in France and Sweden, Douglas fir in Belgium, Sitka Spruce in UK, Caribbean Pine in Australia, Radiata Pine in NZ. In conclusion, we discuss the perspective for improved implementation of this knowledge.

**Evaluation of five reforestation species for manufacture of oriented strand board.** Lim, N.P.T., Pek, Y.K. (*Sarawak Forestry Corporation Malaysia; nlim@sarawakforestry.com.my; ykpek@sarawakforestry.com.my*).

Five reforestation species planted in Sarawak, Malaysia, namely *Acacia mangium*, *Acacia auriculiformis*, *Azadirachta excelsa*, *Hevea brasiliensis*, and *Paraserianthes falcataria* are assessed in terms of suitability for the production of oriented strand board (OSB). Three-layer OSBs with perpendicular to grain orientation of each layer and target board densities of 600, 700 and 800 kg/m<sup>3</sup> are fabricated from wood strands using 5% and 7% phenol formaldehyde (PF) adhesive as binder. At 800 kg/m<sup>3</sup> board density, 'blowing' problems are encountered in the case of *Paraserianthes falcataria* at both percentages of PF and *Azadirachta excelsa* at 7% PF. Sample boards are also tested in respect of dimensional stability and mechanical strength properties with reference to the minimum requirements of Base particleboard Type 24 – 10 as stipulated under the Japanese Industrial Standard JIS A 5908 – 1994. Most of the sample boards with density of more than 700 kg/m<sup>3</sup> and using 7% PF are found to satisfy the stipulated JIS requirements. However, at 5% PF, only *Acacia mangium*, *Acacia auriculiformis* and *Hevea brasiliensis* of similar board density are in compliance. It is inferred that all 5 species are potentially suitable but indications are that *Acacia mangium*, *Acacia auriculiformis*, and *Hevea brasiliensis* offer relatively better promise for OSB manufacture.

**The possibility of *Melia azedarach* as a fast growing tree in Japan.** Matsumura, J., Inoue, M., Yokoo, K., Tanoue, M., Oda, K. (*Kyushu University, Japan; matsumura@agr.kyushu-u.ac.jp*).

Wood properties of *Melia azedarach*, which grows quickly and has good stem-shape, were investigated to clarify the possibility as a fast-growing tree in Japan. The test trees were seedlings, and their mother tree had been selected as a plus-tree. The diameter at breast height was 21.4–32.7 cm in 17 years. The stem-shape became straight by pruning. Growth ring width near pith, up to 3 m height above the ground, was large and became stable beyond the 4th ring regardless of stem height. Specific gravity of air-dry samples increased slightly from the pith outward, and with



increase in stem height. The variation of compression strength in the stem was similar to that of specific gravity. At present, because of umbrella-crown form, only logs up to 4 m in stem height are used, but pruning can correct this stem shape issue, making it possible to use logs up to 8 m in stem height.

**Wood quality of eucalypt sawlogs from intensively managed stands in South America and southern Europe.**

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The demand for hardwood timber motivated *Eucalyptus* growers to enter that market. Initially, wood from pulp or fuelwood plantations was processed in sawmills, using existing equipment and cutting technologies. High growth stresses caused severe timber degradation which limited early markets continues to influence use in sawlog and veneer production. Research in Brazil and Spain was conducted to analyse the complete forest-wood-chain for eucalypt sawlog production. The main species were *E. grandis*, *E. urophylla*, and *E. globulus*. Individual tree growth was analysed to determine growth potential and increment concentration on pre-selected trees. Self-pruning was investigated and pruning strategies developed to optimize quality. Wood properties were analyzed to explain the occurrence and high variability of growth stresses in and between trees. Tree growth and wood quality under different management regimes were explored. The results support eucalypt sawlog production in plantations managed with short rotations, with high growth potential concentrated on a few trees per hectare. Growth models were developed for several species to optimize sawlog management regimes. Modelling live crown base recession permit the optimization of pruning schedules. Detailed wood property analysis identified possible utilizations and improved the understanding of high growth rate on wood properties. The methodologies used to analyse growth stresses and its dynamic evolution help to explain some of the contradictory results found in literature.

**Pulping of *Trema orientalis* (Nalita): A fast growing wood.** Sarwar Jahan, M. (*BCSIR Laboratories, Bangladesh; m\_sarwar@bdonline.com*).

The demands for raw materials in papermaking are continuously increasing due to increased paper consumption, intensifying harvesting demands on natural forests. Harvesting restrictions of natural forests have made short rotation wood crops more attractive as sources of raw materials for papermaking. *Trema orientalis* is one of the fastest growing woods in the world. Therefore, it is important to characterize its raw material for papermaking. This paper describes the anatomical, morphological, and chemical properties of *T. orientalis*. The proportion of fiber having average length of 925 Bm and vessels were 71.4 and 15.4%, respectively. The  $\alpha$ -cellulose, pentosan, and Klason lignin were approximately 50, 22 and 22%, respectively. It was found that xylan was the predominant sugar in the hemicellulose. Alkaline nitrobenzene oxidation of wood meal indicated that the guaiacyl and syringyl units were the major constituents of *T. orientalis* lignin. Studies were undertaken to explore the use of different cooking times and amounts of active alkali during soda-anthraquinone pulping. Increasing cooking time or active alkali resulted in increased screened pulp yield, and decreased total pulp yield and kappa number. The strength properties were comparable to Gamar wood pulp, an important fibrous raw material in Bangladesh.

**Structural utilization of natural and planted softwood timber in Korea.** Shim, K.-B., Yeo, H.-M., Park, B.-S., Shim, S.-R., Park, J.-H., Lee, D.-S., Cho, S.-T., Kim, W.-J. (*Korea Forest Research Institute, Republic of Korea; kbshim@foa.go.kr; frishim@empal.com*).

Approximately 60% of Korean forest is occupied by Korean red pine (*Pinus densiflora*), Korean pine (*Pinus koraiensis*), and Japanese larch (*Larix leptolepis*). Korean red pine is in natural forests, but Korean pine and Japanese larch are in planted forests. Approximately 78% of Japanese larch was graded in No.2 and better, but only 32% and 21% of Korean pine and Korean red pine were graded in No.2 and better. The allowable bending stresses for No. 2 grade structural lumber (2×4) are 60 kgf/cm<sup>2</sup>, 50 kgf/cm<sup>2</sup>, and 100 kgf/cm<sup>2</sup> for the Korean red pine, Korean pine and Japanese larch, respectively. To use softwood timber as value-added structural member, development of high load carrying engineered wood or system is necessary. In this study, space frame members with dimension of 60mm diameter and 800mm length structures were developed for large-span wood structures. Ball-type and bolt connections were used for test specimens. Maximum structural performance of connection with two 12mm diameter bolts was evaluated to be 4723 kg, 1.6 times more than two 8 mm diameter bolts. Applicability of the wooden space truss to mid-scale construction was evaluated by constructing a demonstration building, suitable for stadium or exhibition building. Construction posts, space truss, and roofing were finished within three days. It has high potential for a hybrid building with steel or reinforced concrete structures.

**Spacing, thinning, and wood quality in *Eucalyptus pilularis* plantations in Australia.** Smith, G. (*Forests NSW, Australia; Geoffsm@sf.nsw.gov.au*).

*Eucalyptus pilularis* is an important native hardwood species in northern New South Wales, Australia. Since 1994, a plantation program has been established to replace native forest solid wood production resources by replanting cleared land. One of the major challenges is the wood quality in plantations compared to the native resource. Comparative sawing studies have shown the major difference is knots. Normally pruning would be undertaken, however the response of canopy dynamics and branching characteristics to spacing suggest management should take advantage of self-pruning and branching characteristics in spacing and thinning prescriptions. Initial densities of greater than 1250 trees per hectare allow selection of sufficient high quality stems, restrict the development of large branches, and increase the rate of crown rise. Wider spacings between rows have no effect on branching or form but are directly related to establishment cost.

**Comparative strength and durability of natural and oil-cured bamboo.** Wahab, R., Sudin, M., Mohamed, A. (*Universiti Malaysia Sabah (UMS), Malaysia; drrazakw@ums.edu.my*), Samsi, H. (*Forest Research Institute Malaysia (FRIM), Malaysia*).

This paper investigates the effect of heat treatment on the properties and durability of bamboo, *Gigantochloa scortechinii*. Matured bamboo culms were harvested and subjected to high temperature condition using palm oil as a heating media. Two groups of samples were used in the study: green and air-dried. The temperatures applied were 140, 180, and 220 °C, with exposure duration of 30, 60, and 90 min respectively. Results demonstrated that the heat treated bamboo retained most of the original physical and strength properties after undergoing the heat treatments process. Green or air-dried bamboo culms can be dried to an MC of 6–7% within 2–3 hours of treatment. Basic densities of bamboo were found to improve slightly by the heat application. Overall strength properties of the heat treated bamboo were found to decrease. Modulus of elasticity in bending strength was reduced 2–33% in green condition, and 6–9% in air-dried condition. Modulus of rupture in bending strength values were reduced 1–23% in green condition, and 4–16% in air-dried condition. Compression strengths were reduced 2–3% in green, and 2–35% in air-dried conditions. Shear strengths were reduced 16–24% in green and 12–24% in air-dried conditions.

**Stress wave propagation behaviour in the transverse direction of wood.** Wu, S.-Y., Cho, C.-L. (*National Ilan University, Chinese Taipei; sywu@niu.edu.tw*).

The traveling time of stress waves will be elongated due to the existence of a discontinuity in the propagating path. This research was focused on the study of the most possible traveling path of stress waves propagating in the transverse direction of wood, and the effect of heart check on the traveling time. Stress wave and ultrasonic approach was applied for measuring the traveling time in 200-year old Taiwan red pine and 60-year old Japanese cedar disks. Results indicated that the stress wave velocity was fastest along the radial direction and slower when the angle of deviation between the path and the radial direction was greater. An interesting finding is when a heart check from pith to bark exists, the traveling time measured very close to the value along the radial direction measurement. To analyze the discontinuity effect on the traveling time, a homogenous acrylic plate was used to simulate the stress wave propagating path with a hole or crack. Test results shown that stress waves take the straight path between the nearest peak of a crack and two accelerometers. Since the stress wave travels fastest along the radial direction, it will propagate along the radial direction and diffract after passing through the pith, when heart check exists between the two accelerometers.

**Loss of green sawn recovery of 32-year old *Eucalyptus globulus* due to growth stress.** Yang, J.L. (*ensis – CSIRO and Forest Research, Australia; Junli.yang@csiro.au*).

Thirty dominant or co-dominant straight trees were selected from a 32-year-old thinned plantation of *E. globulus*. Growth strain at breast height was estimated using the CIRAD-forêt method. Pith-to-cambium strip specimens were prepared from 12mm increment cores collected at breast height, and density, microfibril angle, and cellulose crystallite width determined using SilviScan. Log end splits in the 30 butt logs were measured. The butt logs were quarter-sawn following a pre-determined sawing pattern. The most common dimensions were 28 x 105 x 3000 mm and 28 x 77 x 3000 mm. The curved-edge off-cuts were measured and the volume estimated for each log. The end splits in the sawn boards were measured and the volume of green sawn boards containing the splits calculated. The estimated loss of recovery due to log end splits was equivalent to 1% of log volume, or approximately 4% of the dried board volume. The estimated loss of recovery due to removing curved-edge off-cuts in the slabs was 6% of log volume. For a sawmill processing 40,000m<sup>3</sup> of logs per annum, these could translate to an annual loss of \$385,000 and \$758,000 respectively. The severity of log end splits and spring in dried boards were significantly correlated with the estimate of growth strain measured on the surface.

## **Integrating wood production within sustainable forest management**

Session organizers: Robert Deal, *USDA Forest Service, USA*; [rdeal@fs.fed.us](mailto:rdeal@fs.fed.us), and James Barbour

### **The challenge of meeting the increasing need for artificial regeneration of oaks in the eastern United States.**

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Natural regeneration of oaks has become increasingly less successful in the last two decades. Add to that the many natural and anthropogenic disturbances more frequently occurring in oak-dominated stands, and we have the situation that exists today—oak forests are declining in the eastern United States. Artificial regeneration is required following many disturbances, including human caused; however, relatively little has been done to increase the production of quality oak seedlings in nurseries, or to develop biologically successful and affordable seedling reforestation protocols. The challenge focuses on the definition of regeneration success: Seedlings must be grown, planted, and maintained in a manner that they will not only survive, but will also become, at least, co-dominants in the new stand at the time of crown closure. It appears this requirement can be met by either (1) planting relatively large, healthy seedlings with an adequate root system and balanced shoot-to-root ratio, along with some level of protection from vegetation competition, or (2) by planting healthy seedlings of a somewhat lesser size with the same root specifications, but with intensive vegetation and animal damage protection for several years. Seedling and management options being considered and researched, and progress to date, are discussed.

**Measuring sustainable forest management in Tierra del Fuego, Argentina.** Bigsby, H.R., Carabelli, E., Cullen, R. (*Lincoln University, New Zealand*), Peri, P.L. (*Universidad Nacional de la Patagonia Austral, Argentina and Instituto Nacional de Tecnología Agropecuaria, Argentina*).

The Tierra del Fuego government has a statutory responsibility to ensure that *Nothofagus* (Lenga) forests are sustainably used, respecting them as a natural and social heritage to be preserved for future generations. Provincial regulations also require that a Regional Forest Plan and long-term forest policies should be developed. To contribute to the development of this Plan and to provide strategies to maximize the forest's sustainable benefits for society, this research develops indicators of sustainable management of Lenga forests. Multi-criteria methods are used to integrate different perspectives regarding environmental, social, and economic aspects of the forest's management. Using a range of internationally accepted criteria and indicators (C&I) schemes, a local set of C&I were developed to assess the forest's sustainability. The results highlight potential areas of conflict between stakeholders and areas for improving sustainable management.

**Sustainability of natural resource capital and related carbon accounting.** Chikumbo, O. (*ENSIS, NZ*; [Oliver.Chikumbo@ensisjv.com](mailto:Oliver.Chikumbo@ensisjv.com)), Davey, S.M. (*Bureau of Rural Sciences, Australia*; [stuart.davey@brs.gov.au](mailto:stuart.davey@brs.gov.au)).

Sustainability is explained in terms of goals that can be achieved in the context of maintaining and utilizing ecosystem goods and services that human survival depends on. From those goals, four main interrelated strategies/tools are suggested that may assist in modeling and planning for the sustainable supply of ecosystem goods and services. The strategies/tools are systems theory, planning, integrated management information systems, and a decision support system. The systems theory assists in the organization of variables that can be measured and controlled directly and indirectly, in a way that enables extraction of information on how an ecosystem behaves as opposed to how it works. The planning strategy addresses the scale issue at the strategic, tactical, or operational level. It is vitally important to use an integrated management information system that caters to all the critical elements of the ecosystem in question. Finally, a framework for a decision support system is vital, particularly one that enables optimization of conflicting objectives and provides the ability to accommodate constraints of a spatial nature. A case study is presented to verify the above strategies/tools.

**Structural and biometric characterization of *Nothofagus betuloides* forests in Patagonia, Chile.** Cruz, G., Caprile, R., Promis, A., Cabello, G. (*Universidad de Chile, Chile*; [gcruz@uchile.cl](mailto:gcruz@uchile.cl); [rcaprile@uchile.cl](mailto:rcaprile@uchile.cl); [apromis@uchile.cl](mailto:apromis@uchile.cl); [guscab@123mail.cl](mailto:guscab@123mail.cl)).

This study, in the Chilean Patagonia, undertook the structural and biometric characterization of *Nothofagus betuloides* forests to provide information for sustainable forest management. Six geographical locations were surveyed, five on the continent and one on the island of Tierra del Fuego. A total of 6,101 hectares were described according to their location, environmental characteristic, and vegetation type. The degree of human intervention, stage of development, status of regeneration, and composition and cover of the understory were also described. A total of 76% of the forest area had *Nothofagus pumilio* and *N. betuloides* mixed forests. The remaining areas (24%) were pure *N. betuloides* forests. Virgin, old-growth forests covered 49% of the surveyed area. The remaining area (51%) had some human intervention. In the virgin forests, mean volume stocks were 429 m<sup>3</sup>/ha, while in human intervened forests, mean volume stocks were 317 m<sup>3</sup>/ha.

**Sustainable harvesting of *Dicksonia antarctica* in wet forests in Tasmania.** Davies, S., Duncan, F., Chuter, A. (*Forest Practices Board, Tasmania, Australia; simon.davies@fpb.tas.gov.au; fred.duncan@fpb.tas.gov.au; anne.chuter@fpb.tas.gov.au*).

*Dicksonia antarctica* (manfern or soft tree fern) is an attractive trunked fern that is widespread in Tasmanian wet eucalypt forests and rainforests. It can reach 10 m in height, and its fibrous trunk is an important substrate for vascular and non-vascular epiphytes. There has been a long history of unregulated harvesting of *Dicksonia* for local horticultural use. A management plan approved by the Tasmanian and Commonwealth Governments (2001) allowed *Dicksonia* to be exported to lucrative overseas markets, subject to the introduction of a regulatory system that only permitted harvesting of *Dicksonia* from areas where native forest was to be converted to another land use (most commonly plantation). The management plan also initiated research, funded by a harvesting levy, into sustainable management of *Dicksonia*. Replicated studies conducted before and after cable and ground-based logging in wet forest coupes showed how logging affected the ability of harvesters to salvage *Dicksonia*. They also examined the combined effects of logging, regeneration treatment, and *Dicksonia* harvesting on the survival and ecological contribution of *Dicksonia* in re-growth native forests.

**Integrating wood production within sustainable forest management: An Australian viewpoint.** Ferguson, I. (*University of Melbourne, Australia; Iansf@unimelb.edu.au*).

Australia has commenced the implementation of sustainable forest management through Regional Forest Agreements. These represent a substantial advance towards sustainable management of both wood production forests and the national conservation reserve system, if implemented properly and adequately resourced. This paper reviews the ways in which approaches to the sustainable forest management are being implemented as part of the broader social-ecological systems, including the development of forest certification, with particular reference to the states of Tasmania, Victoria, and Western Australia. The paper summarizes the measures implemented, the obstacles, and the results achieved to date. It also examines emerging technologies for sustainable wood production, the role of markets for sustainable forest management, opportunities for improving forest value for landowners, and land use changes and their effects on sustainable wood production. It also explores the wider public image of the forest debate in Australia, which is largely predicated around popular perceptions of 'one tenure-one use,' and what needs to be done to develop a more realistic image around an ecosystem approach to sustainable forest management that spans all tenures. The paper concludes that this change of public image represents the most significant challenge to advancing towards sustainable forest management.

**Integrating concerns about wood production and sustainable forest management in North America.** Haynes, R.W. (*USDA Forest Service, USA; rhaynes@fs.fed.us*).

The United States and Canada are signatories to the Montreal Process for Sustainable Forest Management (SFM). Its implementation in both countries is strongly influenced by US forest products markets and the numerous management decisions made by individual land owners and managers. These decisions are influenced by a mix of market incentives and regulatory actions, reducing predictability in assessing progress towards SFM. This is especially the case with markets, where the unpredictable role prices play causes some proponents of SFM angst, because price may not provide sufficient incentive for what they believe are necessary forest practices. Both countries have increased wood production while simultaneously attempting to make progress towards SFM. Past increases in wood production have relied on sustained upward changes in timber prices to provide positive incentives to improve the intensity and extent of forest management practices. We face a future of relatively stable prices, and some forest management advocates are concerned that expectations of lower returns to various forestry practices may lead the myriad of landowners, each with their own objectives, to respond to various market signals in ways that are not supportive of SFM or expanded wood production.

**Finnish Centre of Expertise for Wood Products: diversification of wood utilization.** Kärnä, J. (*Finnish Forest Research Institute, Finland; jari.karna@metla.fi*).

The Centre of Expertise for Wood Products in Finland is an umbrella organization that takes a market-oriented view of the forestry and wood products business chain, and provides expertise for research and development. It works in co-operation with the Wood Wisdom Research and WoodFinland Action programs. The operations of the Centre are divided into seven fields of expertise, which are coordinated by universities and research institutes, and serve as a network for national and regional experts. The networks improve the transfer of knowledge, the creation of new knowledge, and the production of showcase applications of wood in construction, and form an interface with developers and entrepreneurs. The seven fields are: Modern Wooden Town and Structural Systems, Large-Scale Wood Engineering and Structural Systems, Living with Wood and Design, Diversification of Wood Utilization, Business-Based Development of Technology, New Business Concepts, and Developer Forum. Diversification of Wood Utilization is coordinated by the Finnish Forest Research Institute. The objective is to create an active network between R&D organizations and companies, in order to plan and initiate joint projects. The focus areas are: Utilization of hardwood, utilization of small-diameter wood, and material technology. The poster presents examples of current research projects.

**Factors leading to unsustainable selective harvesting in mixed-species forests: A comparison of mahogany in Quintana Roo, Mexico and red oak in Massachusetts, USA.** Kelty, M., Cámara Cabrales, L. (*University of Massachusetts, USA; kelty@forwild.umass.edu; camaracabrales@forwild.umass.edu*).

Low-impact harvesting associated with uneven-aged management is often promoted for achieving sustainable forest management, but results are not always as desired. This problem was examined in two regions that differ sharply in the economic situation of landowners and the legal framework for land ownership and forest practices. In Quintana Roo (QR), most rural land is owned by villagers as collectives (ejidos), and timber provides the main income. Most rural land in Massachusetts (MA) is owned by individual families as an amenity, and does not produce a substantial part of family income. Natural mixed-species forests predominate in each region, with one highly valuable species, red oak (*Quercus rubra*) in MA and bigleaf mahogany (*Swietenia macrophylla*) in QR, occurring as dominants in a mixture of mainly low-value species. A common silvicultural method in both regions consists of harvesting only the large mahogany or oak, even though this will not sustain either species, because both require canopy openings that are substantially larger than single-tree gaps for regeneration. Two factors common to both regions have led to this approach: 1) the great differential in value among species; 2) the desire to minimize forest disturbance, by landowner choice in MA and by regulation in QR.

**Norway spruce monocultures and their transformation to close-to-nature forests from the point of view of soil changes in the Czech Republic.** Klimo, E., Kulhavy, J. (*Mendel University of Agriculture and Forestry Brno, Czech Republic; kulhavy@mendelu.cz*).

The current proportion of Norway spruce stands in the Czech Republic is approximately 54% – much higher than the natural composition of 11% and the recommended 36.5%. This research focused on: defining the properties of forest sites unsuitable for growing spruce monocultures, changes in elements cycling (particularly nitrogen), processes of the organic residue decomposition, and relationships between nutrition, soil properties, and climatic conditions. A network of sites was established for comparative studies of forest stands in various degrees of transformation. Transformation does not mean the replacement of spruce monocultures with stands of other species, but rather assigning the proportion of spruce in accordance with forest site capacity. Studies were undertaken of organic matter accumulation, nutrient concentrations in the organic layers, acidification, and nutrition in stands ranging from spruce monocultures to mixed composition. Preliminary conclusions are: spruce monocultures change the cycling of elements considerably during the first generation, organic matter accumulation in spruce monocultures is highest in the H-layer and this layer remains to a considerable degree with newly established broadleaved stands, patches of beech retard acidification processes, and the worst nutrition conditions in spruce monocultures have not been statistically related to the lower (50 t/ha) or higher (150 t/ha) accumulation of surface humus.

**Tree growth, lumber drying and wood properties of *Nothofagus betuloides* in Chile.** Manso Martin, M., Nutto, L., Becker, G. (*University of Freiburg, Germany; maria.manso@fobawi.uni-freiburg.de*).

The native forests of southern Chile are dominated by species of the genus *Nothofagus*. A species with valuable wood is *Nothofagus betuloides*. Commercial acceptance of this species is rather low, due to problems while processing and drying the wood. It is estimated that 176,000 m<sup>3</sup>/year could be immediately used by the wood industry. The present study aims to analyse tree growth, wood and cell structure, wood properties and wood quality of *N. betuloides* in order to get new knowledge about how to optimize processing and kiln drying. There were 30 trees selected for the study. For standing trees, dbh, height, growth stresses (at 1.3 and 5.5 m), crown size and form as well as stem inclination and curvature were measured. After felling the trees, sample disks at 1.3 and 5.5 m (for retrospective growth analysis) and small logs of 50 cm length at 1.2 and 5.6 m were taken (for wood property analysis). The logs from 1.5 to 5.5 m were cut into boards using a backsawing system and the wood was classified according to local grading rules. Some of the boards were used for a kiln drying and another sample for a vacuum drying experiment. The data will enable us analyse the interactions between growth, wood properties, drying behaviour and lumber quality. The outcomes will be used to optimize existing management and processing systems of *Nothofagus betuloides*.

**Sustainable forest management in an era of declining timber prices: The British experience.** Mason, B., Kerr, G., Humphrey, J., Quine, C. (*Forest Research UK; gary.kerr@forestry.gsi.gov.uk; bill.mason@forestry.gsi.gov.uk; jonathan.humphrey@forestry.gsi.gov.uk; chris.quine@forestry.gsi.gov.uk*).

Britain has 2.7 million ha of woodland accounting for 11.6% of the land area. This area can be divided between broadleaved woodland (1.1 million ha, of which 46% is ancient woodland) and coniferous, non-native plantations (1.6 million ha). In the last 30 years there has been an ever-increasing awareness of the social and environmental benefits of woodland. This has had many positive outcomes: ancient woodland is fully protected and being restored; forest certification has been embraced through the United Kingdom Woodland Assurance Standard, enhancing biodiversity is a key forest policy objective, and forest managers are increasingly engaging with local communities and wider publics to ensure that social benefits are obtained. Unfortunately during the last 10 years there has been a dramatic reduction in

the market value of timber. The paper will examine how forest science and technology transfer can support managers who are faced with these increasingly complex demands. This will be illustrated using newly developed research tools that can be deployed in combination to support new practice. The developments include: ForestGALES, a model for calculation of wind damage risks to woodland; Ecological Site Classification, a system to help make decisions based on the ecological potential of a site; HARPPS, a knowledge base for the needs of priority species and habitats; and finally, transformation of even-aged woodlands to 'continuous cover'.

**Changes in wood product proportions in the Douglas-fir region with respect to size, age, and time.** Monserud, R.A., Zhou, X. (*USDA Forest Service, USA; rmonserud@fs.fed.us; xzhou@fs.fed.us*).

We examine both the variation and the changing proportions of different wood products obtained from trees and logs in the Douglas-fir region of the northwestern USA. Analyses are based on a large product recovery database covering over 40 years of recovery studies; 18 studies are available for Douglas-fir. Visual lumber grades were combined into four broad value classes. We used the multinomial logistic model to estimate the yield proportion of each value class, while ensuring that the proportions sum to unity for a given tree. In one sense, this is a meta-analysis, except that we have the complete raw data. We also examine changes in wood product proportions with respect to future projections of current management, harvesting trends, and sustainability. Large changes in wood product proportion are observed as the size of trees available for harvest decreases over time. This directly ties the production of classes of wood products to questions of sustainability.

**Stem analysis as an aid for providing annual growth records for plantation forests in the absence of permanent sample plot measurements: the case of teak in Costa Rica.** Pérez, D. (*Ambiente Tierra, Costa Rica; diegoperez@costarricense.cr*), Kanninen, M. (*Center for International Forestry Research (CIFOR), Indonesia; m.kanninen@cgiar.org*).

In the absence of growth series from permanent sample plot records, the forest plantation sector of Costa Rica, and many other countries in Central America, have managed fast-growing plantation species without proper knowledge of stand dynamics. In some cases, not even the stand age has been properly recorded, being unfeasible to develop adequate management regimens for an intensive and economically attractive wood production. The use of stem analyses represents a good possibility for developing growth curves based on yearly time series. From different studies carried out on teak (*Tectona grandis*) plantations in Costa Rica, the stem analysis of different aged trees was used for developing growth curves, aiming at providing useful information on the growth dynamics of the species through different rotation periods and under different management regimens.

**Evaluation of non-destructive testing methods for timber quality assessment on standing trees in mixed hill dipterocarp forests in Sarawak, Malaysia.** Reuter, M. (*Bonn University, Germany; manjareuter@gmx.net*), Trockenbrodt, M. (*Universiti Malaysia Sabah, Malaysia; mtrockenbrodt@gmx.net*), Frühwald, A., Heuveldop, J., Glauner, R. (*Hamburg University, Germany; fruhwald@holz.uni-hamburg.de; r.heuveldop@gmx.net; glauner@holz.uni-hamburg.de*).

Three non-destructive methods for the detection of internal stem decay were evaluated regarding their suitability for large scale application in Sustainable Forest Management Systems. The Resistograph micro-drill, revealing the density profile of the bole, the Metriguard stress wave timer for sound velocity measurements, and the Visual Tree and Site Assessment were applied on 140 trees of four commercial dipterocarp species (dbh > 40 cm). Eighteen of the assessed trees were felled. As micro-drillings proved to detect stem decay with accuracy, they were used to verify the reliability of the other techniques. The high time and power requirements of the Resistograph limited its suitability for large-scale applications. The stress wave timer was faster and less power demanding. A significant difference between hollow and solid trees of high diameter classes was found. The sound velocity was explained by wood density, moisture content, and hollowness in a multiple regression model. The Visual Tree and Site Assessment classified as a reliable, fast, and cost-effective method. A set of parameters for successful visual detection of internal stem rot of *Shorea faguetiana* Heim and *Shorea parvifolia* Dyer was identified.

**Sustaining productivity of eucalypt plantations in Kerala, India.** Sankaran, K.V., Chacko, K.C., Pandalai, R.C. (*Kerala Forest Research Institute, India; sankaran@kfri.org; chacko@kfri.org; rcp@kfri.org*), Mendham, D.S., Grove, T.S. (*CSIRO FFP; Daniel.Mendham@csiro.au; Tim.Grove@csiro.au*).

In India, eucalypt plantations are an important source of fibre for paper making and fuel for local villagers. Large areas of land have been in eucalypt plantations for several rotations, and at many sites the productivity has been declining through successive rotations. In 1997, we initiated a project to examine conservative site management options as a way to restore the productivity of these sites. We established a large experimental infrastructure at four sites in Kerala, consisting of up to seven separate fully randomized block experiments, examining inter-rotation management options (organic matter manipulation, N-rate, P-rate, legume cover cropping, weed control, trenching, and thinning). Two of

the sites were typical lowland *E. tereticornis*, and the other two sites were typical upland *E. grandis*. Following treatments, we intensively monitored plantation productivity and impacts on soil and nutrient cycling for 1 full rotation (6.5 years). We found that it is possible to achieve 2–3 fold growth increases through conservative site practices, but productivity responses are dependent on site-specific factors. The key outcomes of this research will be presented, with special reference to application in the broader context of tropical eucalypt plantations.

**Predicting rot and round-wood end use volume in trembling aspen.** Schneider, R., Riopel, M., Pothier, D. (*Université Laval, Canada; robert.schneider.1@ulaval.ca; martin.riopel@sbf.ulaval.ca; david.pothier@sbf.ulaval.ca*), Côté, L. (*Ministère des Ressources naturelles, de la Faune et des Parcs, Québec, Canada; levis.cote@mrnfp.gouv.qc.ca*).

Predicting net merchantable volume of standing trees is essential in Quebec because it affects stumpage fees. Furthermore, round-wood end use is important in the provincial forest management context because it is used to apportion the allowable annual cut between the different mill types. A new approach is proposed to predict both rot and round-wood end use volumes in trembling aspen (*Populus tremuloides*). Stem age, height, and quality, as well as ecological region and presence of *Phellinus tremulae* and *Ceratocystis fimbriata* fungi are the main factors used in logistic regression to quantify the proportion of rotten merchantable volume. Once the net merchantable volume is estimated, the breakdown to round-wood end use is achieved through a series of steps involving the presence of *Phellinus tremulae*, saw log height, stem quality, and size as explanatory variables. The first step is a multinomial regression which predicts the number of end uses which are present in the stem (i.e., pulp wood, low grade saw logs, saw logs, low grade veneer, veneer). A series of logistic regressions then determines the presence of each end use, with linear regressions predicting the round-wood volume of each end use.

**Effects of thinning on the growth of natural stands of oak in the Ibero-Atlantic Zone.** Silva-Pando, F.J., Rozados Lorenzo, M.J., Rozas, V., López-Sors Cano, C. (*CIFA de Lourizán, Spain; jsilva.cifal@siam-cma.org*).

Oak (*Quercus robur*) is the climactic species in the northwestern Iberian Peninsula. In spite of the extent of this species and the role it plays in the forest landscape, it has received limited scientific attention. Only in recent years has there been an increase in the silvicultural knowledge of *Q. robur*. This project addressed questions regarding thinning in *Q. robur* stands. Experimental plots were established in three different locations on the Iberian Peninsula to explore the effects of different thinning regimes. Thinning treatments reduced basimetric area by 15, 35, and 55 %. On the thinned plots, increases of 2–4 m<sup>3</sup>/ha/yr in the production volume were documented relative to the control plot, as well as notable diameter growth rate increases of up to 2 mm/yr at the 15% thinning level. The study found that growth response following thinning was related to site quality and the physiographical characteristics of the plots.

**Ecological forestry and eucalypt forests of south-western Australia.** Stoneman, G.L. (*Department of Conservation and Land Management, Western Australia, Australia; geoffs@calm.wa.gov.au*).

The model of ecological forestry has evolved as a part of the development of the concepts of ecosystem management and ecologically sustainable forest management. Ecological forestry emphasizes that manipulation of a forest ecosystem should consider, and as far as practicable work within the limits of, natural disturbance patterns prior to extensive human alteration of the landscape. This paper evaluates the extent to which current forest management practices in jarrah (*Eucalyptus marginata*) and karri (*Eucalyptus diversicolor*) forests of south-western Australia align with this view of the characteristics and appropriate silviculture of ecological forestry. Characteristics and appropriate silviculture of ecological forestry are evaluated in relation to (i) the stand level decisions of stand structure and harvest timing and (ii) the landscape level decisions of harvest levels and age structures, and spatial patterns of harvest. The paper also discusses the broader context within which ecological forestry operates, that is, the landscape triad of conservation reserves, areas managed to ecological forestry principles and areas managed to production forestry, in the south-western forests of Australia.

## **Designing policies for the protection of biodiversity in forested environments**

Organizer: George Hoberg *University of British Columbia, Canada; hoberg@interchg.ubc.ca*

**Integrative strategies for human development and biodiversity conservation.** Bantayan, N.C. (*University of the Philippines Los Baños, The Philippines; ncb@laguna.net*), Ong, P. (*University of the Philippines Diliman, The Philippines; ongperry@csi.com.ph*), Boquiren, R. (*University of the Philippines Baguio, The Philippines*), Pido, M.

(Palawan State University, The Philippines), Lagunzad, D. (University of the Philippines Diliman, The Philippines), Lagunzad, C. (Ateneo de Manila University, the Philippines), Balete, D.

In 1999, the Puerto Princesa Subterranean River National Park (PPSRNP) in the Philippines was inscribed as a World Heritage Site because of its unique biodiversity and geological features. The core of the PPSRNP is the Saint Paul Mountain Range, which features a spectacular limestone karst landscape with an underground river that emerges directly into the sea. Integrative strategies for management were generated through a visioning process for biodiversity conservation. The method of analysis and prescriptions for sustainable management was derived from the Pressure-State-Response Model that describes the state of biodiversity. This state is continuously under pressure from various direct factors and underlying socio-economic and political drivers. In response to these pressures on the current state of biodiversity, society undertakes conservation actions to reverse the loss of biodiversity. Illustrative examples under pressure, state, and response were elicited. At every step of the process, indigenous knowledge was integrated until a set of strategies embracing human development and conservation issues were formulated.

**Landscape conservation through partnership in the Emerald Triangle protected forests complex.** Chheang Dany (Forestry Administration, Cambodia; [wpo@forum.org.kh](mailto:wpo@forum.org.kh)), Bun Radar (Forestry and Wildlife Training Centre, Forestry Administration, Cambodia).

This initiative is jointly proposed by the participating countries Thailand, Cambodia, and Laos. This submission is a response to the results of the 3rd PSC meeting held in Bangkok on November 23, 2003. The Project timeframe is proposed for 2 years (2005–2006). The development objective of the project is to conserve trans-boundary biodiversity in the Emerald Triangle Protected Forests Complex, situated between Thailand, Cambodia and Lao PDR, in a framework of trans-boundary biodiversity conservation area (TBCA). Specific objectives are: 1) to strengthen cooperation between Thailand, Cambodia and Laos for biodiversity conservation in respective trans-boundary conservation areas, 2) to enhance protection and monitoring of the biological resources along tri-national borders, and 3) to strengthen the involvement of local communities and stakeholders in sustainable uses and management of natural resources both in enclave communities and in the buffer zones. This initiative will extend lessons learned from each country and focus on implementation of planned biodiversity conservation activities. Among the project's most important outputs will be strengthened cooperation among the three countries on TBCA, increased human resource capacity in biodiversity conservation and management, integrated conservation and development programs in the buffer zone, and nature-based tourism packages to increase livelihood of local residents.

**Science policy and ecosystem goods and services: an Australian forest perspective.** Davey, S.M., Keenan, R. (Bureau of Rural Sciences, Australia; [stuart.davey@brs.gov.au](mailto:stuart.davey@brs.gov.au); [rodney.keenan@brs.gov.au](mailto:rodney.keenan@brs.gov.au)).

The subject of ecosystem goods and services (or ecosystem services) is challenging for scientists and policy makers. Current approaches to forest resource use are compromising the future provision of ecosystem services. This is because of deficiencies in either policy and/or science. Hence there are growing requirements to consider ecosystem services in forest policy, both domestically and internationally, involving issues associated with biodiversity conservation and use, trade and the environment, land degradation, human health, water, economics, sustainable development, and global sustainability. The forest science-policy dimensions of ecosystem services, and the connectivity of science and policy, are reviewed from an Australian perspective. Science has a significant role in informing and shaping policies associated with forest resources and ecosystem services. The subject of ecosystem services requires a coordinated and strategic approach, domestically and internationally, to benefit both the scientific and policy considerations of the subject. Such an approach would benefit the sustainable future of forests, and enhance natural resource and environmental management and associated production systems, rural industries, and communities.

**The CBD expanded programme of work on forest biodiversity as a global instrument for forest conservation. Economic consequences of forest biodiversity conservation in Finland.** Hänninen, R., Kallio, M. (Finnish Forest Research Institute, Finland; [riitta.hanninen@metla.fi](mailto:riitta.hanninen@metla.fi); [maarit.kallio@metla.fi](mailto:maarit.kallio@metla.fi)).

Decisions have been made to increase forest biodiversity conservation in southern Finland in the coming years. In this study, we address economical consequences on the Finnish forest sector of alternative biodiversity conservation schemes. Their potential impacts on supply, demand, prices, regional trade of wood, and forest industry products are assessed. We also study how conservation could be allocated regionally to minimize potential economical loss to the forest sector. In the study, we use a partial equilibrium model of the Finnish forest sector and the main export markets. The model is disaggregated regionally, and based on production technologies. All the Finnish pulp and paper production lines as well as major mill producing mechanical forest industry products are individually modeled.



**Policies for protecting biodiversity in Canada's forests: Divergent approaches among the provinces.** Hoberg, G., Karmona, J. (*University of British Columbia, Canada; george.hoberg@ubc.ca; jkarmo@interchange.ubc.ca*).

This paper examines the development and implementation of biodiversity policies in forested environments in Canada. It examines the specific policies adopted by the federal government and a number of provinces and territories. After an over-view of the division of powers over biodiversity policy in Canada, we apply a modified version of Lindenmayer's checklist to examine policies in British Columbia, Alberta, Ontario, Quebec, Newfoundland, and the Yukon: protected area targets, and progress towards those targets; protection of biodiversity in the 'matrix' outside of protected areas at both the landscape and stand level; and connectivity. All the jurisdictions studied have elements of each component of the checklist, with the exception of connectivity. Some jurisdictions are more advanced in terms of matrix biodiversity protection, but there is a general pattern of implementation being constrained by socio-economic pressures to maintain timber supply.

**Designing socially acceptable conservation policy for biodiversity in private forests: Forest owners and citizens views.** Horne, P. (*Finnish Forest Research Institute, Finland; paula.horne@metla.fi*).

While biodiversity preservation is acknowledged to be an important part of ecologically sustainable forest management, securing the social sustainability of the policy measures and regulations applied is vital for obtaining the objectives of preservation in the long run. In private forests, incentive-based conservation mechanisms have been advocated as a promising tool for integrating local forest owners into the conservation process voluntarily. This project aimed at understanding the often heterogeneous and conflicting preferences for biodiversity conservation in forest management, and the level of acceptance of potential policy instruments. Empirical data were collected by postal surveys both from the supply side—private forest owners—and the demand side—Finnish citizens—who also pay for the conservation costs. The value of and trade-offs between multiple attributes of nature conservation were analyzed using the 'choice experiment method'. The results showed that the preferences for conservation policy differed between the attitude clusters. When the nature conservation values were placed abreast the socio-economic costs of the conservation action, most of the respondents faced a trade-off situation. Policy instruments based on the cooperation of forest owners were preferred to a more authoritarian approach in biodiversity conservation.

**Lessons from biodiversity campaigns by non-governmental organisations in Japan and Germany: Learning it the hard way?** Kohsaka, R., Makoto, I. (*The University of Tokyo, Japan; ryo@kohsaka.jp*), Kanuma, K. (*The University of Hokkaido, Japan*).

Concerns for biodiversity have become a major ethical issue for governments, businesses, and scientists alike. Non-governmental organizations (NGOs) have taken on active roles by raising awareness, advocating changes in legislation, and mounting pressure at both national and international levels. These global movements have highlighted the culturally embedded character of NGO campaigns and public perceptions. With the aim of improving understanding, we studied the topical and multi-faceted issue of biodiversity, by comparing NGO campaigns and their perceptions within an international setting (Germany and Japan). The project consists of three phases: collection and analysis of campaign materials, interviews with campaigners or PR experts, and interviews with members of the public. Visual materials are given priority. The expectation is that by providing NGOs with evaluation information on their campaign, and they implement recommended changes, then their campaigns will be better accepted by their target audiences. Contentious misunderstandings (between countries or between experts and public) can easily become emotional and sensitive, but through the proposed systematic scientific analysis, different cultures and societies may learn to adopt different ways of looking at such issues and begin developing a common dialogue for communication.

**A general framework and checklist for biodiversity conservation.** Lindenmayer, D. (*The Australian National University, Australia; davidl@cres.anu.edu.au*).

An overarching theme in forest biodiversity conservation is to maintain habitat suitability for forest biota. This is because habitat loss is a key factor underpinning both the loss of biodiversity *per se* and the loss of species in forest ecosystems. Five general principles can help meet the critical goal of maintaining habitat across the full range of spatial scales: 1) the maintenance of connectivity, 2) the maintenance of landscape heterogeneity, 3) the maintenance of stand structural complexity, 4) the maintenance of the integrity of aquatic ecosystems by sustaining hydrological and geomorphological processes, and 5) the use of knowledge of natural disturbance regimes in natural forests to guide off-reserve forest management practices. Developing management plans and strategies consistent with these five general principles is a complex, challenging, and multi-scaled task. In attempting to meet this challenge, there are three broad groups of conservation strategies that together form part of any credible approach to forest biodiversity conservation: 1) setting aside large ecological reserves, 2) adopting landscape-level off-reserve management strategies, and 3) adopting stand-level off-

reserve management strategies. I present a simple, hierarchically arranged checklist of conservation strategies to guide the development of forest conservation plans. The checklist is intuitive, but its elements have not previously been presented.

**Planning optimal landscape configurations for the persistence of multiple species in a production landscape.**

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Conservation planning methods have struggled to accommodate the viability of multiple species in a landscape. Rules of thumb, such as aiming for larger and more connected areas of habitat, do not explicitly incorporate the dynamic between amount and configuration of habitat from a species' perspective. One way of dealing with this is to use a metapopulation approach, where viability is a function of the landscape configuration and the species' ecology. We present a novel method for optimizing landscape configuration for more than one species by minimizing the combined extinction risk, subject to a conservation budget. The budget may be area of habitat, cost of acquiring land, or forgone timber in a forestry region. We estimate metapopulation extinction risk with a stochastic spatially-explicit metapopulation model, and optimize across the species using simulated annealing. As a result, we are able to incorporate both the amount and spatial arrangement of habitat areas from a species-specific perspective, such as the species' capacity to move between areas, directly into the objective of our conservation planning method. Because this optimization problem is too large to solve exactly, we use a fast approximating method—simulated annealing. We apply this method to a forestry landscape in northeast Tasmania, Australia, where population models for several forest-dependent species, encompassing a broad taxonomic spectrum and large variation in life history attributes, were developed.

**Biodiversity policy assimilation to forest management in Finland: an institutional analysis of professional organizations' practices.** Primmer, E. (*Finnish Environment Institute, Finland; eeva.primmer@ymparisto.fi*).

Biodiversity has been on the global forest policy agenda for over a decade, and in Finland, it gained status as a central objective parallel to timber production in forest legislation in 1996. The actors operating in this new context include a vast range of public and private organizations, which serve the 600,000 non-industrial private forest owners in an operating environment where forestry extension systems are far institutionalized. These organizations are in key positions to interpret biodiversity policies and integrate biodiversity conservation in their practices. This group of actors poses both a challenge and an opportunity for biodiversity policy design. Responding to multiple incentives, including the legal stipulations, forestry and nature conservation organizations develop strategies to guarantee their subsistence and maximise their own interests. The strategies are based on their resources, competencies and values, and constrained and enabled by formal and informal institutions. Understanding strategy formulation requires acknowledgement of both compliance and innovative solutions. This presentation will portray a framework developed for analyzing biodiversity policy implementation by forestry and nature conservation authorities as well as public, private, and associational professional organizations. The framework, to be applied in empirical research in the future, will be discussed within the context of current institutional patterns in Finland.

**Economics of forest multi-functionality**

Organizer: Jean-Luc Peyron *GIP ECOFOR, France, and ENGREF/INRA, France; peyron@gip-ecofor.org; peyron@nancy-engref.inra.fr*

**Valuing Mediterranean forests: Towards total economic value.** Croitoru, L. (*University of Padua, Italy; lelia@contagra.unipd.it*), Peyron, J.-L. (*GIP ECOFOR, France, and ENGREF/INRA, France; peyron@gip-ecofor.org*).

Mediterranean forests are outstanding for the public goods and externalities they provide, rather than wood production. Yet, few efforts for their comprehensive valuation have been undertaken, previously, with results poorly disseminated worldwide. This paper discusses the methodology and results of a project to value the benefits of MEDiterranean FORest public goods and EXternalities (MEDFOREX). MEDFOREX involved collecting estimates of forest benefits in each Mediterranean country according to the Total Economic Value (TEV) concept. Valuation was based on a wide range of methods, drawing on official statistics, supplemented by results of local surveys. The estimates were then analyzed at regional, country and cross-country levels. In several countries, the most significant benefit is that of regulating water-related issues, reaching up to \$122/ha. Grazing and non-wood forest products are important benefits in the south and east, while recreation and carbon sequestration tend to be higher in the north. Negative externalities arise primarily from forest fires in the north and from erosion due to poor forest management in the south. Achieving a consistent valuation of forest benefits is difficult. MEDFOREX exercise shows how available data can be used to arrive at such estimates, and identify areas where additional research is particularly needed.

**Policy instruments to enhance multi-functional forest management.** Cubbage, F.W., Sills, E. (*North Carolina State University, USA; fred\_cubbage@ncsu.edu*), Harou, P. (*World Bank, USA, and ENGREF/INRA, France; harou@nancy-engref.inra.fr*).

Sustainable forest management has become the salient theme in forestry throughout the world today. This theme recognizes that forests are managed for a variety of economic, social, and ecological benefits. This explicit recognition of many outputs and services as management objectives has recast our economic analyses on the values of forests. Similarly, our policy tools must be reformed to achieve the goals of multi-functional forestry and must span many dimensions of forest characteristics. First, they must consider the existing land tenure and ownership and the concomitant private and public goals. Second, they must consider this social context and select appropriate means of allocating resources. Third, they must consider the values of these goods and services in market and non-market terms, and the mix of these values at the stand, landscape, and regional scales. Fourth, they must consider the types of policy instruments available and their success at achieving our private and social goals for multifunctional management. We review our policy tools in this context and assess their potential success in meeting the objectives of forest landowners and society in achieving sustainable forestry goals in the future.

**Costs and benefits of multifunctional alpine forests.** Goio, I. (*IVALSA-CNR, Italy; ilaria.goio@ivalsa.cnr.it; ilaria.goio@libero.it*), Gios, G., Notaro, S., Raffaelli, R. (*University of Trento, Italy; geremia.gios@economia.unitn.it; notaro.sandra@economia.unitn.it; roberta.raffaelli@economia.unitn.it*).

The multifunctional role of Alpine forests was recognized long before the term 'multi-functionality' became popular in the debate on economics and policy. In fact, along with traditional products (timber and non-timber), mountain forests have always produced different outputs such as landscape and recreational amenities, biodiversity conservation, and flood protection. The scientific debate about multi-functionality has been focused on the analysis of the public good and externality aspects of forest production in an efficiency framework. Relatively little attention has been paid to welfare implications. For this reason, the aim of this paper is to determine 1) who bears the costs associated with the outputs provided by Alpine forests, situated in the province of Trento (north-east of Italy) and who are the beneficiaries, and 2) what is the amount of cost and benefit flows. A comprehensive evaluation of costs and benefits permits discussion of different mechanisms in order to maintain multifunctional Alpine forests.

**Forest valuation strategies for Northwest Himalayas, India.** Gupta, H.K. (*Forest Survey of India, India; ghemant\_sml@hotmail.com*), Joshi, M. (*University of Horticulture & Forestry at Solan, India; joshi\_manoj1@rediffmail.com*).

The valuation of Northwest Himalayan forests are most viable options for supporting and maintaining natural resources and sustained livelihood opportunities for forest dwelling rural people. Micro level assessment of the different perceptions of the stakeholders is required for effective valuation of plant diversity, watershed values, nature-based tourism, and livelihood incentives for participatory forest management. The biotic resources of the Himalayas are under continuous threat due to developmental activities. Nature-based tourism is promoted without any attention to the ecology that is also threatening the biotic component. There is not much awareness about the value of dwindling genetic resource base among the local population. Local communities are displaced and deprived of their customary rights of access to resources due to development projects and deprived of livelihood incentives drawn from surrounding forests. Participatory forest management incentives need to be assessed for benefit and cost of participation of local forest users to develop effective strategies for increasing livelihood avenues. Economic and equity aspects of medicinal plants have been discussed with special focus on Northwest Himalayas.

**Valuing recreational benefit of forest resources: An application of individual travel cost and contingent valuation methods in Turkey.** Pak, M. (*Kahramanmaraş Sütçü İmam University, Turkey; mpak@ksu.edu.tr*), Türker, M.F. (*Karadeniz Technical University, Turkey; mft@ktu.edu.tr*).

The wood based products and some non-wood products supplied by forest resources can be stated in monetary term in Turkey, but the economic values of other forest goods and services cannot be properly calculated. Consequently, although forests cover more than ¼ of the land area, forestry amounts to only 0.5% of the GDP. Travel Cost, and Contingent Valuation Methods are most widely used in the determination of value of recreational use of forests. However, these methods are not well known and used in Turkey. In this paper, the value of recreational use of forests was estimated by using the Individual Travel Cost, and Contingent Valuation methods with the case study of Dülük Baba Forest Recreation site located in the East Mediterranean Region of Turkey. As a result of the study, the value of Dülük Baba Forest Recreation Site (Consumer Surplus) was estimated as \$5 per person per visit. According to the contingent valuation method, total willingness to pay per year was calculated as \$150,565 for the current situation, \$405,105 Lira for the developed situation 1, and \$409,262 for the developed situation 2 of Dülük Baba Forest Recreation Site.

**Implementation of multifunctionality under cost-benefit analysis.** Peyron, J.-L. (*GIP ECOFOR, France, and ENGREF/INRA, France; peyron@gip-ecofor.org*).

Cost-Benefit Analysis is a widespread economic approach. It allows consideration of market- and non-market-oriented forest issues with a global view, and evaluation of corresponding solutions. It is particularly valuable to think about multifunctionality and its implementation, either in a social perspective or in a private one when public policies are at stake. At the stand level, many situations exist between the extreme monospecific even-aged or mixed-species uneven-aged ones. The main issues addressed are the rotation age (monospecific, even-aged stands), optimal stocking, diameter distribution and species composition (mixed-species uneven-aged stands) according to land and stock values, flows of environmental services and links between several functions in connection with the forest conditions. Conversion from one stand structure to another is also a promising issue in order to increase the fit between supply and demand of these many forest functions. Forest conditions vary from one place to another and the spatial distribution of forest functions has to be dealt with at more aggregated levels. Although theoretical approaches have been developed in all these fields, much work remains in order to precisely estimate, in time and space, the different values involved and evaluate more accurately forest multifunctionality.

**On forest externalities, valuation and related concepts.** Riera, P. (*Universitat Autonomia de Barcelona, Spain, and Centre Tecnologic Forestal de Catalunya, Spain; pere.riera@uab.es*).

The externalities and multiple products and services offered by forests to society are reflected in the economic analysis through the use of different concepts. The labels used for those concepts are sometimes confusing, and may mislead the uninformed reader. Furthermore, it is not exceptional in the literature to see the labels and concepts misused. This paper is an attempt to clarify some of these concepts, placing especial emphasis on the origin of labels like externalities, public goods, contingent valuation method, travel-cost method, hedonic pricing, private value, social value, total economic value, use value, existence value, option and quasi-option values, and others. Together with the justification for their appearance, the paper reviews the evolution of the concepts and the consolidated current use by economists and foresters, referencing the key contributions from the main authors, particularly in forest economics.

**Forest products markets: More than just selling and buying.** Ronalds, G., Jerez, M., Rosales, G. (*Universidad de Los Andes, Venezuela; ronalds@ureach.com; mjerezr@cantv.net; geovannirr@yahoo.com*).

Forest products markets must fulfil many functions that are more relevant than the simple commercialization of its products. It is not enough to verify on these markets if a product comes from sustainable production sources. We must go further than this and try to favor the marketing of products which come from management systems that help the people of greatest need to improve their standard of living. More simply speaking, we must try to promote the economic development of places that are repressed by the market itself. In an integrate way, we have to make sure that small producers can get the highest benefits from forest production by improving their access to the markets, and by showing them how to diversify their production and increase the added value of their products. This presentation looks at international policies that have been adopted in order to promote the development of such markets. At the same time, it presents some practical considerations founded on other studies, which in a real and tangible way help to achieve the implementation of these policies effectively and efficiently.

**Multifunctionality in a sustainable global and national forest system.** Sedjo, R.A. (*Resources for the Future, USA; sedjo@rff.org*).

Multifunctionality is the recognition that forests have to fulfill several functions such as production, conservation, and recreation. It is directly linked with sustainable forest management. The Earth Summit of Rio in 1992 gave a definition of sustainable management in the following terms: 'Sustainable management means the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions at local, national and global levels, and that does not cause damage to other ecosystems'. This paper examines the concepts of forest multifunctional sustainability in both a global and a national context. In many cases the ecological, economic and social functions of sustainable forestry are complementary. However, in some cases conflicts may exist. Is there an opportunity to achieve both the benefits of specialization while maintaining the multifunctionality of the forests? The suggested answer is 'yes' in a global or even regional context, but in many cases 'no' at the stand or forest level.

**Rational valuation of socio-economic importance of forest services for the society: basic prerequisite for calculation of socio-economic effectiveness of multifunctional forestry.** Sisak, L. (*Czech University of Agriculture in Prague, Czech Republic; sisak@fle.czu.cz*).

Socio-economic effectiveness reflects the relationships between outputs and inputs. Inputs, i.e. costs, spent in processes connected with providing the society with forest services can be usually expressed with sufficient

accuracy. But socio-economic outputs – important forest services for the society – are treated and calculated with extreme difficulty by different methods. It is questionable to base the valuation of non-market forest services uniformly on approaches that result, generally, in extremely high values. Some examples are valuation of ecosystem services, and expression of existence values. Such values would justify almost any high cost in forestry, and any share of forest lands in the landscape to the detriment of all other parts and uses of landscape in Central Europe. Non-market forest services are not uniform from the view of their socio-economic impact (mediated market, non-market) on the society. Valuation methods must reflect different socio-economic impacts (tangible and intangible) on the society, and different purposes of valuation. It should be taken into account that both market and non-market forest services are generally equal in their importance for the society as both of them are of vital significance for the society, and for the environment.

**Long term economic analysis of multi-products from *Quercus suber* forests managed under discontinuous and continuous cover forest management systems.** Tomé, M., Paulo, J. (*Instituto Superior de Agronomia, Portugal; magatome@isa.utl.pt; joanaap@isa.utl.pt*).

Cork oak (*Quercus suber* L.) in Portugal are a very particular system. The main product is not wood but the cork (bark), stands have a relatively small number of trees per ha (sparse forest) and it is an usual practice to grow agricultural crops or grass and herbage in association with the trees (agroforestry system). There is a need to decide about the best management option/silvicultural system towards the rejuvenation/maintenance of these stands. One alternative may be to clear-cut the stand (as a whole or by small plots) followed by natural or artificial establishment of a new stand. A second alternative may be the gradual transformation of the stand towards continuous cover forestry. A third alternative, for instance, is the use of successive regeneration fellings. In this poster an existing growth and yield model is used to simulate long-term management of cork oak stands under different management alternatives. Model output includes both wood and cork. An economic analysis of each of the alternatives tested is made considering not only the forest products but also the possibility to grow sheep or cattle if stand density is maintained at a low level.

**Estimation of benefits and costs to stakeholders of Joint Forest Management: Case of central Indian tropical forests.** Verma, M., Singh, U. (*Indian Institute of Forest Management, India; mverma@iifm.org; us7\_sara@yahoo.com; usingh@iifm.org*).

Research on Economic Analysis of Joint Forest Management (JFM), a forest management strategy under which the government and the local forest users jointly protect and manage the forest and share responsibilities and benefits, practice is elementary. Many research studies on social- and farm forestry in India are lopsided and focused only on marketed costs and benefits. Even in exploratory research on JFM, holistic analysis is lacking. To assess the economic viability of the JFM intervention, various tangible and intangible benefits and costs are being estimated. The study is underway in tropical forest regions of central India. Data, from different group of stakeholders of JFM, is collected on various forest goods and services. Data on direct costs along with opportunity and transaction costs are also gathered. These benefits and costs are being estimated by employing evaluation techniques for different goods and services. To measure the project worth and economic efficiency, extended cost benefit analysis will be done. Results of the study will be used to find ways to sustain the livelihood of vulnerable sections of the society and reduce poverty. It also develops a comprehensive methodology of economic analysis of Forest Management activities.

**Multi-criteria and multivariate methods for multi-functional forest management.** Zadnick Stirn, L. (*University of Ljubljana, Slovenia*).

Decisions in forest management are subjected to multiple objectives stemming on the one hand from individuals, such as owners, experts, investors, and on the other from the society, represented by the public. The problem of such a multi-functional decision making deals with conflicts and calls for a satisfactory attainment of economic, ecological, and social objectives and a balance between the needs of the society and the individual. The problem has precipitated the development of a decision support model in which the decisions are first evaluated from an individual's point of view. In this case, for each decision, the objectives are assessed by a multidimensional linear utility function, verified by economic and environmental indicators. Further, the society's participation in decision making is expressed through surveys and the use of multivariate methods. Finally, knowing the effects of decisions on the individual and the public, the analyst determines the best compromise decision. If he finds out that both evaluations are in disagreement, the analytic hierarchy process is used to manage the conflict, produce judgment and develop a compromise decision. To demonstrate this approach, a case study involving a forest in Slovenia was used.

## **Environmental planning for harmonizing forest biodiversity conservation and sustainable development**

Organizers: V.B. Mathur and Asha Rajvanshi *Wildlife Institute of India, India; vbm@wii.gov.in; ar@wii.gov.in*

**Restoring forests on mined land in the USA: results and outcomes of a 25-year research program.** Burger, J.A. (*Virginia Polytechnic Institute and State University, USA; jaburger@vt.edu*).

The mixed mesophytic forest of the eastern USA is one of the most diverse, productive, and valuable temperate forests in the world. Strip mining for coal totally removes the forest ecosystem. Over 500,000 ha of native forest land have been converted to mine spoils, vegetated primarily with unproductive grasses and shrubs replete with invasive species—less than 10% of mined land is replanted with native forests due to inadequate technology, economic disincentives, and regulatory constraints. I established a long-term forestland reclamation program in 1980 to develop mined land reclamation techniques specific for restoration of the native forest. Our studies show that forest site quality was routinely degraded in the process of mining, but, if properly reclaimed based on our guidelines, post mining forests can be as diverse and productive as native forests. Thousands of hectares of forest land are now being restored to native forests for multiple forest values. The results of this 25-year research program are consistent with other disturbed land reforestation programs in other parts of the world.

**The future of biodiversity conservation amidst development: reflection and vision.** Marcot, B.G. (*USDA Forest Service, USA; bmarcot@fs.fed.us*), Nyberg, J.B. (*B.C. Ministry of Forests, Canada; brian.nyberg@gems6.gov.bc.ca*).

Evaluating anthropogenic influences on biodiversity should span freshwater, aquatic, marine, and terrestrial environments. Protected areas alone cannot save biodiversity because boundary effects pervade landscapes, as learnt from the situation in Zimbabwe. Instead, we should clearly articulate goals and realistic expectations for biodiversity elements on each land use allocation, as being attempted in India. Relying only on threatened, endemic, indicator, flagship, and umbrella species will not suffice. We must look across taxonomic and functional groups, and also better account for local extirpations of species, subspecies, demes, and metapopulations. We need a clear classification and valuation method of ecosystem services. Trends of simplification as seen in Germany and China, and the conversion and loss of forests witnessed in Ecuador, have degraded biodiversity, but variable retention in Canadian forests and selection harvesting practices adopted in Russia, can help maintain forest biodiversity elements. Integrating cultural and religious interests with sustenance and conservation will be a major theme in Alaska, Malawi, and northeast India. We need to emphasize biodiversity conservation more at local project scales in Cameroon and Congo, and use landscape ecology to redesign urban sprawl and reduce impacts on hydrologic systems as in Florida. Ultimately, population density and growth in countries like China, India, and Mexico will determine what our planet will be capable of producing and supporting for centuries to come.

**Mitigation of biodiversity impacts of water resource projects: Pitfalls and lessons learned.** Mathur, V.B. (*Wildlife Institute of India, India; vbm@wii.gov.in*).

India and Sri Lanka are the leading countries in South Asia in harnessing water resources for economic development. As a consequence of rapid strides in dam building, the impoundment of vast tracts of rich and diverse forests and habitats of endangered species is the major cause of biodiversity decline. This paper stresses the relevance of mainstreaming biodiversity issues in water resources planning and emphasizes the need to adopt mitigation strategies that tend to promote proactive approaches for biodiversity conservation. The paper presents the findings of the environmental assessment of Narmadasagar Project on the Narmada River in the State of Madhya Pradesh and the Mahaweli Project in Sri Lanka. These projects involved submergence of large forested tracts and relocation of sizable human population. The impacts of the Mahaweli project on the conservation of Asian elephant and of the Narmadasagar Project on biodiversity values have remained significant due to inadequate mitigation planning in the former and lack of implementation of well conceived mitigation measures in the latter. Although public participation in environmental planning is gradually improving, experience suggests that neglect of people's participation in development planning can seriously undermine the effectiveness of the long-term prospects of biodiversity conservation.

**Road induced threats to biodiversity conservation: the need for better mitigation planning and design options.** Rajvanshi, A. (*Wildlife Institute of India, India; ar@wii.gov.in*).

While the timeless debate on the issue whether development leads to roads or roads lead to development may still continue, the role of roads in inducing threats to biodiversity has never been a subject of contention among ecologists. With the existing road length exceeding 3.0 million km in India, transport infrastructure still remains a rapidly expanding sector in the country. These road building initiatives in India, involving new highways, expressways, and link roads, and upgrading and widening of existing roads pose major challenges for biodiversity conservation. This paper discusses the

experiences and lessons drawn from environmental assessment of some road projects in India. Although species specific and ecosystem based mitigation strategies, and enabling design options can provide feasible approaches for mitigating biodiversity impacts, a more practical strategy for addressing biodiversity related impacts of road projects requires greater focus on elements of larger ecosystem infrastructure, critical habitats, threatened and valued ecosystem components, and a fair knowledge of other developments in the surrounds. Implementation of monitoring plans for ensuring compliance of proposed mitigation measures and well conceived species specific conservation plans ultimately determine the levels of success that would be achieved in effectively mitigating the impacts on wildlife and habitats.

### **Uneven-aged silviculture: from temperate to tropical forests**

Organizers: Kevin O'Hara *University of California, USA; o\_hara@nature.berkeley.edu*, and Armin Seydack *South African National Parks, South Africa; ArminS@SANParks.org*

**Using a hybrid model (GLOB-3PG) to predict future wood and biomass production in *Eucalyptus globulus* plantations in Portugal under different climate scenarios (catchment level).** Amaral, A., González, R.S., Páscoa, F. (*Escola Superior Agrária de Coimbra, Bencanta, Portugal; amaral@esac.pt; rsalas@esac.pt; fpascoa@esac.pt*), Tomé, M., Tomé, J., Cortiçada, A. (*Instituto Superior de Agronomia, Portugal; magatome@isa.utl.pt; joseatome@isa.utl.pt; anacorticada@isa.utl.pt*).

*Eucalyptus* plantations cover 672,149 ha of continental Portugal and represent 21% of the total forest area. *Eucalyptus* is mainly used by the pulp industry, which is of great relevance to the national economy. As a consequence, this species has had the most attention for growth and yield empirical modeling. The development of process-based models applied to eucalyptus is a recent area of research in Portugal. These models require large amounts of input data and parameter values, and do not produce simple and useful results to most practical applications. Models of the 3PG type are simple process-based models requiring few parameters and readily available data as input. Data available in Portugal have been used to calibrate and adapt 3PG to Portuguese *E. globulus* plantations. GLOB-3PG is a hybrid model that has been developed based on 3PG and existing growth and yield models in Portugal (GLOBULUS and GLOB-tree). This paper describes an application of GLOB-3PG to predict future wood and biomass production in small eucalyptus catchments located in central coastal Portugal. Data from forest inventory of the stands is the main input for the simulations and alternative future climate scenarios will be considered.

**Application of the forest growth model 3-PG to *Eucalyptus globulus* stands in the central region of Portugal.**

Amaral, A., González, R.S., Páscoa, F. (*Escola Superior Agrária de Coimbra, Bencanta, Portugal; amaral@esac.pt; rsalas@esac.pt; fpascoa@esac.pt*), Tomé, M., Tomé, J., Soares, P. (*Instituto Superior de Agronomia, Portugal; magatome@isa.utl.pt; joseatome@isa.utl.pt; anacorticada@isa.utl.pt*).

Great efforts have been carried out on modelling *Eucalyptus globulus* growth in Portugal, with the objective that those models can become reliable decision tools to forest planning and management. Models based on physiologic processes and environmental variables have as main advantages the possibility to: foresee the consequences of climate changes to forest growth, estimate the growth potential of places never planted before, estimate the growth of stands for which no measurements were made, and determine the effect of management practices. These attributes make process-based models an essential instrument for current forest management. Process-based models require a large number of initial parameters, which are difficult to gather, limiting their practical application. The present work describes the application of a hybrid model combining the 3PG process model – requiring a restricted number of parameters easy to get – and the Globulus 2.1 model. The study was carried out in *E. globulus* stands in two catchments in Caramulo, Portugal. In this work we present the results achieved with the new tuned parameters for Portugal. The first results evidence a good general behaviour of the model, in what concerns to its predictive capacity of volume and biomass.

**Light requirement model for beech (*Fagus orientalis* Lipsky) in natural and unevenaged stands.** Azadfar, D.

(*Gorgan University of Agricultural Sciences and Natural Resources, Iran; azadfar.d@gau.ac.ir*).

This research has been done in order to consider quantitative and qualitative alterations of peroxidase enzyme and the Crown Illumination Index on different growth stages of beech (*Fagus orientalis* Lipsky). Crown position classes were classified for this species according to its light reaction. Then, from two natural and uneven-aged stands, 1–4-year-old branches in each crown position class of 84 randomly selected individuals were collected for analysis. All crown characteristics of the individuals was measured. Quantitative and qualitative activities of peroxidase were determined by spectrophotometer and electrophoresis respectively. Results indicated that there is a clination point for beech reaction on light intensity from pole stage (25–30-year-old) to sawtimber stage (45–50-year-old). Generally, it can be concluded that this species is adapted to low and lateral light before 25–30-year-old and direct light after that up to maturity.

**Generalized tree biomass equations: an accurate and cost-effect foundation for regional biomass estimation?**

Case, B.S. (*Lincoln University, New Zealand; caseb@lincoln.ac.nz*), Hall, R.J. (*Natural Resources Canada, Canada; rhall@nrca.gc.ca*).

Accurate estimates of aboveground tree biomass (ATB) are fundamental for forest ecosystem modeling and regional carbon accounting. Despite the abundance of ATB equations in the published literature, most have been developed for relatively small geographic areas, thereby limiting their general applicability and accuracy for regional scale analyses. Generalized biomass equations have been proposed as a more regionally-applicable and cost-effective alternative for ATB estimation. Developed using geographically-extensive datasets that incorporate a large range of site and environmental variation, generalized equations are hypothesized to generate relatively accurate predictions for the entire regional extent. However, a critical question remains unanswered: is there a significant loss in predictive accuracy in using generalized ATB equations at a site scale relative to site specific equations? To address this question, we developed a set of generalized ATB equations using data pooled for a large portion of western Canada and then tested the equations at 147 individual sites. Biomass estimates produced using the generalized equations did not differ statistically on average from those based on local site equations across all sites. The results suggest that more effort should be directed towards exploring the development and validation of generalized ATB equations by collating existing regional biomass datasets.

**Forest dynamics models as decision tools for managers: state of the art in tropical moist forests.** Gourlet-Fleury, S., Picard, N., Cornu, G. (*Forest Department of Cirad, France; nicolas.picard@cirad.fr; guillaume.cornu@cirad.fr*).

Forest modelling for yield prediction has been an active topic for more than one century in temperate countries. Yet, until recently the models developed deal mainly with mono-specific, usually even-aged stands, while modelling mixed forests stands remains a challenging matter. Highly heterogeneous multi-specific moist forests encountered in the tropics set particular problems to modellers: scarcity of permanent sample plots on which to calibrate models, lack of data, and limited knowledge of most of the species encountered, result in uncertainty of predictions of the highly detailed models needed to take into account the heterogeneity of the stands. Nevertheless, in a context where most of those forests are threatened and growing efforts are made to put them under management plans, tools able to help managers to explore silvicultural options and evaluate their compatibility with the demographic characteristics of exploited species are of utmost importance. Based on a review of published work, and inquiries of various decision-makers in the three continents, we analysed: 1) the progress made and the main constraints remaining in building modelling tools and software for tropical forests, and 2) the reasons why the use of models by many managers remains anecdotal, despite important progress realized during the last 10 years.

**Silviculture and management in uneven-aged temperate forests.** Hasenauer, H. (*BOKU University of Natural Resources and Applied Life Sciences Vienna, Austria; hubert.hasenauer@boku.ac.at*), Zingg, A. (*Swiss Federal Institute for Forest, Snow and Landscape Research WSL Birmensdorf, Switzerland; andreas.zingg@wsl.ch*).

Forests have a long history of human influence. The results have been a reduction in forest covered land area, changes in species distribution as well as intensive thinning and harvesting to ensure sustainable timber supply. During the 17<sup>th</sup> and 18<sup>th</sup> centuries, catastrophic events resulting from uncontrolled harvesting operations led to the implementation of rigorous forest laws, the founding of forest research organizations, and forest education programs throughout Europe. The main focus was to enhance our understanding of sustainable forest management and to ensure sustained timber and fuel wood supply. These, mainly production driven ideas, have been implemented in different silvicultural management systems and have helped to enhance sustainable forest management practices. The purpose of this presentation is to give an historical overview of silvicultural concepts including the main achievements. Open research questions as well as concepts and philosophies in managing forests (e.g., uneven vs. even aged management, different mixtures, and species changes) are discussed and application examples are presented.

**Sustainable forest management tools.** Hasenauer, H. (*University of Natural Resources and Applied Life Sciences Vienna, Austria; hubert.hasenauer@boku.ac.at*).

Within the past two decades, and particularly since the 'Brundtland Report,' sustainability has become a key term in emphasizing the relationship between economic progress and nature. Forests, as one of the main ecosystems within the landscape, have been severely modified by humans. The result is a reduction in forest covered land area, a change in tree species distribution, and a deterioration of forest soils. With the improvements in our understanding of key ecosystem processes and the change towards a multidisciplinary approach to define sustainability, many models have been developed. Such forest ecosystem models are designed to reproduce, quantify, and describe ecosystem processes, and may be understood as diagnostic tools to study forest production issues, water balance issues, etc. Conflicting interests such as simplicity, observability, and biological realism must be addressed to ensure a well balanced modeling approach. According to the end user needs they may work at different temporal and spatial scales. This presentation introduces different concepts, explains key principles as they are important for the formal description of the system, and addresses



advantages and disadvantages in using modeling tools at various scales. Application examples demonstrate how detailed plot specific information may be generalized so that an efficient use of existing information across scales is possible.

**Biodiversity conservation in strip and group cutting systems in conifer plantations in Japan.** Ito, S., Ishigami, S. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp*), Mizoue, N. (*Kyushu University, Japan; mizoue@agr.kyushu-u.ac.jp*), Buckley, G.P. (*Imperial College, UK; peter.buckley@imperial.ac.uk*).

There have been increasing demands in many countries to improve biodiversity conservation by moving away from large-scale clear-cutting systems and adopting alternative silvicultural systems. Applying group and strip cutting systems (GCS and SCS) is being considered as an effective way to transform simple even-aged to uneven-aged plantation forests, and thus to maintain or encourage the biodiversity in managed forests. We investigated the understory vegetation in mature sugi (*Cryptomeria japonica*) and hinoki (*Chamaecyparis obtusa*) plantations in which GCS and SCS had been carried out for 30–40 years. The results were compared with those of large-scale conventional clear-cutting systems (CCS) to examine the advantages of the alternative systems in biodiversity conservation. Vegetation cover, height, and light environments in the understory of GCS and SCS stands had no clear difference compared with those in CCS. However, cluster analysis and DCA ordination indicated important differences in species composition, with GCS and SCS vegetation being characterized by species more typical of semi-natural forests, while that of CCS vegetation had more disturbance-related species able to colonize open sites. These results suggest that GCS and SCS may be more effective than CCS in conserving plant species of natural forests.

**Response of uneven-aged interior Douglas-fir to different thinning regimes: 11-year results.** Lee, T., Marshall, P., Day, K. (*University of British Columbia, Canada; terryubc@interchange.ubc.ca; peter.marshall@ubc.ca; ken.day@ubc.ca*).

A thinning trial was installed in stands of uneven-aged Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Mirb.) Franco) in the early 1990s on the Knife Creek Block of the University of British Columbia's Alex Fraser Research Forest, near Williams Lake, British Columbia, Canada. Three thinning regimes plus a control were applied randomly to one-quarter of each of three 40 ha blocks (replicates). Each thinning regime and block combination was sampled with two plots, yielding 24 plots in total. The plots were last measured following the 2003 growing season; this represented the third measurement subsequent to the thinning treatments. This paper presents the growth differences among the treatments, on both a per tree (size class) and a per ha (stand-level) basis, since the time of thinning. Responses are explained in terms of apparent competition mechanisms that occur in moisture-deficient stands such as these.

**Implications of strip and group cutting systems in conifer plantations in Japan.** Mizoue, N. (*Kyushu University, Japan; mizoue@agr.kyushu-u.ac.jp*), Ito, S. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp*), Inoue, A. (*Tottori University, Japan; iakio@muses.tottori-u.ac.jp*).

There have been increasing demands in many countries to move away from large-scale clear-cutting systems and adopt alternative silvicultural systems. In Japan, plantation forests occupy about 10 million ha, 40% of forested lands, most of which are simple, even-aged conifer forests of sugi (*Cryptomeria japonica*) or hinoki (*Chamaecyparis obtusa*). Applying group and strip cutting system are being considered as an effective way to transform simple, even-aged to uneven-aged plantation forests. These systems had been originally adopted in the 1940s in Hokkaido, northern Japan, in order to encourage the early growth of planted trees and to prevent frost damage. In the 1970s, these systems were applied to conifer plantations in central and southern Japan in order to maintain scenic beauty as viewed from sightseeing roads in mountainous terrain. What advantages do strip and group cutting systems in sugi and hinoki plantations have in temperate regions of southern Japan in terms of sustainable forest management concepts? In this paper, we re-evaluate the small-scale group and strip cutting systems in terms of tree growth and biodiversity, based on case studies in old group and strip cutting sites of sugi and hinoki. We then propose spatial arrangement methods of cutting areas based on the case studies.

**Effects of gap size and density on the growth of *Quercus gilva* saplings. Which gap creation is advantageous to gap-planting—many small gaps or few large gaps?** Mizunaga, H. (*Shizuoka University, Japan; mizunaga@agr.shizuoka.ac.jp*).

Gap-planting is often used for the rehabilitation of degraded forests, and for the transition of even-aged plantations to uneven-aged forests. Both gap size (area of a gap) and gap density (number of gaps in a unit area) may promote growth of seedlings, however these two parameters have reciprocal relationships in a given unit area. I examined the mutual relationships of these two parameters for with regard to effective gap-planting. Temporal and spatial changes of photosynthetic photon flux density (PPFD) and photosynthetic index (PI) were predicted for saplings of *Quercus gilva* in a Japanese cedar plantation by the Canopy Structure Model. This model showed that the maximum PI increased with gap size in width within the range being equivalent to half the canopy height. Horizontal changes of PI from gap edge to beneath the canopy were not affected by gap size, but the minimum PI in the many-small-gaps scenario was

higher than that in the few-large-gaps scenario. In this presentation, a comparison is presented of available planting area produced by different gap types that have a threefold range of PI.

**Extrapolation of a detailed tree model to stand level.** Perttunen, J., Sievänen, R. (*Finnish Forest Research Institute, Finland; jari.perttunen@metla.fi*), Nikinmaa, E., Mäkelä, A. (*University of Helsinki, Finland*).

We report the work where we extended the functional-structural individual tree model (LIGNUM) to simulate the growth of Scots pine stands, that is, group of trees in mutual interaction. For this we have implemented a voxel space approach for calculation of irradiance inside the canopy instead of pair-wise comparison of shading elements that has been applied in single tree simulations. We have studied how well the architectural growth rules of individual tree simulations apply in different stand densities and if they produce the observed plasticity of Scots pines. We have produced parameters describing crown shape and stem form during early stand development and compared these to empirical observations. The parameters are then to be used in a higher scale model (CROBAS) for model aggregation. Our future work will concentrate on improving functions determining the senescence of the buds (to better represent the shedding of branches) and assessing growth factors other than light (e.g., vigour).

**Possibilities and production parameters of selection forests in central Bohemia and Czech Republic.** Remes, J., Podrazsky, V. (*Czech University of Agriculture Prague, Czech Republic; remes@fle.czu.cz; podrazsky@fle.czu.cz*).

Selection forests are the result of the application of selection silvicultural systems by highly skilled foresters. These forests are also referred to as 'close-to-nature-forestry' particularly by the 'ecological public'. Selection systems represents a blocked phase of the natural forest regeneration cycle, but it is fully controlled by the forester. Selection systems originated in the Alpine countries because of the demand for sustainable yield and permanent forest cover. This system was broadly accepted and prescribed in other regions with widely differing conditions. This poster, based on data collected from a literature review, compares production outputs of selection and even-aged forests in the Czech Republic. Environmental aspects and practical management rules are also documented. The aspects of timber production from selection forests include both quality and quantity. The transition from an even-aged to an uneven-aged forest is a critical, long-term (decades to century) undertaking.

**Yield regulation systems for tropical/subtropical forests: Ecosilvicultural paradigms and economic constraints.** Seydack, A. (*South African National Parks, South Africa; ArminS@SANParks.org*).

Yield regulation in the narrow sense should be viewed as embedded within a particular yield regulation system involving three components: yield optimization, stand regeneration strategy, and harvest tree selection criteria. All yield regulation systems occupy a position on the spatiotemporal harvest concentration continuum. High harvest intensity systems are characterized by relatively low minimum harvestable diameters and/or high harvest volumes realized at any given harvesting event (long felling cycles), whereas low harvest intensity systems pursue mortality pre-emption. The choice of system depends on: 1) management objectives, 2) economic considerations, and 3) the ecological characteristics of the forest or target species involved. High harvesting intensity approaches tend to be functionally even-aged, often representing deviations from natural forest dynamics. This poses risks in terms of long-term sustainability and necessitates silvicultural interventions. The potential risks, particularly in relation to the dynamics of the large-size upper canopy-occupying species guild, are highlighted regarding: 1) role of the forest matrix, 2) inter- versus intra-specific interactions, and 3) the possible disruption of reproductive systems. Furthermore, the role and limitations of silvicultural interventions are discussed. Both sustainability risk minimization, through the lowering of harvest intensities, and required silvicultural interventions have economic implications that have to be balanced with economic gains associated with high harvesting intensity systems.

**Towards sustainable management of tropical forest: Moving beyond polycyclic felling systems based on minimum diameter cutting limits.** Sist, P. (*Cirad-Forêt, Embrapa Amazonia Oriental, Brazil; plinio@cpatu.embrapa.br*), Kanashiro, M. (*Embrapa Amazonia Oriental, Brazil; Milton@cpatu.embrapa.br*), Nasi, R. (*CIRAD-CIFOR, Cirad-Montpellier; rnasi@cgiar.org*).

The history of silviculture in the three main tropical rainforest regions (Western Malesia, South America, and Africa) shows a general trend towards the adoption of polycyclic selective felling systems. The sustainability of these systems depends mostly on the regeneration capacity of the forest and the post-logging dynamic processes which are mainly determined by the harvesting modalities. In these systems, harvesting operations are undoubtedly most important silvicultural treatment that is applied. For this reason, special attention has been to improve harvesting operations in tropical forests. In the early 1990s, reduced impact logging techniques (RIL) were therefore implemented in the three major tropical forests. The main concept is that by reducing damage in stands, the forest will regenerate better. RIL was rapidly and widely recognized as an essential component of sustainable timber harvesting prescriptions. However, RIL operations are still based, as all other selective logging systems in the tropics, on a very simple rule: the minimum

diameter limit applied to all commercial species. Based on the specific ecological characteristics of the three main tropical forests, and the specific impact of logging on the ecology of the commercial timber species, this paper aims to propose guidelines to improve the ecological sustainability of tropical production rainforests.

**Natural regeneration and succession process associated with forest decline in the Sumava (Bohemian Forest) National Park.** Ulbrichova, I., Svoboda, M., Podrazsky, V., Remes, J. (*Czech University of Agriculture Prague, Czech Republic; ulbrichova@fle.czu.cz; svoboda@fle.czu.cz; podrazsky@fle.czu.cz; remes@fle.czu.cz*).

Extensive forests in the Sumava (Bohemian Forest) Mts. died because of inadequate management and consequent extended bark-beetle infestations. After the Sumava National Park was declared in the early 1990s, even-aged Norway spruce monocultures (140–180-years-old) were left for so-called ‘natural development’. As a consequence, there are currently 4000–5000 ha of dead forests on both the German and Czech side of the border. Up-to-date studies, presented here, revealed considerable natural regeneration on the majority of the impacted area. This study was undertaken on 11 permanent research plots (50 x 50 m in size) and many small-scale additional plots located in the region. The numbers, structure, and spatial distribution of spruce regeneration represent a good basis for the natural restoration of spruce mountain forests. Seedlings, present in most of living stands in large numbers (4000–40,000 individuals per ha), respond well to the increased light and thermal conditions. The problem associated with this regeneration trend is that the outlook is for the re-establishment of a more or less even-aged forest again, and a future bark-beetle infestation—something that is not considered natural in mid-European conditions.

**Back to the 90s: Retrospective analyses as a tool to demonstrate past natural regeneration dynamics and predict developments.** Wijdeven, S.M.J., Koelewijn, H.P. (*Alterra – Centre for Ecosystem Studies, the Netherlands; Sander.Wijdeven@wur.nl; HansPeter.koelewijn@wur.nl*).

The early development phase in uneven-aged mixed forests can be characterized by a high diversity in natural regeneration assemblages and high dynamics. Given this variety, predicting and managing developments is a complex task. Natural regeneration of four main tree species in the Netherlands was studied 15 years after canopy gap formation. By means of retrospective analyses, the 3-dimensional position of all individuals each year was assessed and detailed development series of natural regeneration constructed. A species-specific, spatially explicit competition index was defined and the effects on growth were analyzed accordingly. Species showed different patterns of gap colonization, establishing up to 10 years after gap formation. Neighborhood density and composition had a species-specific effect on growth. Birch (*Betula pendula* Roth) was least affected, Larch (*Larix kaempferi* Carrière) and Scots pine (*Pinus sylvestris* L.) were moderately affected, and Douglas fir (*Pseudotsuga menziesii* Franco) was most affected by competition. Larch was most competitive, having a higher competition effect on Scots pine and Douglas fir than vice versa, while the latter two have equivalent competition effects. The derived species inter-specific competition effects can be used to predict development of various compositions and densities. The approach thus offers options to manage regeneration assemblages.

## **Harmonizing commercial utilization, social, and conservation values through intensive tropical forest management (ITFM)**

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**Managing tropical forest intensively for timber and biodiversity conservation.** Abd. Rahman, K., Shamsudin, I., Raja Barizan, R.S., Samsudin, M., Ismail, H. (*Forest Research Institute Malaysia; rahmank@frim.gov.my*).

In many developing tropical countries, forests have been looked upon as the source of income for country development. There is broad consensus that it is possible to manage tropical forests in various ways for the production of timber and other products while still maintaining considerable biological diversity. The tropical forest ecosystem can be extremely fragile when it is being converted to other land uses. The forest itself is reasonably robust and capable to recover from localized and periodic natural and low impact disturbances, such as tree falls and storms damaged. In managed production forest, low-impact disturbance can be emulated through selective removal of trees. Changes to the forest management system are necessary to protect the integrity of the forest ecosystem services. Current practices such as the minimum diameter limit approach, has been blamed for the over-exploitation of many tropical forests in South East Asia, despite low impact logging practices, largely due to the presence of many large trees. Few countries have specific measures in their forestry regulations to address the need to conserve the broad range of biological diversity in production forests. In general, management prescriptions aim to maintain timber yields, prevent soil erosion and protect hydrological functions. The growing capacity of the natural forest is also slower to recover after disturbance from logging as compared to plantations of

native species. Results from long-term research into plantations of commercial indigenous species at the Forest Research Institute of Malaysia has shown that timber production can be three to four times the rate of stand growth from natural production forests, thus providing us with the opportunity to manage production intensively while conserving biodiversity. The paper discusses options for an intensive tropical forest management system through a combination of improved intensive planting methods of promising natives tree species in degraded areas, and integration of sustainable utilization of non-timber forest produce while conserving biological diversity within the managed production tropical forest.

**Structure of a tropical dry forest at the Jalisco coast, Mexico.** Abundio R., E., Gallegos R., A. (*Guadalajara University, Mexico; Caobana@yahoo.com; gra09526@cucba.udg.mx*).

A tropical dry forest, with an area of 4600 ha on the Jalisco coast of Mexico, was structurally analyzed with regard to basal area, importance index, diameter classes, the importance index, and density analysis for very young and medium sized plants. Analysis was based on 357 sample plots. The mean basal area was  $21.7 \pm 1.3$  m<sup>2</sup>/ha, and 68% of the sites had basal area between 9 and 24.9 m<sup>2</sup>/ha. A significant number of species were identified: 150 species of trees with dbh >10 cm, 101 species of medium sized plants, and 62 species of very young plants. The most abundant species were *Brosimum alicastrum*, *Hura polyandra*, and *Tabebuia rosea*, the most abundant medium sized species were *Pterocarpus acapulcensis* and *Tabebuia rosea*, and the most abundant species among the very young plants were *Tabebuia rosea* and *Bursera* sp. A plot of diameter classes had the typical inverse 'J' curve found in many tropical forests. The species of high importance index, however, showed a discontinuity in the first class due to the low incorporation of individuals. Harvesting has had an effect on basal area and natural regeneration, and has caused disturbances in this area.

**Recent Development on the Teak reforestation programme in Malaysia.** Ahmad Zuhaidi, Y., Krishnapillay, B. (*Forest Research Institute Malaysia; zuhaidi@frim.gov.my*).

Forest plantations or man-made forests are becoming increasingly important in supplying forest products throughout the world. Some of the successful stories of forest plantations in Asia Pacific are the plantations of *Araucaria* in Australia and Papua New Guinea, *Pinus radiata* in New Zealand and *Tectona grandis* in Indonesia and Thailand. In Malaysia the concept of commercial planting of timber is new, and awareness has been created over the last 5 to 6 years. The government and the forest-based industries have recognized that existing forests cannot continue to meet their raw materials requirements, and are expected to play a significant role in increasing investments in plantation programmes in the coming years. This is in line with government efforts under the existing tropical forest management to reduce pressure on natural forests and preservation of forest areas including recreational, flora and fauna and water catchments. The government, through the Malaysian Timber Industrial Board (MTIB), has formed the National Timber Industrial Policy for the purpose of coordinating all related government agencies, private companies in the rehabilitation of existing land with the establishment of plantations. Commercial planting of teak began in 1997 and 5,000 ha of teak have now been established. Plantings involve the involve the state government and private owners such as the state-owned Innoprise Corporation Sendirian Berhad (ICSB), Lembaga Urusan Tabung Haji (LUTH) Plantation Sdn. Bhd., Modal Jati Sdn. Bhd., PLUS Expressway Sdn. Bhd., state government agencies, private estates and small holders. This paper highlights the recent development of teak reforestation in Malaysia, government initiatives to encourage more stakeholders to participate in the reforestation programme, challenges and problems faced by investors, particularly small holders, and the suitability for growth of the species.

**Jeju Experiment Forest: Building it up for sustainable forest management.** Chong, S.-K., Lee, K.H., Joo, R.W., Kim, J.M., Son, Y.M., Oh, J.S. (*Republic of Korea; skchong@foa.go.kr*).

This project was initiated to build Jeju Experiment Forest into an exemplary model forest, located in the warm temperate zone and the low middle part of Hala mountain of Jeju Island, Korea, through implementing sustainable forest management on site and pursuing forest management certification. The area of Jeju Experiment Forest has been extensively managed. There have been diverse demands for biological conservation and eco-tourism as well as timber production. In order to meet the demands sustainably, intensive care and forest management is required. Forest surveys were initially conducted in 2004 in terms of ecological, social, economic and managerial aspects. The survey results will be elaborated to provide the implications for the forest's future development as a model forest. For further studies, based on the results of questionnaire survey carried out with local people, a participatory approach will be undertaken to involve all stakeholders by building a partnership and to get support from local communities in building an exemplary forest. Criteria and indicators for sustainable forest management will be developed and monitored at the local level. Options for management actions and eco-tourism development will be also examined. The progress and overall future direction will be explored to share the experiences and exchange information. The expected outputs differ from the traditional way of managing forests in that they provide an effective framework for a participatory approach involving all concerned parties. They also will establish an integrated forest management plan, that places greater emphasis on intangible values of forests such as biodiversity, landscapes and water resources.

**Seeking a middle path to conservation, wise use and socio-economic development: Challenges in peat swamp forest management, Malaysia.** Efransjah, E., Khali, A.H., Rashid, A.S., K. Sayok, A., Abdul Rahim, N. (*Forest Research Institute Malaysia; Ministry of Natural Resources and Environment, Malaysia*).

With rapid development and mounting population pressures exerted on natural resources, peat swamp forests (PSF) in tropical regions are increasingly under threat. Initiated by the Malaysian Government and supported by the UNDP/GEF, a five-year project is being implemented to address the conservation and wise use of the remaining PSFs and associated wetland ecosystems in Malaysia. The main management issue is the often-conflicting interests of economics and the environment; and the increasing demand for conversion of peatlands to other uses. The Project had identified the major threats; and assessed the PSF biodiversity richness and its ecological integrity. Addressing the differing site-specific issues presents a challenge to management planning. Hence, the Project initiated a participatory, multi-tiered process involving key stakeholders to develop an integrated management plan (IMP) in the respective states. Among others, it has embarked on the IMP development by highlighting the site-specific problems based on scientific evidence to the state authorities, proposing mitigation measures, encouraging inter-sectoral coordination, facilitating the policy-making processes, and undertaking training and awareness raising programmes. This holistic approach is found to be effective and some achievements made in the IMP development indicate that success is likely. The IMP is an important planning tool that binds the various agencies, sectors and habitats into a coherent 'ecological network'. Highlighted in this paper are some lessons learnt and impacts of the management planning process in Pahang for the conservation of the south-east Pahang Peat Swamp Forest, which is one of the three project sites.

**Rehabilitation of a damaged tropical rain forest in Sabah, Borneo: Experiences of a large scale experiment on environmental, economic, and social effects during a six year period.** Falck, J., Alloysius, D., Garcia, C. (*Sweden; Jan.Falck@ssko.slu.se*).

In all regions with tropical rain forests, there are secondary forests degraded by intensive logging or wild fire. The demand for rehabilitation is heard from conservationists and some forest owners. This paper describes the experience gained during a 6-year collaborative project between IKEA of Sweden, the Sabah Foundation, and the Swedish University of Agricultural Sciences. The main aim of the project was to improve the biodiversity of a forest, destroyed by wild fire in 1983. Economic and social benefits are also presented. Under the canopy of a *Macaranga*-dominated pioneer forest, more than 25 species, mainly belonging to the Dipterocarp family, and at least 5 % fruit trees were planted using two different plantation concepts—line and gap plantations. Today, 5300 ha have been enrichment planted with seedlings and wildlings. Results of ecological relevance are that resources must be established for tending (beating up, weeding, and shade adjustment) for a ten year period. Costs for rehabilitation can be judged as moderate. Socially, the project has had positive influences with the employment of approximately 160 forest workers. Newly constructed family housing in the village of Luasong has increased the number of children at school and use of the cottage hospital.

**Integrating wildlife conservation in forest management.** Fletcher, S.C. (*Forest Research Institute Malaysia, Malaysia; cdfletch@frim.gov.my*).

There are continuous calls from individuals and establishments alike to take consider wildlife conservation in forest management. However, this is still a long way from being a reality. Taking Malaysian bats as an example, this paper reviews how ecological studies on bat populations are able to assist decision makers in including wildlife conservation in their forest management plans. Among recommendations presented in this review include retaining sufficient tracts of old growth forests to provide suitable roosts for bats that are very selective towards large fallen trees, retaining a selection of mature fruit tree species after logging that play a major role in the diet of fruit bats and conserving sensitive areas containing unique roost attributes that are crucial to bats. This review further supports the inclusion of faunal wildlife assessments in the Malaysian Criteria and Indicators (MC&I) in passing forest certifications.

**Optimum cutting cycle for sustainable harvest in timber production forests in Peninsular Malaysia.** Ismail, H., Shamsudin, I., Abd. Rahman, K., Wan Mohd Shukri, W.A., Nurhajar, Z.S. (*Forest Research Institute Malaysia (FRIM), Malaysia*), Awang Nor, A.G. (*Universiti Putra Malaysia, Malaysia; ismail@frim.gov.my*).

Accurate estimation of cutting cycles, growing stock and the allowable harvest that is biologically sustainable and financially viable is important in achieving sustainable forest management in the production forests of Peninsular Malaysia. Under the current system, except for economic cuts, the cutting cycle is purely based on the rate of forest growth and has never been based on financial aspects. This study developed more reliable growth models to estimate the optimal cutting cycles based on both biological and financial aspects. A stand projection model was developed based on MYRLIN. For the economic optimization modelling, data from five states (Pahang, Terengganu, Kelantan, Kedah and Perak) were collected and analysed. A growth and yield prediction model was developed and validated. Using actual growth data from Tekam, Gunung Tebu, Jengka and Lesong, the Relative Forecast Error (RFE) was

between -2.1 and 6.9%. The model has been used to project stand table, basal area and volume of 11 growth and yield study sites in Peninsular Malaysia. The model is also able to calculate the optimum cutting cycle using a generalized Faustmann Model. A mathematical function that relates Stand Volume (Q) at year t and initial growing stock (g) was also developed. By solving the equation, the optimum cutting cycle stock for Peninsular Malaysia is at 51. Using a Generalized Faustmann Model, the optimum financial harvesting cycle for tropical mixed forest in Peninsular Malaysia is at year 60–65. Overall results indicated that the current cutting cycle of 25 to 30 years should be extended to 50–60. The results of this study are very important in refining the current management system and adjustments have to be made to ensure that management of productive forests in the country is not only biologically sustainable, but also financially viable.

**Can intensive forest management help save natural forests?** Kaimowitz, D. (*Center for International Forestry Research (CIFOR), Indonesia; d.kaimowitz@cgiar.org*).

Some argue that forest plantations and more intensive logging of selected natural forests will take pressure off other natural forests. Increased timber supply from such intensive systems could lower timber prices and reduce the incentive to log in remote natural forests. The availability of timber from intensively managed systems might also make it more politically viable to prohibit logging in other natural forests. More intensive systems could lead to smaller areas being made accessible through logging roads, which often open up new areas for forest conversation and forest fires. More intensive logging of some natural forests also greatly increases the mean annual increments of commercial timber. This paper assesses each of those arguments using examples from different locations around the world. It concludes that all have some validity, but that the magnitudes of these effects have often been greatly exaggerated.

**Social needs of ITFM in China: Theory and practice.** Liu, S., Li, Y. (*Chinese Academy of Forestry, P.R. China; liusr@forestry.ac.cn*).

The tropical forest area in China covers an area of 10.7 million ha, of which 6 million ha (56.5%) are tropical natural forest areas and 4.7 million ha (43.5%) tropical plantation areas. The tropical forest flora in China is transitional between the tropics and subtropics. Although only 3–5% of China is tropical, plant species in this zone account for 30–40% of the total flora. Concentrated in areas where there are many minorities, the tradition, culture and social-economic development of these minorities exert a great influence on the tropical forest resources. With increasing population and rapid social-economic growth, tropical forest resources have been greatly reduced and traditional tropical forest management practices are no longer able to meet the increasing demand for eco-environment protection and social-economic development. Objective-based forestry management and ecological forestry were therefore proposed as new principles in China and furthermore a forest classification management system has been developed, composed of three major types, i.e., industry-based tropical plantation, ecology-targeted forest and multi-purpose forest. An ITFM case study in Hainan Island, funded by ITTO, had successfully implemented this forest classification management system. Pilot demonstrations in Hainan Island included industry-based tropical plantations, tropical economic forests, close-hill for natural regeneration and vegetation restoration, conservation of the existing natural tropical rain forests and man-made complex ecosystems composed of agriculture-forestry-husbandry.

**Adopting improved planting techniques to assist intensive management of tropical forests.** Raja Barizan, R.S., Samsudin, M., Shamsudin, I., Abd. Rahman, K. (*Forest Research Institute Malaysia, Malaysia; barizan@frim.gov.my*).

A key component in addressing the sustainable management of tropical forest ecosystems is having a proper silvicultural system in place. Such a system should entail prescriptions or protocols that allow removal of timber through a sustainable harvest and at the same time include prescriptions to enhance recovery. Thus, an intensive rehabilitation programme with adequate allocation of funding is introduced into silvicultural operations in natural tropical forests to enhance and accelerate natural processes of forest regeneration to reestablish a healthy and resilient forest stand. It is perceived in a way that species composition, stand structure, biodiversity functions and processes of the restored forest will match, as closely as feasible, those of the site-specific original forests. It is equally important in restoring critical ecosystem functions in regulating micro-climate conditions necessary for plant growth, controlling soil erosion, minimizing the occurrence of flooding and excessive drought, protecting biodiversity and reviving an important role as carbon sink from newly rehabilitated areas. However, the silvicultural treatments currently applied following forest harvesting have been shown to be inadequate in enhancing recovery of the residual forests within the determined cutting cycle. Thus, changes to the forest rehabilitation programme of logged-over forests are essential. The paper addresses this issue and describes the application of improved planting techniques in forest rehabilitation using promising indigenous tree species. It highlights encouraging results of research that has been undertaken in successfully rehabilitating logged forests in Negeri Sembilan and Perak. It further recommends the planting technique as a pragmatic rehabilitation method within an intensive forest management system.

**Implementing intensive forest management through better understanding of changes in vegetation stocking and composition.** Samsudin, M., Ismail, H., Abd. Rahman, K., Shamsudin, I. (*Forest Research Institute Malaysia (FRIM), Malaysia; shams@frim.gov.my*).

The management of forests in Malaysia is expected to face new challenges as exploitation of production forests are shifting from the generally rich and productive undisturbed forests stands to the logged-over forests. In the very near future, all forest harvesting is expected to be undertaken only in logged-over forests. In this respect, there are concerns that logged-over forests which are in their second rotation are not as rich and well stocked as the undisturbed forests and thus the supply of quality raw materials may be hampered in the future. According to the forests management systems applied in these forests, namely the Selective Management Systems (SMS) and the Malayan Uniform Systems (MUS), the residual forest should be able to recover in the specified rotation cycles and there should sufficient quality crop for the second and subsequent harvests. However, limited studies undertaken have indicated that the residual stand within the production forests within the Permanent Reserved Forests is dissimilar to the original forest, especially in terms of species composition. It has been found that the proportion of the more valuable and commercial dipterocarps is much lower and that variations are much higher in the residual stands. Intensive management is required, and forest managers will need a better understanding of the impacts of forest management on the recovery of the residual stand in terms of the changes in stocking, stand structure, species composition and growth. Factors leading to the higher proportion of non-dipterocarp species include the slower recovery of the forest after the first cut, higher mortality due to logging damage and implementation of cutting limit prescriptions that favour high removals of dipterocarps.

**Mechanization in timber harvesting is the way forward in intensive management of tropical forest.** Shamsudin, I. (*Forest Research Institute Malaysia (FRIM), Malaysia; sham@frim.gov.my*).

A more innovative way in managing the hill forest for timber production is needed in order to allow the forest to serve other values and functions. Mechanized technology was originally designed and developed for temperate timber species but can be easily developed to suit tropical timber species of higher density and the size can be monitored through intensive planting. The problem of utilizing small diameter logs can be overcome through chemical and pressure treatments. Intensive planting of timber species in more accessible areas in hill forests will be the only solution to improve productivity and helps to overcome timber shortages in the future. Planting will only be done in accessible areas where harvesting machines can easily be deployed with little damage caused to the environment. Those areas that have not been planted will not be disturbed at all during harvesting. Under the Convention of Biodiversity (CBD), Malaysia made a firm commitment to protect its natural heritage and recognized that hill tropical forests have unique biodiversity that remain to be explored. The mechanization of timber harvesting in intensive forest management will only allow heavy machineries to move in designated areas where trees are to be harvested and other areas will be protected for conservation. The paper highlights the right balance of managing the remaining natural hill forests for timber production and biodiversity conservation through improved technologies in timber harvesting.

**Current approaches in modelling the growth of forestry tree species in India.** Tewari, V.P. (*Arid Forest Research Institute, India; vptewari@afri.res.in*).

The forests of India are under tremendous pressure and large extents of such forests are under various stages of degradation. The efficiency of the forest production system needs to be augmented by optimal management decisions, which need quality information on basic parameters of the forests, such a growth. Such information is scanty and concern has been expressed about its inadequacy. A brief account of the modelling approach presently in vogue in Indian forest management system is presented.

**A review of natural forest management in Venezuela and perspectives of sustainable development.** Torres-Lezama, A., Ramírez-Angulo, H., Vilanova, E., Barros, R. (*Universidad de Los Andes, Venezuela; torres@ula.ve; rhirma@ula.ve; vilanova@ula.ve*).

After three decades of natural forest management in Venezuela, we examine its strengths and weaknesses, and propose solutions toward the establishment of sustainable development. More than three millions hectares of forest were awarded in long term concession. In the western plains, however, the forest has almost disappeared, due to strong human pressure and ineffective forest management. Unfortunately, the social component has received the least attention. Furthermore, the forest sector's contribution to the country's GNP did not increase, remaining very low (1%). Similarly, the majority of the adopted forest regeneration methods were based on transformation of the forest. This approach has generated strong criticism regarding the conservation of biological diversity. Likewise, the indiscriminate use of minimum felling diameter, inappropriate felling cycles, and the application of selective logging

methods (i.e., high-grading) characterized by deficient planning and high environmental impacts have led to forest deterioration, thus casting doubts on the ecological and economical sustainability of the system. We propose a complete revision of forest management in Venezuela that should lead, among other goals, to a strengthening of the forest sector, the development of new policies for forest concessions, a more effective incorporation of local communities, and lower impact on the forests.

**Sampling intensity of pre-felling (pre-f) inventory: implications for the current forest management system.** Wan Mohd Shukri, W.A., Samsudin, M., Ismail, H., Nur Hajar, Z.S. (*Forest Research Institute Malaysia (FRIM), Malaysia; shukri@frim.gov.my*).

Various management systems have been implemented in Malaysia to manage the country's valuable forest. The Selective Management System (SMS) was introduced late in 1978 to allow a more flexible timber-harvesting regime, which is consistent with the need to safeguard the environment and at the same time take advantage of the demand of the timber market. The systems often relied on rules concerning pre-felling (pre-f) and post-felling (post-f) inventories and timber stand improvements. Thus the reliability of the inventory is crucial in ensuring correct prescriptions are adopted under the SMS. Towards this end, a study was carried out on a randomly selected 30-ha (500 x 600 m) forest area within the 50-ha Demography Project of the Forest Research Institute Malaysia (FRIM) in Pasoh Forest Reserve, Negeri Sembilan to ascertain the required sampling intensity for pre-f inventories. The study showed that a higher sampling intensity was needed when sampling species groups that were lower in their frequency of occurrence. Dipterocarp species group (ALL DIPT) needs a higher sampling intensity to detect its occurrence compared to non-dipterocarp species groups (ALL NON-DIPT). A different intensity of sampling was required when considering either species groups or tree parameters separately. The implications of the intensity of pre-f inventory by species group currently used in Selective Management System are discussed.

**Tropical forest management based on the harmonization of economy and ecology in China.** Wen, Z. (*Nanjing Forestry University, P.R. China; zuominwen@sina.com*).

In implementing classified management, Chinese tropical forests are divided into commonwealth and commercial forest. They are managed purely for ecological and economic purposes, respectively. At the same time, large parts of traditional forests are being preserved for multi-functional purposes. The Chinese tropical forests integrated development model is based on a theory developed by the Hainan tropical forests project that aims to ensure of sustainable development of tropical forests. The theory of classified management considered economic and social measures that would solve the social and economic problems that deplete tropical forest resources. For natural forests, scientific models for cutting and renewing forests are implemented based on the standards and indexes outlined by ITTO. This approach encourages the effective protection of biodiversity and the development of alternative industries to replace those that would involve forest-cutting in the tropical region. In surrounding forest areas, the development of intensive agriculture, e.g., animal husbandry, the courtyard economy and ecological agriculture, has been encouraged to boost the income of local people while protecting and improving the original forest ecosystem. A management model of industrial plantations that will develop the wood industries will be introduced in order to produce high quality and high yield products, which at the same time will benefit the local forest community.

### **Properties and utilization of plantation timbers: Plantation wood as a substitute for native forest resources**

Organizers: KeeSeng Gan *Forest Research Institute Malaysia (FRIM), Malaysia; ganks@frim.gov.my*, and Gary Waugh *University of Melbourne, Australia; Garyx.waugh@bigpond.com*

**Dynamic growth of Uttis (*Alnus nepalensis*) monitored for ten years at the special plantation plots of ARS Pakhribas, Dhankuta.** Barakoti, T.P. (*Nepal Agricultural Research Council, Nepal; tpbarakoti@yahoo.com; arsp@ntc.net.np*).

Result of an on-station long-term growth monitoring trial on alder (*Alnus nepalensis*) in the permanent sample plots carried out at the Agricultural Research Station (ARS) Pakhribas, Dhankuta, Nepal showed that diameter and height of plants varied with the age of trees. The diameter at breast height (DBH) increased by 2.14 cm in 8th year, whereas the rate was 0.13 cm only at 16th year. The growing rate of trees was 44 cm to 130 cm per year irrespective of the age, based mainly on distribution of precipitation in the year. Highest growth rate would be achieved if good rainfall occurs during the summer (March–April). The biomass and volume also differed with age



and environment. Estimated biomass of the stem and branches increased by 2–2.5 times within the 10 years period. Volume of wood also varied accordingly. Thinning and felling every year provided better management practice of the plantation. Based on the result some suggestions and recommendations were made. The information would be useful for community forest users and forest managers in planning and management of Uttis in private and community forests.

**Sound adsorption coefficient of plantation timbers – *Acacia mangium* and rubberwood.** Kee Seng, G., Lim, S.C. (*Forest Research Institute Malaysia, Malaysia; ganks@frim.gov.my*).

Timber is a very versatile traditional material with many applications. Its uses range from structural members in building construction to disposal items such as match splints and chopsticks. Each of these uses requires the timber to fulfill certain performance criteria like mechanical, physical or/and chemical properties. Plantation timbers are sometimes fast growing but are deficient in certain other properties. For uses in buildings, the requirements for good acoustic properties are becoming very important. In many instances, timbers have been used for sound insulation and sound absorption. To use the plantation species efficiently, data on the acoustics properties are indispensable. The absorption coefficient of timber was measured by using the standing wave method. It uses a small sample size and gives accurate results. The absorption coefficients of *Acacia mangium*, rubberwood (*Hevea brasiliensis*) and five tropical timber species, namely ramin (*Gonystylus* spp.), bintangor (*Calophyllum* spp.), chengal (*Neobalanocarpus heimii*), penaga (*Mesua ferrea*) and meranti pa'ang (*Shorea bracteolata*), were measured in the frequency of between 125 and 6300 Hz. Both the radial and tangential faces of each timber species were measured. This paper discusses the differences in characteristic curves of absorption coefficients of the timber tested.

**A case study on clonal forestry for conservation of natural tropical forests in Indonesia.** Kim, H. (*KORINDO, Indonesia; khoon@korindo.co.id*), Lee, D.K., Kang, H.-S. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr; silvi@chol.com*).

A tropical forest is invaluable but its high biological diversity and delicate ecological characteristics put its resources at risk when exposed to unsustainable practices in forest management systems. Over the past several decades, tropical forests have been rapidly disappearing, triggering concern among the domestic and international communities. The objective of this study was to provide sustained yield of wood production using intensive plantation and conserve the natural tropical forests. The result of the analysis of commercial wood production data in Indonesia over the past several decades shows that productivity is very low, at only 0.5 m<sup>3</sup>/ha/year. The major factor for this low productivity rate is its inherited ecological characteristics. The accumulated results of poor forest management (overexploitation, illegal logging, smuggling, erosion, flooding, fires, and large-scale forest destruction) over the last several decades have had a bad effect on the environment. Analyzing several types of plantation systems shows that an intensive plantation system with advanced breeding programs is a strong potential for producing a high yield of wood. A case study on clonal forestry in Indonesia shows that clonal forestry has a strong potential and also that a short- and long-term breeding programs need to be implemented.

**Properties of Japanese Cedar planted by Director Nishikawa.** Leong, C.-M., Jien, S.-N., Lin, Y.-T., Yang, T.-S., Wang, S.-Y., Lin, F.-C. (*National Taiwan University, Chinese Taipei; L5010554@ms15.hinet.net*).

The 'Nishikawa Japanese Cedar' is the oldest plantation in Taiwan. It was introduced by Mr. Nishikawa, the first director of the Experimental Forest, Tokyo Imperial University, from Yoshino in 1912. The experimental site was established in 1926 and the plantings are more than 93 years old. In the autumn of 2001, the experimental site suffered damage from debris flow triggered by heavy precipitation from the Toraji typhoon. The cambium of the trees located at the edge of the stand was damaged and died. Two years later, two of the dead trees were used for academic research. The purpose of this study was to investigate the basic mechanical properties, particularly bending, compression, and shear strength, in order to understand how they differ from other planted Japanese Cedar and to improve the silvicultural techniques in the future.

**Sapwood in plantation-grown teak in Peninsular Malaysia.** Lim, S.C., Gan, K.S., Tan, Y.E., Thi, B.K. (*Forest Research Institute Malaysia (FRIM), Malaysia; limsc@frim.gov.my*).

The presence of a high percentage of sapwood, particularly prevalent in plantation-grown timber, has significantly lowered the value of wood because sapwood has always been regarded as the inferior part of the wood. As such, it is important that during the harvesting of plantation-grown trees, the percentage of sapwood be kept as low as possible. This study attempts to investigate whether the ages of tree have any effect on the amount of sapwood present. Discs of about 50 mm in thickness were cut at 10%, 30%, 50%, 70% and 90% heights of the clear bole from plantation-grown teak of ages 8, 16 and 28 years. Sapwood thickness was measured at four different positions of a disc and an average

sapwood percentage was calculated. Statistical analysis indicated that only the age significantly affected sapwood percentage whereas the height was found to be insignificant.

**Measurement of longitudinal surface released strains of trees using strain gauge and CIRAD-Forêt method.** Liu, X., Jiang, X., Yin, Y. (*Chinese Academy of Forestry, China*).

In this paper, the CIRAD-Forêt method and the strain gauge method were used to measure the longitudinal surface strains released from fallen woods. Comparison was also done between two methods for measurements at the same point (sawing grooves inside the position pins) and at two points. Results showed that the values obtained from the CIRAD-Forêt method were bigger than those from the strain gauge method. The former was 1.3 time as high as the latter for the measurement at two points, and it was twice as high as the latter for the measurement at the same point. There was no distinct difference in the longitudinal surface strains from the strain gauge method with measuring way at the same point and two points. However, the differences were obvious for the strains from the CIRAD-Forêt method with two measuring ways. They indicated that there was little effect on the values from the strain gauge method, when measuring at the same point or at two points, and that the measuring way would influence measured results when the CIRAD-Forêt method was applied. In general, in comparison with the CIRAD-Forêt method, the strain gauge method is more stable.

**Increasing the value of tropical lumber in the Philippines through machine stress grading.** Manalo, A.C., Soriano, F.P., Saralde Jr., T.C., Bonaagua, E.A., Pabuayon, I.M., Garcia, C.M.C., Lapitan, F.G. (*Forest Products Research and Development Institute, Philippines; engr\_manalo@yahoo.com; struclab@laguna.net; wood@laguna.net; erwinbonaagua@yahoo.com; fprdi@laguna.net*).

This paper resulted from the project 'Development and Implementation of Stress Grading Rules for Tropical Timber in the Philippines' jointly implemented by the Forest Products Research and Development Institute (FPRDI) and the International Tropical Timber Organization (ITTO). A grading system for full-size lumber based on ISO standards for machine grading (TC 165 N 321 DIS 13910) was developed. The corresponding grading modulus and allowable design stresses for each grade were determined. Five stress grades were established: M5, M10, M15, M20 and M25 where numbers 5 to 25 indicate the allowable bending stress in MPa. A builder's manual and a timber design software called the Truss Designer were also developed. Consequently, a model framework was established to harmonize lumber stress grading rules in tropical timber producing and consumer countries. The cost and return analysis on production of machine graded lumber (MGL) showed that there is an incentive for lumber producers, importers or dealers. The additional benefits from grading outweigh the added costs. Construction applications of MGL include trusses, roof frames, wall and floor frames, ceiling joists, beams and posts. MGL can also pave the way for engineered housing components such as laminated and built-up columns, long span beams and prefabricated trusses.

**Sawlog availability from Australia's hardwood plantations.** Parsons, M. (*Bureau of Rural Sciences, Australia; Mark.Parsons@brs.gov.au*), Nolan, G. (*University of Tasmania, Australia; Gregory.Nolan@utas.edu.au*).

Australia has over 700,000 hectares of eucalypt plantations, but how much sawlogs can they provide? As part of a national review of hardwood plantations for solid wood products, a survey of Australian hardwood plantations was undertaken. This showed that most plantations are being grown for fibre, that is, they are unlikely to produce any significant quantity of logs suitable for solid wood products. An estimated 106,000 ha, or about 17%, of hardwood plantations are being managed specifically for sawlog production. These plantations are young, with 62% planted since 1995 and an expected rotation length of 20–35 years. Many of the nominal sawlog managed plantations established before this were planted for fibre but have been allowed to grow on, often after thinning. Log availability projections indicate that supply from hardwood plantations will total about 375,000 m<sup>3</sup>/year in 2035. However, when combined with availability projections from native forest, it can be seen that plantations can provide less than half of the estimated log availability lost from public native forest between 2000 and 2035. Total hardwood sawlog supply is likely to fall by more than 600,000 m<sup>3</sup>/year by 2035.

**Preliminary study of sawing on China's *Eucalyptus* plantation timber.** Zhou, Y., Jiang, X. (*Chinese Academy of Forestry, P.R. China; zhoudy@forestry.ac.cn*).

The current trend in forestry in China toward managed plantation resources has been driven by environmental concerns, which focus on the cessation of native forest logging and replacing this industry with plantation for industrial wood production. The sawing of eucalyptus plantation timber in China is studied in this paper. Live sawing, cant sawing and center sawing pattern were used in experiments, the strain in tangential/longitudinal direction, bow deformation and other quality concerned factors were analyzed, and a method with center sawing to

know the residue stress is tried. Conclusion was drawn, the end-split and bow deformation exist in 4 species of eucalyptus lumber, the sawing sequence affects the bow deformation of lumber evidently, the bow deformation with center sawing pattern is the least, and the residue strain induced by center sawing is in accordance with the bow deformation from cant sawing pattern.

## **Modelling multi-dimensional forest dynamics for multiple-purpose management objectives**

Organizer: Jens Peter Skovsgaard *Forest and Landscape, Royal Veterinary and Agricultural University; jps@kvl.dk*

**How do forests grow?** Bezak, K. (*Hrvatske šume d.o.o., Hungary; karlo.bezak@hrsume.hr*).

Forests are complex and chaotic nonlinear dynamic systems. The theory of complexity and the theory of chaos are component parts of the theory of nonlinear dynamic systems, the ultimate scientific achievement of the past 20 years. In traditional physics and applied mathematics, an equation which describes a system under study is one among the most important things in the world. The universally accepted paradigm states that the road to modelling nature leads through differential equations. The key to understanding the growth and increment of forests lies in differential equations of damped and forced oscillations.

**FORECAST: A stand-level decision-support tool for multi-objective forest (modification and validation).**

Lo, Y.-H., Kimmins, J.P. (*University of British Columbia, Canada; yhlo@seed.net.tw*).

Although multi-objective forest management is a pervasive trend towards ecosystem-based management associated with national sustainable forest management (SFM), not many tools are suitable to reach this goal. FORECAST, a management oriented stand-level forest growth simulator, can fulfill this requirement. It is suitable for SFM purposes because it includes both ecology and economic factors. It is also a multi-component model and has incorporated a variety of different ecosystem processes (e.g. nutrient cycling, understory competition, production) and the feedback loop (i.e. nutrient feedback) which other models usually ignore or omit. However, FORECAST is not perfect and has some weaknesses. It does not perfectly represent the hydrological dynamic within an ecosystem and the climate change impacts to forest ecosystems. The research group is working on adding the climatic components into the model and linking it with three other components: hydrology, wildlife and fire. Also, by using the dendrochronology, I will validate the simulated results from the modified FORECAST model. Once the whole links are built and tested, the modified FORECAST model could predict the future forestry ecosystem condition. As a result, it will be a good decision tool by giving the possible direction for sustainable forest management under climate change.

**Predicting Lodgepole Pine productivity from climatic parameters in Alberta.** Monserud, R.A. (*USDA Forest Service, USA; rmonserud@fs.fed.us*), Huang, S.

We seek to connect site productivity to climatic parameters for the Canadian province of Alberta. Climatic data are obtained from a province-wide climatic mapping model based on 30-year normals from the provincial weather station network. Mapping methods are based on ANUSPLIN, Hutchinson's thin-plate smoothing spline in four dimensions (latitude, longitude, elevation, climatic variable). Forest site productivity data are observed site index by species based on stem analysis (observed height at an index breast height age of 50 years). Over 1200 site locations are available for lodgepole pine, the major forest species of Alberta. Regression analyses are used to predict site index as a function of the climate at each stem analysis location. Implications for bioclimatic modeling and climate change are discussed.

**Needs and opportunities for using a forest dynamic model as a practical tool in biodiversity conservation and management.** Ngugi, M.R. (*Environmental Protection Agency, Queensland, Australia; michael.ngugi@epa.qld.gov.au*), Botkin, D.B. (*The Center for the Study of the Environment, USA*), Jones, B., Williams, A. (*Environmental Protection Agency, Queensland, Australia*).

The state government of Queensland is committed to conservation of biological diversity, with about 5 million hectares under nature conservation reserves and 3 million hectares under multiple-use forests managed for a range of values including conservation of biodiversity. The structure and composition of most native vegetation in Queensland have been greatly influenced by agricultural practices, selective harvesting, controlled burning and wildfires. There is an

urgent need to develop long-term predictions of change in forest composition to aid in determining whether biodiversity conservation, habitat diversity and the protection of rare and endangered species are being achieved under current management practices. A vegetation dynamic simulation model was calibrated to the species, climatic and site conditions in St Mary state forest, Queensland and then validated using data-set that had been collected on permanent sample plots for a period of 50 years. The model was capable of mimicking the stand dynamics of mixed species sclerophyll forest to sufficient accuracy of less than 10 % error in 50 years and goodness of fit between predicted and observed basal area was high ( $r^2 > 0.90$ ). This paper demonstrates opportunities for application of a forest dynamic model as a practical tool in the conservation of biodiversity.

**Models for forest management: A review of European experience and perspectives.** Pretzsch, H. (*Technical University of Munich, Germany*), Skovsgaard, J.P. (*Forest and Landscape, Royal Veterinary and Agricultural University, Denmark; jps@kvl.dk*).

The succession of model approaches in forestry and forest science – from experience tables through normal yield tables, models for stand growth, diameter distributions, and individual tree behaviour, to landscape management systems – clearly reflects changing demands on forest management. At the beginning of planned forestry in Europe the focus of sustainable management was mainly on wood production. Subsequently, more and more forest functions were taken into consideration. European foresters' current understanding of multifunctional forest management is reflected in the six Pan-European criteria for sustainable forestry, including forest resources, forest ecosystem vitality, productive functions, biological diversity, protective functions, and socio-economic functions. As a consequence of this development, revised concepts and tools for multicriteria strategic planning are being developed in different regions of Europe. Here, we briefly review ways to complement models of forest growth, stand dynamics and landscape development with integral functions for assessment of carbon retention, biodiversity, esthetic value, financial yield, etc. We highlight the social process of model development, including the hurdles needed to go beyond model extension, model calibration, and model evaluation, to successfully implement the models into the information flow of forest ecosystem management.

**Modelling multi-dimensional forest dynamics for multi-purpose management objectives: A case study from Sweden.** Sverdrup, H., Wallman, P., Belyazid, S. (*Lund University, Sweden; Harald.Sverdrup@chemeng.lth.se*).

The present study describes application of natural, social and economic sustainability limitations to forest management for profitable production, based on Swedish experiences developed in the SUFOR and ASTA research programs. We suggest a method of analyzing the sustainability conditions for forestry from three major realms, environmental, social and economic, and the tools and methods were tested at sites in Sweden. Assessments were made for the long-term sustainability concerning the impact of present management practices on the balance for nutrients in monocultures versus mixed stands of Norway spruce, hardwoods and birch. In the economic assessments, both traditional terms but also costs and revenues from adaptation to biodiversity criteria and public service demands were accounted for. An alternative to traditional discounting was used for transferring monetary value over time, by introducing spruce pulpwood equivalent units. A new tool, combining mechanistic models to involve full feedbacks between the nitrogen-, carbon- and chemical cycle, mineral weathering, soil chemistry, hydrology, forest growth and nutrient cycling has been developed (FORSAFE). The model has been combined with a ground vegetation module (VEG) into the integrated forest sustainability assessment tool (FORSAFE-VEG). Results showed that changes in management methods potentially needed are both possible and feasible.

**Cavity tree abundance and stand characteristics in Western Oregon forests: Relationships and prediction.**

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Cavity trees contribute to diverse forest structure and wildlife habitat. For a given stand, size and density of cavity trees indicate its diversity, complexity, and suitability for wildlife habitat. Size and density of cavity trees vary with stand age, density, and structure. To examine the relationships between cavity tree abundance and stand characteristics, we applied correlation analysis and graphical approaches to Forest Inventory and Analysis (FIA) data collected in Western Oregon. Cavity tree abundance was negatively correlated with site index and percent composition of conifers, but positively correlated with stand density, crown closure, and percent composition of hardwoods. Thirty-nine percent of the FIA plots had a least one cavity tree, and 29% of the sampled plots had more than 14.1 m<sup>2</sup>/ha basal area of cavity trees. To estimate cavity tree abundance from stand attributes, we compared the most similar neighbour, the Classification and Regression Tree (CART), and Weibull function using FIA plots. The CART approach provided better estimates of cavity tree abundance. Potential applications of this approach include selecting and modeling wildlife habitat that can be linked with forest planning efforts, regional inventories, and evaluation of different management scenarios.

## **Monitoring and indicators of forest biodiversity: Towards a harmonized system at country, landscape and stand scale**

Organizers: Tor-Bjorn Larsson *European Environment Agency, Denmark; Tor-Bjorn.Larsson@eea.eu.int*, and Anna Barbati *Italian Academy of Forest Sciences, Italy; annabarbati@tiscali.it*

**European forest types for biodiversity assessment.** Barbati, A., Corona, P., Marchetti, M. (*Italian Academy of Forest Sciences, Italy; annabarbati@tiscali.it*).

The European Environment Agency has funded a project titled 'European Forest Types for biodiversity assessment: a user guide' aimed at consolidating and presenting, in a user-friendly way, a scheme of European-level forest types intended as a tool to assess the state and development of biological diversity. The guide is designed to serve primarily European and national organizations involved in European policy for the sustainable management of forests (SFM). The aim of this paper is to give an overview of the state of progress of the activities carried out under this project. The presentation includes: principles of the classification and overview of the hierarchical structure nomenclature of European Forest Types for biodiversity assessment; examples of the descriptive frame adopted to classify forest types; cross-walks of European Forest Types to most important forest habitat classification systems applied in Europe (Eunis Habitat classification, Natura 2000-Annex I Habitat Directive); insights on the benefits of using European forest types to enhance the specificity and interpretability of the biodiversity indicators assessed in the framework of 'Ministerial Conference on the Protection of Forests in Europe'.

**Semi-quantitative insight into the forest biodiversity of an eastern Romanian area.** Creanga, I.A. (*Territorial Forestry Office, Romania; creanga52@yahoo.com*).

Biodiversity in some natural and artificial poplar forests, as well as in some natural oak stands, was evaluated to reveal the impact of human activity on forest sustainability. Considering the number of the species present in the forests, the Shannon's index, defined accordingly to the information theory, was used as a semi-quantitative approach to determine biodiversity. Graphical dependence between the Shannon's index and the percentage of *Populus alba* and *P. nigra* in natural poplar and willow stands was revealed. Similarly, in the mix oak stands, the dependence of the biodiversity index on the percentage of *Quercus robur* and *Q. petraea* could be emphasized. The impact of economic needs upon the oak mix forests was investigated by comparative statistic representation of the stem diameter values in well-managed forests and in the other ones. The box-plot technique was able to reveal the negative role of non-rational tree extraction upon the natural oak stands. The necessity of visionary forest administration can be discussed on the basis of these numerical data.

**Mycobiota monitoring as an indicator of forest biodiversity.** La Porta, N., Valentinotti, R., Salvadori, C., Ambrosi, P. (*IASMA, Italy; nicola.laporta@iasma.it; ruggero.valentinotti@iasma.it; cristina.salvadori@iasma.it; paolo.ambrosi@iasma.it*).

An analysis of the macromycete communities of four different types of alpine forests was carried out to characterize their ecological value. Number, frequency, and biomass of the fungi species were assessed weekly from March–November for a 10-year period. The total surveyed surface of 2700 m<sup>2</sup> was divided into 12 different parcels. More than 900 fungal species belonging to more than 140 genera were collected. A few species represented the majority of the mycetic biomass. Results from the analyses between chemical parameters and biomass of the two mycological groups indicate significant correlations: with an increase in rainfall acidity there is a decrease in mycorrhizal species and a substantial change in the saprophyte species. These results are encouraging for the use of macromycetes for bio-indicators of long-term atmospheric depositions. A comparison of several biodiversity indexes based on the preliminary analysis of the presence/absence of species collected in the four locations shows that they can strongly modify the differences among the localities, and sometimes the rank of the biodiversity. Such results may be an important contribution for a rational approach to strategies for environmental protection.

**Report from the IUFRO Conference 'Monitoring and indicators of forest biodiversity in Europe' Florence, November 2003.** Marchetti, M. (*Italian Academy of Forest Sciences, Italy; marcom@unipa.it*), Larsson, T.-B. (*European Environment Agency, Denmark; Tor-Bjorn.Larsson@eea.eu.int*).

The main objectives of this conference was to take stock of the potential to further improve the biodiversity related indicators on sustainable forest management that were revised by the Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 2002 as well as allowing the growing scientific community addressing forest biodiversity to meet, present results and exchange ideas. The programme was structured in seven sessions: emerging user needs and pressures on forest biodiversity; forest classification and assessment strategies; stand-level indicators: dead wood; stand-level indicators: the heterotrophic phase; forest indicator development at landscape scale, methods for data collection and evolution of monitoring schemes; human influence on biodiversity. The conference gathered some 150 participants and the proceedings, now available through the European Forest Institute, comprise some 500 pages.

**Implementing biodiversity in the EU Forest Focus monitoring programme.** Neville, P. (*Coillte R&E, Ireland; pat.neville@coillte.ie*), Bastrup-Birk, A. (*Joint Research Centre, Italy*), Fischer, R. (*BFH, Hamburg*), Axelsson, A.-L. (*MLU, Sweden*), Aamlid, D. (*Skog Forsk, Norway*), Marchetti, M. (*AISF, Italy*), Larsson, T.-B. (*EEA, Denmark*).

The joint network of tree crown condition monitoring under the EU and ICP Forests operates at two levels, a systematic extensive approach (Level I) based on a 16 km x 16 km trans-national grid of sample plots (>6000 plots) and an intensive approach (Level II) on more than 800 plots across continental Europe. Three ongoing projects embrace the different levels of monitoring, the above mentioned Level I and Level II systems, and the National Forest Inventories (NFIs). All of the three projects are based on a stand structure approach that assumes an increased potential for species diversity with increasing complexity of stand structure. An intensive test-phase of forest biodiversity assessment at more than 100 Level II plots, known as ForestBIOTA is underway during 2005. This project aims to test standardized methods of forest biodiversity assessment in the field and examine the relationship between stand structure, forest deadwood, ground vegetation and epiphytic lichens. A forest classification of the plots is also included. A separate approach, known as BioSoil (due to its combination with a detailed chemical inventory of the soils) is a demonstration project which aims to record indicators of forest biodiversity at the extensive Level I plots. Practical measures of stand structure, including records of tree species, lists of vascular plant species, and simple measures of forest deadwood are included for field assessment during 2006. A pan-European forest type classification elaborating on the EUNIS system and including the Natura 2000 habitat types is proposed. These initiatives are linked to a third project, COMON, operating at the level of the National Forest Inventories aiming to test the same core variables at national levels.

**Forest management and biodiversity: Insects as indicators.** Paiva, M.R. (*Universidade Nova de Lisboa, Portugal, mrp@fct.unl.pt*).

Although links between the main ecosystem functions and biodiversity have been recognized, an exact description and quantification of such relationships has yet to be established. Regarding forest ecosystems, experimentation within this context and model validation prove particularly difficult, given the time scales operating. In temperate / warm regions, most insects react quickly to alterations of their habitats and thus serve as indicators of disturbances and of the resulting impacts. Field work, conducted in a Mediterranean region, to compare three types of forest ecosystems, detected a link between the frequency of occurrence of large perturbations and ant community structure and biodiversity. In separate studies, diurnal butterflies were identified as indicators of anthropogenic disturbances and of land use change, over a gradient of habitats, ranging from little disturbed forest sites to agricultural plots. In pine plantations under different management regimes, the composition of the under story affected the diversity of both parasitoids and predators of the most important Mediterranean pine defoliator, the pine processionary moth. Perturbations appear to affect interspecific competition by enhancing the ability of certain species, either native or exotic, to dominate their communities. Forest management practices clearly reflect on the composition of insect communities belonging to different trophic levels.

**Biodiversity resources in the southern Philippines: Vital for sustainable management of mountain ecosystems.**

Pampolina, N.M., Torres, M.J.A., Piñon, A.A., Pollisco, J.P., Duran, N.J.E., Adiova, J.M. (*University of the Philippines Los Baños, Philippines; nelpampolina@yahoo.com*).

This poster highlights a biodiversity study conducted in the copper-rich mountains of southern Mindanao, Philippines. Thirty, 10 m square plots were established along an elevation gradient between 615 and 1575 m asl. Each plot was divided to quantify intermediate plants and undergrowth within 3- and 1-m square plots, respectively. Biometrics and ecological variables were measured to determine diversity indices, carbon estimates, and phytoremediators. Macrofungi were collected and identified. Forest litter and undergrowth were sampled, oven-dried, and weighed. Soil was collected for nutrient and mycorrhizal analysis. Diversity of vertebrate and invertebrate wildlife was computed. Status of all organisms was verified from IUCN. Endanger plants were: *Shorea contorta*, *Parashorea malaanonan*, *Podocarpus imbricatus*, and *Dacrydium elatum*. Potential copper phytoremediators included: *Piper aduncum*, *Melastoma malabatricum*, and ferns. Numbers of wildlife species were: 35 bird, 4 frog, 3 snake, 2 lizard, and 1 mammal. Most birds were endemic while frogs could be new species. Sixty macrofungi and three mycorrhizal species important in nutrient cycling were abundant in moist, mossy secondary forests. In dense forest ecosystems, carbon stocks were higher in aboveground than belowground biomass. Overall, biodiversity was richer in mossy forests than disturbed ecosystems. Results indicate priority areas for conservation, protection, rehabilitation, livelihood, ecotourism, and research to address issues essential for sustainable management of mountain ecosystems.

**Structure and biodiversity of a natural Silver fir–European beech forest.** Petritan, A.-M., Petritan, I.-C., Nicolescu, N.-V. (*Forest Research and Management Institute, Romania; apetrit@gwdg.de; University “Transylvania” of Brasov, Romania; petritan@unitbv.ro*).

Natural forests represent a complex research laboratory of ecological phenomena and processes. To study the structure of a natural forest, several sample plots were established in a natural silver fir–European beech forest located in the

Taga Massif of the Transylvanian Alps in Romania. Considering the proportion of the two species (living, standing dead, and fallen trees), the forest is dominated by living trees (87% by volume and 76% by number of trees) followed by standing dead and fallen (13% by volume and 24% by number of trees). The biodiversity level of the herbaceous layer was determined using the Shannon index, maximum possible diversity index, and Pielou's index. Some indices based on neighbourhood relations (contagion index, mingling index, and diameter differentiation index) and the Pielou's coefficient of segregation (index based on the degree of mixing the trees of two species) were also calculated to describe the structure of the tree layer. All indices calculated for both tree and herbaceous layers show a high level of biodiversity and a complex structure of the natural forest.

**Application of ecosystem diversity based on the Shannon index for a Taiwan red cypress plantation and secondary broadleaf forest at Hue-Sun Forest Station in Taiwan.** Tsai, S.-T. (*Transworld Institute of Technology, Chinese Taipei; tsai.st@msa.hinet.net*), Lu, K.-C., Ou, C.-H., Tang, L.-C., Wu, S.-H. (*National Chung Hsing University, Taichung, Taiwan; kclu@nchu.edu.tw; chou@nchu.edu.tw; lctang@nchu.edu.tw; shwu@nchu.edu.tw*).

We constructed a conceptual food-web model of night taxonomic groups to explore the application of ecosystem diversity index based on the summation of Shannon indices of inter-species, intra-species, and structure diversity. The model was based on the practical monitoring data collected in a Taiwan red cypress (*Chamaecyparis formosensis* Matsum.) plantation and a secondary broadleaf forest at Hue-Sun Forest Station in central Taiwan. The highest structure diversity occurred in the summer for all sampling plots, and the red cypress plantation, with a high number of invaded broadleaf trees, had the highest structure diversity. The variation of total inter-species diversity among plots was high, possibly due to the seasonal variation of species in several taxonomic groups, especially secondary carnivorous and detritivorous-phytophagous animals, and carnivorous, phytophagous, omnivorous, and detritivore insects. The uniformity of tree diameter was the main reason for composite intra-species diversity in the secondary forest plot, which was higher than any plots in the red cypress plantation. In term of ecosystem diversity based on Shannon index, all plots in the summer were higher than in other seasons. The secondary forest plot and the red cypress plot with the most broadleaf invasion also were higher in the ecosystem diversity index.

**Is there any progress towards halting biodiversity loss in European forests?** Van Brusselen, J., Schuck, A. (*European Forest Institute, Joensuu, Finland; jo.vanbrusselen@efi.fi*).

About 30 percent of the European land area is covered with forests, which comprise a key repository for biological diversity. In accordance with decisions of the Convention on Biological Diversity's 6th and 7th Conference of the Parties, high-level European policy has outlined the target to significantly reduce the rate of biodiversity loss by 2010 and to develop a framework for assessing progress towards the target. A summary and appreciation of key trends is presented, with attention to the biogeographical diversity on the European continent where necessary. The key issues concerning forest biodiversity are described using the model 'state-pressure-response'. Major developments are highlighted in the fields of policy, monitoring and practical forest management. Some indirect indicators of biodiversity allow cautious optimism: the forest area has generally increased; native old forests are residual, but managed forests are growing older; and some countries have measured an increase of the amount of dead wood in their forests. However, a large number of threatened species indicates a quality problem. Major pressures come from effects of air pollution, forest management practices and invasive species. Responses to these pressures are implemented through various levels of forest protection, ranging from strict forest reserves to voluntary 'closer to nature' forest management.

**Fungal and bacterial diversity in post-harvest stump residues.** Woodward, S. (*University of Aberdeen, UK; s.woodward@abdn.ac.uk*).

Microbial diversity is a highly significant, but generally overlooked, component of ecosystem biodiversity. This paper examines the total diversity of culturable micro-organisms found in Sitka spruce (*Picea sitchensis*) stumps in Scotland. Numbers of Basidiomycota and mitosporic fungi increased with time from felling; Zygomycota were rare. Yeasts were also abundant at sampling points from seven days after felling. High numbers of culturable bacteria were obtained from the upper layers of the outer sapwood in first and second years after felling; diversity was highest near the stump surface. By the third year after felling, numbers of culturable bacteria had dropped considerably. Euclidean distance measure and the group average linking method revealed four groups of culturable bacteria, based on 13 phenotypic characteristics. The proportions of the four groups varied significantly with stump age. Both fungi and bacteria are clearly abundant in this woody resource; numbers of species of fungi were comparable with quantitative estimates made in more natural forest ecosystems. It is proposed that the microbial community contributes greatly to general biodiversity in the forest ecosystems of both highly managed plantations and natural forests, and should be considered alongside diversity of larger organisms in order to develop a complete understanding of ecosystem function.

## Managing forest landscape mosaics for production and conservation

Organizers: Geoffrey Smith *Environmental Protection Agency, Queensland, Australia*; [geoffrey.smith@epa.qld.gov.au](mailto:geoffrey.smith@epa.qld.gov.au), and David Taylor *Department of Primary Industries and Fisheries, Queensland, Australia*; [Dave.Taylor@dpi.qld.gov.au](mailto:Dave.Taylor@dpi.qld.gov.au)

**Using red alder to develop multi-functional forests in Alaska.** Deal, R.L., Hennon, P.E., Hanley, T.A., Orlikowska, E.H. (*USDA Forest Service, USA*; [rdeal@fs.fed.us](mailto:rdeal@fs.fed.us)).

Red alder (*Alnus rubra* Bong.) appears to influence the productivity and structural diversity of young-growth conifer forests and affect the major resources (timber, wildlife, and fisheries) of forested ecosystems in southeast Alaska. Stand dynamics were evaluated in mixed red alder-conifer forests of southeast Alaska by assessing stand development, tree regeneration, total basal area, and understory plant diversity in 40-year-old red alder-conifer stands that developed following logging. Red alder offers prospects for increasing biodiversity, wildlife habitat value, tree regeneration, and growth when included as a hardwood species in mixed hardwood-conifer, young-growth forests. Overall, these mixed red alder-conifer stands provided more heterogeneous structures, multiple canopy layers, and greater diversity and abundance of understory plants. Headwater streams with more riparian alder also provided more invertebrates and supported more downstream fish biomass than those basins with little or no riparian alder. Red alder may serve as an effective tool for improving terrestrial and aquatic habitat and for restoring important ecosystem functions in regenerating forests following timber harvesting. Silvicultural systems are being implemented with a mixture of red alder-conifer compositions to improve diversity of regeneration and also enhance forest resources that are often compromised in pure conifer young growth forests in the region.

**Conservation and management of grassy *Eucalyptus globulus* forests in southeast Tasmania.** Duncan, F., Munks, S.A. (*Forest Practices Board, Tasmania, Australia*; [Fred.Duncan@fpb.tas.gov.au](mailto:Fred.Duncan@fpb.tas.gov.au); [Sarah.Munks@fpb.tas.gov.au](mailto:Sarah.Munks@fpb.tas.gov.au)).

Several policies and processes have been implemented to conserve threatened forest communities and species in Tasmania. Grassy *Eucalyptus globulus* forest is a threatened community (>60% loss) occupying approximately 14 900 ha (80% on private land) in southeast Tasmania. Secure reserves contain about 1760 ha of grassy *E. globulus* forest on public land and 2200 ha on private land. Many other occurrences are informally reserved. Logging followed by regeneration to native forest is permitted in threatened communities on private land, subject to requirements of Tasmania's forest practices system, including prescriptions for rare or threatened species. Such plant species are generally maintained on-site by typical logging practices in this community. Management for threatened fauna can be more complex, as demonstrated by approaches to maintain foraging and breeding habitat of the swift parrot (*Lathamus discolor*), a migratory species strongly associated with *E. globulus* forest. Post-logging auditing (1995–1998) revealed unacceptable disturbance in clumps of mature trees retained by prescriptions, and supported retention of larger areas of prime foraging habitat. Improvements to training, planning tools and on-ground practices, and ongoing refinement of policies, have given better protection to grassy *E. globulus* forest and its species.

**A research-based method for identifying important areas for biodiversity at the forest stand level.** Gjerde, I., Sætersdal, M., Blom, H.H. (*Norwegian Forest Research Institute, Norway*; [ivar.gjerde@skogforsk.no](mailto:ivar.gjerde@skogforsk.no)).

Protection of habitats is necessary to preserve species that are negatively affected by forestry. Usually, only a minor part of the forests can be protected, and only a minor part of the species can be surveyed. There are two basic and partly opposing strategies for maximizing species diversity in selected sites under such conditions: The hotspot strategy and the complementary strategy. If hotspot patterns are weak, complementary selection becomes more important. If only hotspots are selected, many species are not included. For localization of hotspots, indicators of areas with the highest number of species are needed. For identification of complementary sites, indicators of areas with different species composition are needed. In both cases indicators should be accurate, reliable, and easy to register in the field. These requirements are very often not met, and we stress the importance of basic research preceding management actions. We report results from a research program on fine-scale spatial distribution of species and indicators, and describe how the hotspot and complementary approaches have been implemented in a method currently used for identifying important areas for biodiversity at the forest-stand level in Norway.

**How well can current planning measures maintain ecological integrity in the Tasmanian production forest landscape?** Grove, S.J. (*Forestry Tasmania, Australia*; [simon.grove@forestrytas.com.au](mailto:simon.grove@forestrytas.com.au)).

Production forests cover a large proportion of Tasmania's land surface, and are the dominant land use in many parts of the State. The Forest Practices Code was introduced in the 1980s and has been updated regularly since then. Its implementation



has resulted in increasing emphasis by forestry on the needs of forest biodiversity conservation at a range of spatial scales, both in areas dominated by native forests and in areas dominated by plantations. Code provisions include the requirement for retaining mature forest in riparian strips, wildlife habitat strips, and clumps. Forestry Tasmania, as manager of the State forests, has further developed a range of protocols to reduce the ecological impact of harvesting, roading, and plantation establishment at the landscape scale. Coming almost two decades after the first of these provisions were implemented, this paper reports on recent research findings that enable a consideration of the extent to which they have so far been successful in maintaining ecological integrity in areas where production forestry dominates the landscape. It pays special attention to the value of riparian and wildlife habitat strips, and also reports on the results of a landscape-scale multi-species modeling exercise centered on the bio-diverse production forests of northeast Tasmania.

**Alternatives to clearfell silviculture in tall old-growth forests in Tasmania.** Hickey, J.E. (*Forestry Tasmania, Australia; john.hickey@forestrytas.com.au*).

The clearfell, burn, and sow (CBS) technique is applied to wet eucalypt forests wood production in Tasmania. This system is safest for forest workers, gives the highest return, maximizes eucalypt growth, and reduces wildfire risk. However, the CBS system attracts public concern: high visual impact, smoke nuisance, reduction in rainforest species, rotting logs, hollow-dependent birds and mammals, and reduced special species timbers and leatherwood nectar. In response to social concerns, alternatives are being explored that meet safety and regeneration standards, and the legislated annual sawlog supply. One alternative is a variable retention (VR) harvest system, where the majority of each coupe is within one tree height of the base of an old-growth tree, or trees, for at least one rotation of about 90 years. Another option is to use single tree/small group selection (SGS) harvest systems where less than 20% of the stand is harvested at each of five cutting cycles over 100 years. These systems have been implemented at the Warra silviculture trial in southern Tasmania and their economic, environmental and social performance will be reported in 2007 when the coupes are at least three years old. Preliminary findings are positive, but issues remain: reducing residues, creating seedbeds, and maintaining the sawlog supply means extensive activity that will impact biodiversity.

**Old-growth forest protection in production areas in Western Australia.** Hughson, T., Baldwin, P. (*Conservation Commission of Western Australia, Australia; tomhu@conservation.wa.gov.au*).

Society's need to protect old growth forests has become a significant political issue both in Australia and abroad in recent years. In Western Australia many commentators view the 2001 pre-election commitment to end logging in old-growth forests by the Labor Party as instrumental in its victory. However, Labour's victory did not end public concern over old-growth issues as there was ongoing concern with smaller fragmented old-growth patches left within production forest areas. Most concern arose when community groups became aware that areas previously classified as old-growth were being declassified during detailed planning phases and subsequently were available for logging. In order to resolve the ongoing controversy, the State government asked the Conservation Commission of Western Australia to review areas reclassified by the managing agency. The paper provides background to this issue and details the process of reviewing the reclassified areas at appropriate scales. A systematic approach to the on-ground truthing of old-growth classification is described, which although relatively resource intensive, reflects community perception of the value of old-growth forest and a growing need for transparency in decision making in relation to forest management issues particularly within production areas.

**Towards an integrated landscape model of wildlife habitat availability and wood supply in south-eastern New South Wales, Australia.** Kavanagh, R., Stanton, M., Haywood, A., Turland, J., Duc Tuan, P. (*NSW Department of Primary Industries, Australia; rodk@sf.nsw.gov.au*).

Forest managers require decision-support tools to understand the consequences of alternative management scenarios in terms of their effects on wildlife habitat availability and wood supply projections into the future. In the past, wildlife management for sensitive species in Australian forests has focused on the provision of core habitat or limiting resources without fully recognizing the contributions to wildlife habitat provided by the mosaic of 'disturbed' areas within the production forest landscape. Recent studies of the spatial and temporal responses to intensive logging of large forest owls and their arboreal marsupial prey show that both logged and unlogged forests contribute significantly to the habitat requirements, and hence the population status, of these conservation-priority species in production forest environments. Independently, significant efforts have been made to apply spatially-explicit scheduling of wood supply (yield) in the forests of south-eastern New South Wales (NSW). The tasks of developing and then successfully integrating these spatial and temporal models of wildlife habitat availability and wood supply are daunting and will require considerable investment. Important issues needing to be addressed include the identification of goals and constraints so that conservation and production objectives can be optimized. This paper outlines some of the key steps required and progress to date in developing a decision-support tool for forest management in south-eastern NSW.

**Echoes of clutter: the response of bats to attributes of Australian re-growth forest.** Law, B., Chidel, M. (*Department of Primary Industries, New South Wales, Australia; bradl@sf.nsw.gov.au*).

Extensive areas of re-growth forest constitute much of the timber production matrix in Australia. These areas provide habitat for many species that will never be represented in a Reserve network. Ecologically sustainable management of re-growth forest requires knowledge about species responses to the changing dynamics characterized by regenerating forests. Bats are a particularly diverse group of mammals that warrant attention because many are hollow-dependent and they are likely to play an important functional role as consumers of insect pests. Fundamental to understanding the response of bats to the structure of re-growth forests is the fact that they use a different sensory system (echolocation), which means they perceive their environment differently to other fauna. Clutter in the form of obstacles is prevalent in re-growth and this impedes echolocation and flight, depending on the particular adaptations of different species. We outline three studies that demonstrate a negative response of a suite of bat species to dense clutter in three distinct Australian re-growth forests. Small tracks that typically penetrate re-growth are identified as a key feature of the landscape that are exploited by bats and that potentially ameliorate the negative effects of clutter. Clutter needs to be incorporated into the concept of what constitutes a structurally diverse forest.

**Managing forest mosaics: values of eucalypt plantations, re-growth stands, and retained mature forest as habitat for fauna.** Loyn, R.H., McNabb, E.G., MacHunter, J., Rossi, S., Wright, W. (*Arthur Rylah Institute for Environmental Research, Australia; richard.loyn@dse.vic.gov.au*).

Several studies have been conducted in mosaic landscapes in Victoria to determine the relative values of different habitats and their spatial arrangements for fauna. Special attention has been paid to birds, but bats and other mammals have also been considered. This paper summarizes some key conclusions that may help improve conservation management of mosaic landscapes. Eucalypt plantations can provide valuable habitat for some species, and can help buffer remnant vegetation against adverse effects of stock and invasive birds—notably native Noisy Miners, *Manorina melanocephala*. Plantations on farmland allow some bird species to extend their foraging into parts of the cleared landscape that had formerly been denied to them. Eucalypt plantations and re-growth from logging support lower densities of forest birds and mammals than mature forest, and higher densities than cleared farmland. Various habitat features contribute to the value of plantations and re-growth as habitat for fauna. In some cases, habitat values can be enhanced through small changes to the design or management of plantations, and small changes in management practices within native forest. These enhancements can apply within the habitats themselves, and to a lesser extent in adjacent cleared or forested land.

**Natural disturbance regimes, and landscape and stand structural targets in cool temperate rainforests of coastal British Columbia.** Mitchell, S.J., Pearson, A., Kimmins, J.P., Stull, R. (*University of British Columbia, Canada; smitchel@interchg.ubc.ca*).

The government of British Columbia, Canada, has specified landscape-level targets for seral stage distribution and patch size, and approximately 60% of current harvesting is under the retention system. These targets typically reflect experience in fire-dominated ecosystems. In B.C.'s cool temperate rain forests, wind, fluvial, and geomorphic events are the principle natural disturbance agents. We have been investigating landscape and stand-level disturbance patterns and structure in coastal forests using historical aerial photographs, GIS databases, and field sampling. In our work to date we have found that 1–4% of the forested area in hypermaritime ecosystems on southwest Vancouver Island is occupied by windthrow-origin single-cohort stands. Patches average 8.5 ha and range from 0.3–59 ha. Our logistic regression models indicate that these stands are more likely in locations with high topographic exposure, good soil drainage, and high soil fertility. We are working on predictive models for occurrence of cohort and gap-phase stands, expanding our work to the Queen Charlotte Islands, and using meso-scale modeling to improve predictions of extreme wind patterns in complex coastal terrain. Our research: improves tools for investigating disturbance processes, improves our understanding of natural landscape and stand dynamics, and enables us to make recommendations on target conditions and silvicultural systems.

**Managing landscape mosaics at the forest-agriculture interface for improved rural livelihoods: A case of study in the Congo Basin.** Ngobo, M., Weise, S., Robiglio, V., Bakam, I., Nolte, C., Hauser, S. (*IITA, Yaoundé, Cameroon; m.ngobo@cgiar.org; s.weise@cgiar.org; v.robiglio@cgiar.org; i.bakam@cgiar.org; c.nolte@cgiar.org; s.hauser@cgiar.org*), Legg, C. (*IITA, Nigeria; c.legg@cgiar.org*), Tonye, J. (*IRAD, Cameroon; j.tonye@camnet.cm*), Diaw, C., Mala, W.A. (*CIFOR, Yaoundé, Cameroon; c.diaw@cgiar.org; w.mala@cgiar.org*).

Most of the deforestation in the Congo basin is attributed to smallhold agriculturalists using extensive slash-and-burn techniques. Improved rural livelihoods are the key to poverty reduction and sustainability of landscape mosaics at the forest-agriculture interface in the region. A collaborative partnership uniting research institutes, non-governmental organizations, and universities members of the Alternatives to Slash-and-Burn (ASB) national Consortium in Cameroon has worked with local communities to identify and develop options that can improve rural livelihoods while preserving forests. The objectives of the project have been to: 1) characterize and evaluate existing land use systems, 2) modify or develop

alternative technologies to the practice of slash-and-burn cropping system, and 3) identify, assess and design policy tools and mechanisms through which they could be implemented. The main project outputs include: baseline datasets, tested resource management options for increased productivity of cropping systems, development of integrative models and participatory community action methodologies, and improved mechanisms for policy formulation and dialogue at various levels. It is concluded that there is no single 'best bet' solution to rural poverty alleviation at the forest-agriculture interface in the Congo Basin. Only by integrating various components can the question 'are sustainable landscape mosaics feasible at the forest-agriculture interface in the region?' be addressed objectively.

**Managing forest mosaics in the south-west of Western Australia.** Stoneman, G.L., Rayner, M.E. (*Department of Conservation and Land Management, Western Australia, Australia; geoffs@calm.wa.gov.au*).

This paper examines mosaics in terms of spatial and temporal patterns, and intensity of disturbance. Mosaic will also be considered in terms of scales of management, from the whole forest, to the landscape, and to the stand scale. The concepts of connectivity, landscape heterogeneity, and stand structural complexity are integrated in this discussion. The paper presents a broad overview of the current management system and how it addresses mosaics within this management matrix. New and novel features of the management system will be emphasized. In particular, the criteria for selection, and guidelines for implementation, of fauna habitat zones with State forest and timber reserves will be examined. Additionally, some of the tools used to facilitate the integration of forest management across the landscape to provide for the range of values desired by the community are examined. Strengths and weaknesses of the management system are analyzed.

## **The expanding international role of agroforestry in the establishment and management of planted forests: Impediments and success stories**

Organizer: Heather Crompton *Department of Agriculture, Fisheries and Forestry, Australia; Heather.Crompton@affa.gov.au*

### **New model of agroforestry system tested and preferred by farmers in the terrace-farming area of Nepal.**

Barakoti, T.P. (*Nepal Agricultural Research Council, Nepal; tpbarakoti@yahoo.com*).

Experiments to produce fodder year-round and utilize unproductive terrace risers of cropping land were conducted in the hills of Nepal during 2000–2004. Fodder trees were planted on the edges, and forage species were grown on the terrace risers to meet the need for fodder and fuel-wood. The long-term objective of the experiment is to quantify shade effects of fodder trees on forage species and their combined effect on field crops. Almost all tested fodder trees and forage species had high survival and good growth in the terrace risers. Of the ten species tested, excellent growth was observed in *Ficus semicordata*, *Leucaena leucocephala*, *Grewia oppositifolia*, *Ficus auriculata*, and *Albizia julibrissin*. Data on plant height, number of tillers, size of leaf, plant stand, survival, dry matter, fresh and dry yield of fodder recorded at harvesting varied significantly. Napier, Dhus, *Setaria* and *Desmodium* had vigorous growth, yielded higher, and was harvested 3–4 times/yr. Dry matter and fodder yield were higher in the FYM applied (20 t/ha) treatments. The highest growth was in *Ficus semicordata* (4–5 m within 3 yrs) followed by *Leucaena leucocephala* and *Grewia oppositifolia*, whereas lowest rate was in *Bauhinia purpurea*, *Litsea polyantha* and *Artocarpus lakoocha*. Farmers were impressed with the new model and started to grow/replicate the fodder species in their land.

**Silvicultural performance of “são-do-campo” trees (*Mimosa caesalpiniaefolia* Benth., Mimosaceae) in agroforestry systems.** Campoe, O.C., Engel, V.L. (*occampoe@fca.unesp.br; veralex@fca.unesp.br*), Parrotta, J.A. (*USDA Forest Service, USA; jparrotta@fs.fed.us*).

For both ecological and socioeconomic reasons, agroforestry systems are being considered an alternative for restoring Atlantic Forest patches in southeastern Brazil. The project reported in this paper evaluated the silvicultural performance of 'são-do-campo' trees (*Mimosa caesalpiniaefolia* Benth., Mimosaceae) in an eight-year-old modified 'Taungya' system. The research was undertaken on two different sites. We sampled and measured 15 individuals on each site for total biomass production, and six individuals for fine- and woody-root biomass analysis. The average individual dry biomass did not vary significantly between sites (155 kg in red clay soil and 153 kg in red-yellow soil); root total dry biomass was higher (245 kg/ind;) than shoot biomass in both sites. Trunks represented 62 % (108 t/ha) of the aboveground biomass, while branches represented 29% (37 t/ha) and leaves 8.5% (8.5 t/ha). Annual litterfall production was 4.8 and 5.4 t/ha in red clay and red-yellow soils, respectively. The species was considered a good multipurpose tree for forest restoration, comparable to other better known ones, because its fast growth, high production of aboveground, root and litter biomass, and good adaptability to most sites.

**Potential of agroforestry as a land-use option in Punjab, India.** Dogra, A.S., Upadhyay, A. (*Punjab State Forest Department, India; asdogra@sify.com; aku@menf.delhi.nic.in*), Dhanda, R.S. (*Punjab Agricultural University, India; dhandars2002@yahoo.co.in*).

Punjab, with a forest and tree cover of only 8.1%, falls far short of the stipulated national goal of 33%. Diversification from intense agriculture, that is depleting soil of its nutrients and lowering ground-water table, is needed. This requires technological and policy interventions in critical areas to offer farmers practical, viable, and economically attractive alternate land use options. Agroforestry offers a better livelihood strategy to farmers due to relatively low input costs, flexible labour requirements, higher profitability, diversity of income sources, and more negotiating power at the marketing stage than with annual crops. Interest in trees is higher with increasing labour opportunity cost. Tree-crop combinations have been found to give better economic returns than trees or annual crops alone. This paper addresses the challenges that lie in optimizing economic returns by determining suitable: site-specific tree-crop models, management strategies and harvest cycles, fast growing and high yielding planting stocks, developing efficient marketing mechanism, and optimum wood balance through integration of plantations and wood-based industries. The issue of short-rotation forestry as a clean development mechanism for optimizing carbon credits will also be discussed.

**Sustainability through agroforestry: farmer's innovations.** Gangadharappa, N.R., Ibrahim, S., Sajeev, M.V., Shivamurthy, M., Srinivasa Reddy, M.V., Nagesha, G., Ranganath, A.D. (*University of Agricultural Sciences, India; nrganga@yahoo.co.in*).

Social, marketing, economic, or institutional issues still hinder transfer of agro-forestry techniques to areas that appear biologically suitable. Hence this research paper examines the issue relating to cost-benefit analysis of mapped agroforestry models, marketing channels used, and problems faced and solutions adopted. PRA techniques such as transect walk, multiple time line analysis, matrix ranking, and problem and solution tree, were used and primary data was obtained through personal interview methods by using a pre-tested schedule from 558 farmers. The study revealed that all the seven identified agroforestry models are profitable in various proportions, but, agriculture-pasture, agriculture-silviculture, and agriculture-silviculture-pasture models are more profitable. The factors that contributed to the phenomenon were land holding, social participation, mass media participation, motivation, and farm power status. The majority of the farmers marketed timber and firewood through middlemen or in the local market. Though non-availability of tree saplings, uncontrolled grazing, and lack of awareness were the very significant perceived problems, farmers themselves have solved these problems by establishing nurseries, forming associations, and conducting education activities by involving resource persons. The study also revealed that farmers preferred teak, tamarind, jack, and neem tree species.

**Policy and legal constraints for agroforestry development in the Indian Himalayas.** Gupta, H.K. (*Forest Survey of India, India; ghemant\_sml@hotmail.com*).

Agroforestry has traditionally been an integral part of the complex, highly interactive, and substantive farming system in the Indian Himalayas. Farmers on their private lands under different agro-systems maintain different tree species. Agroforestry systems based on need, economy, and environment are practiced in Himalayas. The programs for forestry development have been attempted through three-dimensional forest farming, social forestry, joint forest management, integrated watershed development, and now under the sustainable livelihoods framework. Existing policy and legal provisions on the control, use, and management of forests and government lands, are scattered over several acts, rules, settlement reports, notifications, and government orders. This paper discusses the acts relating to the management, harvesting, transport, and marketing of trees grown on private lands and explains that the existing forestry legal framework is a major deterrent to agroforestry development. The legal provisions are found to contain conflicting and contradictory provisions. There needs to be a careful and systematic analysis of policy objectives to develop and redesign regulatory instruments to support development of agroforestry. This study established that rules and regulations are required to encourage people to promote agroforestry species and emphasizes that there is a need for a coherent national and state-wide agroforestry policy.

**The influence of nurse-trees on initial seedling establishment and tending operations in agroforestry experimental sites in Sabah, Malaysia.** Kamo, K. (*Forestry and Forest Products Research Institute, Japan; kamo@ffpri.affrc.go.jp*), Jamalung, L. (*Forest Research Centre Sabah, Malaysia*).

We studied the initial survival and growth of 25 plant species near Sandakan, eastern Sabah, Malaysia, in 2002 and 2003 to clarify suitable shading conditions and thinning method on initial establishment of mixed forests. Species included: Dipterocarpaceae, indigenous fast-growing trees, fruits trees, medicinal plants, and cash crops. Study sites were: 1) an *Acacia mangium* stand (1.6 ha) and secondary forest (2.9 ha) with thinning plots in two directions—east-west and north-south, 2) a plantation of six exotic species, and 3) in a cleared (2 ha) forest site. Weeding requirements were investigated. Results are: the majority of plant species had higher survival rates in thinned *A. mangium*, secondary forest, and under canopies of exotic tree species, than in cleared sites. Most Dipterocarpaceae species showed higher

mortality rates in cleared plots than in thinned plots. Except for shade-intolerant tree species, most plant species showed significantly higher growth rates in thinned than cleared plots, and significantly higher growth rates in north-south line thinning plots. Weeding time was approximately 40% shorter and weeding conditions were less harsh in thinned than cleared sites. Results suggest moderate shade (RLI: 10–20%) cast by forest canopies facilitate seedling establishment and reduce weeding, in comparison with conventional planting in cleared forest sites.

**Inventory of Guadua bamboo: a complex and special case of forest mosaic in the coffee region of Colombia.** Morales, D., Kleinn, C. (*Georg-August-Universität Göttingen, Germany; dmorale@gwdg.de*).

For a sustainable management of any type of resource it is imperative to know about the growing stock, its location, and changes. In this context, mapping and forest inventory play an important role. In forestry there are many studies and references on this topic, but less so about the assessment of landscape mosaics with many and irregular patches of forest and bamboo. In 2002, an inventory of Guadua bamboo (*Guadua angustifolia*) stands was carried out in the central area of Colombia. Guadua ‘forests’ are found along rivers and creeks, and also in patches away from water bodies. Their spatial distribution and fragmentation makes Guadua an interesting object in the context of the assessment of forest landscape mosaics. Area estimation was made by sampling aerial photographs and the growing stock was inventoried by a two stage field sample. In this paper, the approach, experiences, and results of this inventory of stands of *G. angustifolia* are presented and discussed.

**The development status of agroforestry in Korea.** Shon, C.H., Seok, H.D. (*Korea Rural Economic Institute, Republic of Korea; shon9@krei.re.kr*).

This paper reports on a study that analyzed the developmental stages of agroforestry in Korea. Three stages are classified by the types of developmental processes and time sequences. The first stage, from the early 1960s to the late 1970s, aimed at acquiring arable lands in mountainous areas in order to provide crops. This type was discontinued due to considerable degradation of mountainous areas, mainly by erosion. The second stage provided lands for another type of agricultural usage. Due to the enhance life style during the 1970s and 1980s, there was an increased demand for meat, but there was a considerable storage of land for livestock farming. This stage was also unsuccessful due to inappropriate conditions for livestock grazing in mountainous areas. The third stage is multiple use of mountainous areas by applying systematic utilization—a combination of forestry, agriculture, and livestock farming—which is presently the general approach in mountainous areas of Korea.

**Phylogenetic preferences of farmers’ communities during a crisis context in the cocoa agroforest area of the humid forest zone of southern Cameroon.** Sonwa, D.J., Weise, S. (*International Institute of Tropical Agriculture, Cameroon; dsonwa@cgiar.org; desonwa@yahoo.fr*), Adesina, A.A. (*The Rockefeller Foundation, USA*), Tchata, M. (*Institut de Recherche Agronomique pour le Développement (IRAD), Cameroon*), Nkongmeneck, A.B. (*University of Yaounde I, Cameroon*), Ndoye, O. (*Center for International Forestry Research (CIFOR) IITA-HFC, Cameroon*), Endamana, D. (*International Institute of Tropical Agriculture, Cameroon*).

A long tradition of cocoa growing has allowed farmers to rely mainly on this commodity as their main income sources despite the potential of: 1) plants associated with cocoa inside agroforest, and 2) crops growing outside cocoa agroforestry. With the drop of cocoa prices and liberalization of economic and agricultural sectors, farmers’ strategies to maintain and increase their incomes shifted toward the latest commodities. Intensifying and diversifying non-cocoa phylogenetic resources inside agroforestry can help in minimizing ecological/economical risk and increase ecosystem services. Based on the participatory rural appraisal with 45 rural communities in southern Cameroon, the study evaluated: 1) the dynamics of farmers’ practices before/during the cocoa crisis and devaluation of the local currency, 2) the contribution mix of incomes between cocoa and other phylogenetic resources, 3) the current constraints on cocoa production, and 4) phylogenetic resource preferences of farmers in view of diversifying and increase their income in and outside cocoa agroforests. With the cocoa crisis and agricultural reforms (implemented under the advices of bilateral and multilaterals partners of Cameroon), according to farmers, income contribution from plants (inside cocoa agroforest) and crops (outside cocoa agroforest) has increased. Putting efforts to diversify inside cocoa agroforests will help to minimize risks associated with livelihood and sustainability in forested areas.

**Potentials of agroforestry for improving local socioeconomy and environment with particular reference to damar (*Shorea javanica*) agroforest.** Sukandi, T. (*Research and Development Centre for Forest and Nature Conservation, Indonesia; taulana@forda.org*).

Damar (*Shorea javanica*) based agroforestry has been practiced for more than a century by most local people in Krui area, West Lampung, Indonesia. This paper reviews potentials of damar agroforest in terms of its socioeconomic and

environmental benefits based on studies conducted by some researchers. Damar agroforest contributed 45–100% of the total income of local people, while financial analysis indicated that its benefit-cost ratio was 7.41 with the break even point in the fourth year. Damar agroforest is a multi-strata agroforest that is ecologically similar to the forest ecosystem. Soil conditions in some mature agroforests were not significantly different from mature secondary forests. Although it has a relatively low carbon stock (43.9 t C/ha/cycle), damar agroforest provides long-term for sequestering of carbon. Problems faced in the management of damar agroforest are identified and alternative solutions are discussed in this paper.

**Management of upland temperate agroforestry systems for improving productivity under rain-fed conditions in northwestern India.** Thakur, P.S., Dutt, V., Lal, C., Singh, S. (*University of Horticulture and Forestry, India; ps\_thakur@yaspuniversity.ac.in*).

Diversification and sustainability in production are the two main goals to be achieved through short- and long-term strategies. Management of agroforestry systems in general, and the tree component in particular, exert strong influence on the performance and production ability of associated components. Our studies over the last eight years on location-specific agroforestry models developed for upland terraces as well as silvi-pastoral models for sloping, degraded land in the northwestern Indian Himalayas indicate that suitable tree-crop combinations, followed by proper tree canopy management are the deciding factors for making upland temperate agroforestry a viable and profitable land use system. Proper tree crown management has been found to regulate belowground and aboveground biological interactions for critical resources between the components of the systems, and also maintains vigour and biomass production ability for prolonged duration. Various canopy management practices—maintenance of tree components as hedgerows at different spacing, retention of canopies by the cutting of stems to different heights, and removal of crown to 25, 50, and 75%—have been found to strongly influence performance, production abilities, and physiological status of associated agricultural crops to a large extent. The findings suggest an additional advantage of suitable management approaches in improving production and monetary gains to the hill farming community.

**Repeated measurements in agroforestry research.** Tumwebaze, S.B. (*Makerere University, Uganda; tumwebaze@forest.mak.ac.ug; tsbalaba@sy.edu*), Allan, E. (*University of Reading, UK; e.f.allan@reading.ac.uk*).

The paper investigates repeated measurement methods for the analysis of agroforestry data and explores ways to determine the utility of undertaking more complex procedures. Data used are from an experiment conducted from 1993–1997 at the International Centre for Research in Agroforestry Station in Machakos, Kenya. The objective was to obtain information that could be used in the selection of multipurpose trees and for the development of agroforestry technologies that minimize competition and improve crop yield. Different approaches (exploratory analysis, ANOVA, conventional split-plot, random coefficient regression, and fixed-effects models) were used in the analysis, taking into consideration repeated measures. Results revealed that crop yields increased in a non-linear manner with distance from trees. This trend differed for treatments and blocks. ANOVA was used to test for whole-plot differences. Mixed-model methods were used to take into account the covariance structure and non-linear behaviour of the data. Comparisons between the different analysis methods suggest that, although ANOVA gives similar results and conclusions for data without missing values, it has a higher standard error of difference between treatments compared to the mixed-model procedures. The number of replicates needs to be increased from 4–8 to obtain the same precision when using summary statistics. Overall, the mixed-model methods, though complex, are worth doing if higher precision of treatment comparisons is required.

**The uses of *Borassus flabellifer*, a dominant woody species of the agroforestry parklands to the Southwest of Burkina Faso.** Yameogo, J., Bayala, J. (*CNRST/INERA/DPF, Burkina Faso, and University of Ouagadougou, Burkina Faso; finayame@yahoo.fr*), Ouedraogo, S.J., Belem, O.M. (*CNRST/INERA/DPF, Burkina Faso*).

*Borassus flabellifer* (L.) (rônier) marks the southwesterly rustic landscape of Burkina Faso. It has been integrated into the life of the local people. This poster is about its uses, and its socioeconomic and cultural repercussions in this region. Investigations have been made in three localities and in the markets of Banfora. The interviewed people were the outfitters of derivative objects of rônier—dealers, extractors of sap and rôniers owners. The poster presents the population's knowledge concerning rônier uses. The roots, trunk, leaves, and flowers are all implied in uses, grouped into six categories: 1) fruits, mesocarp, and walnuts are food, 2) buds ashes are used as potash, 3) the sap is extracted for consumption and sale, 4) leafstalks are used for domestic uses objects such as sieves, five kinds of baskets, braids, sifter, and objects of decorations, and 5) construction of houses use trunks for rafters of the roofs, frameworks of doors and windows, posts for fences and parks for livestock, and 6) as a medicine, the young leaves, resin, flowers, and the boiled mesocarp are used to treat male impotence, dental pains, ear aches, dermatitis, tooth decays, and the intestinal parasites. In addition, seats, bridges, hives, and electric posts are made of trunks.

## Research demonstration: Long-term multi-purpose experiments in the forest sector

Organizer: Charley Peterson *USDA Forest Service, USA; cepeterson@fs.fed.us*

**Biomass and nutrient concentration in *Nothofagus betuloides* second-growth forest stands.** Caldentey, J., Fuentes, J.P. (*Universidad de Chile, Chile; jcaldent@uchile.cl*).

Above ground biomass and nutrient concentrations were estimated in two *Nothofagus betuloides* second-growth forest stands located in Magallanes, Chile (53° 45' ; 71° 9' W). Allometric equations, generated from the destructive sampling of 50 trees, were used for biomass determination. Nutrient contents at the stand level were estimated from biomass values and average nutrient concentrations. At the younger stand (65 years old; 4,100 trees/ha; 15.2 BDH; mean tree height of 13.2 m) the total biomass was 216.6 t/ha, which was distributed as: 168.7 t/ha stem-wood, 22.2 t/ha bark, 19.8 t/ha branches, 5.9 t/ha leaves. Total concentrations of N, P, K, Ca, Mg, Zn, Mn, Fe, Cu, and B, were 545.8, 37.8, 65.9, 685.0, 73.3, 4.8, 33.7, 15.3, 0.47 and 1.3 kg/ha, respectively. At the older stand (75 years old; 1,880 trees/ha; 21.6 BDH; mean tree height of 18.2 m) the total biomass was 301.3 t/ha, and was distributed as: 229 t/ha stem-wood, 27.3 t/ha bark, 38.6 t/ha branches, and 6.4 t/ha leaves. Total concentrations of N, P, K, Ca, Mg, Zn, Mn, Fe, Cu, and B were 769.0, 50.3, 86.3, 892.6, 98.9, 6.4, 44.9, 21.2, 0.6, and 1.8 kg/ha, respectively.

**Microclimatic variations in a *Nothofagus pumilio* forest caused by shelterwood systems: Results of seven years of observations.** Caldentey, J., Ibarra, M., Promis, A. (*Universidad de Chile, Chile; jcaldent@uchile.cl*).

Based on seven years of meteorological data (1997–2003), the microclimate effects of a shelterwood system in Lenga (*Nothofagus pumilio*) forest stands located in the region of Magallanes, Chile were studied. Two weather stations were installed under managed and non-managed Lenga stands. The managed stand had 50% basal area reduction as a result of the application of the shelterwood silviculture system in 1995. Global solar radiation, air temperature, soil temperature at 15 and 30 cm depth, relative humidity, and wind speed were measured hourly. The parameters, degree-days, chilling hours, and evapotranspiration were estimated from the previous parameters. Significant statistical differences ( $P < 0.05$ ) in all parameters were found. Global radiation and average wind speed were respectively, tree and two times greater in the managed forest stand than in the non-managed stand. During the study period, with the exception of extreme wind speed values, all parameters showed no significant year-to-year variations. Cumulative degree-days were greater under the managed forest stand than under the non-managed stand. Cumulative chilling hours was greater under the non-managed stand than under the managed stand. Higher global radiation, air temperature and wind speed, and lower relative humidity in the managed forest stand caused greater evapotranspiration than under the non-managed forest stand.

**Effects of shelterwood system on photosynthetically active radiation (PAR) and plan regeneration in *Nothofagus Pumilio* stands in Chile.** Caldentey, J., Ibarra, M., Promis, A., Hernández, P. (*Universidad de Chile, Chile; jcaldent@uchile.cl*).

The effects of a shelterwood system on photosynthetically active radiation (PAR) and plant regeneration were analyzed in two *Nothofagus pumilio* stands in Magallanes, Chile. A non-disturbed forest stand (ND) and a shelterwood-managed (SM) forest stand were selected. At each stand, 15 quantum sensors were distributed according to three levels of canopy coverage. Photosynthetically active radiation was measured during two growing seasons. Four plots (1 m<sup>2</sup> each) were established around each quantum sensor and stem height and basal diameter were measured at each plot in ten labeled plants of upper-regeneration layer. Plants were measured on February of 2001, 2002 and 2003. Photosynthetically active radiation was 2.4 and 2.9 times greater under the SM stands than under the ND stand. During the study period, PAR increased with less canopy coverage. A similar pattern was observed with increments in regeneration height and basal diameter. These results show a clear effect of shelterwood systems and canopy coverage on the amount of radiation received and plant regeneration growth.

**Results of fifty years of monitoring the growth and development of a 161 year old Norway spruce culture.**

Dubravac, T., Vrbek, B., Benko, M., Vuletić, D., Littvay, T. (*Forest Research Institute, Croatia; tomod@sumins.hr*).

The natural course of development of the structure and re-establishment of the stand was monitored during the period from 1956 to 2004 on a permanent experimental plot, established in 1956 in a culture of Norway spruce in the montane region of Croatia. The plot borders a natural forest of beech and fir (*Abieti-Fagetum croaticum*, Horv. 1938) on dolomite. At the time of establishment in 1956, and on the basis of an analysis of 16 Norway spruce trees, the stand was 113 years old. The plots were 100x100 m in size, with 10x100m subplots, on which all trees were numbered,

measured, and phenotypically described. During 1957, thinning was performed on 39 trees, and in 1962, another 27 trees (felling intensity 19%). In 1994 and again in 2004, the trees were remeasured according to the same principles as during the first measurement, the state of the young growth was recorded, and horizontal and vertical crown projections of all trees were expressed in digital form. The abundance of data and the permanent plot, which is particularly well preserved, provide the possibility of multidisciplinary monitoring in the natural course of development of these stands.

**Challenges in statistical inference for large-scale operational experiments.** Ganio, L.M. (*Oregon State University, USA; lisa.ganio@oregonstate.edu*).

Incorporating the results of research investigations into public forest policy and land management decisions has become more prevalent. And yet there is much discussion of the role of scientific research into public decision-making and how research can be incorporated effectively. Ideally the best available science would be used in these endeavors. However, scientific investigations take many forms and it is not always clear whether a study can be applied to a specific setting. Accordingly, the appropriate strength of a particular result requires an understanding of the differences and interactions among the design components for specific objectives. The study design, or structure of an investigation, classifies it into one of several broad groups that differ in their strength of generalizable or repeatable results. Operational-scale management experiments, designed to achieve multiple research objectives at multiple spatial and temporal scales, incorporate features of several types of study designs complicating the inferential process. For example, the strength of inference for a large-scale primary objective may differ from that for a finer-scaled objective. This work examines how the differences and interactions among study design components, research objectives and response variables affect the strength of inference in large-scale field research.

**From little things big things grow: The Warra Silvicultural Systems Trial in Tasmanian tall *Eucalyptus obliqua* forest.** Hickey, J.E. (*Forestry Tasmania, Australia; john.hickey@forestrytas.com.au*), Neyland, M.G. (*Forestry Tasmania, Australia*), Grove, S.J. (*Forestry Tasmania, Australia*).

Clearfell, burn and sow (CBS) is the prescribed silvicultural system for wet eucalypt forests in south-east Australia but raises concerns due to aesthetics and a reduction in late successional species and structures when rotations of 90 years are used. The 200 ha Warra Silvicultural Systems Trial was established from 1998–2004 in Tasmanian multi-aged tall *Eucalyptus obliqua* forest to compare CBS with five alternatives: CBS with understorey islands, stripfells, 10–15% dispersed retention, 30% aggregated retention and single tree/small group selection. Our design, of two replicates per treatment, was simple but well matched to our modest research funding, and the challenges of implementing adjacent treatments that prescribed nil, low- or high-intensity burning. Small group selection caused major safety concerns for forest workers. Preliminary results indicate highest stocking of eucalypt seedlings, and greatest profitability, under CBS. However, the dispersed and aggregated forms of variable retention were more acceptable to the public. Aggregates retained late successional understorey species and structures and also provided propagules for recolonisation. Management of logging residue to provide a seedbed for regeneration and to reduce future fire hazard remains a critical issue under variable retention. Despite its limitations, the trial has been instrumental in rethinking silvicultural approaches for wet eucalypt forests.

**Stand dynamics after variable-retention harvesting in mature Douglas-fir forests of western North America.** Maguire, D.A. (*Oregon State University, USA; doug.maguire@oregonstate.edu*), Mainwaring, D.B. (*Oregon State University, USA*); Halpern, C.B. (*University of Washington, USA*).

Variable retention harvests have been advocated for maintaining biological diversity on harvested sites, but the details of a successful silvicultural system based on variable retention harvests have yet to be specified. The Demonstration of Ecosystem Management Options (DEMO) study was established in mature Douglas-fir (*Pseudotsuga menziesii*) forests to test the effects of varying levels and patterns of residual trees on a range of forest taxa, ecosystem processes, and public perceptions at an operational scale. The following six treatments were assigned randomly to 13-ha treatment units at each of six blocks in western Oregon and Washington, USA: 100% retention, 75% aggregated retention, 40% dispersed retention, 40% aggregated retention, 15% dispersed retention, and 15% aggregated retention. Planted seedling mortality increased with decreasing levels of retention, and mortality was greater under aggregated retention. Advance regeneration and planted seedlings generally grew greater under lower levels of dispersed retention. In contrast to the rapid release of *Abies concolor* and *Abies amabilis* advance regeneration, *P. menziesii* exhibited some height growth reduction immediately after release in some variable-retention treatments. Basal area growth of retained overstory trees accelerated during the first 5-yr period after harvest, but dispersed treatments experienced considerable overstory mortality from uprooting or stem breakage.



**Forestry heritage: Research plots.** Podrazsky, V., Remes, J., Svoboda, M., (*Faculty of Forestry and Environment, Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz; kremes@fle.czu.cz; svoboda@fle.czu.cz*).

The long-term character of forestry represents a buffering factor that partially eliminates societal changes throughout the centuries. Shifts of economic- and management conditions have occurred much faster than the growth processes of forest stands. Economic and environmental demands of the public on forests often differ considerably, and forestry research is facing similar problems. Permanent research plots then represent a constant, whereby societal needs and demands can be changed, as necessary. The appropriate establishment and continuous preservation of the research plots is the main treasure of any forestry research institution. The poster documents the problems of long-term research plots of the Faculty of Forestry and Environment, which were closed for political reasons between 1964 and 1990. The location of old research plots in the forest, their re-establishment, re-construction and cost saving in commercial forest management are important objectives of our staff.

**Large-scale, long-term silvicultural experiments in the USA.** Seymour, R.S. (*University of Maine, USA; Seymour@umenfa.maine.edu*), Guldin, J., Marshall, D., Palik, B. (*USDA Forest Service, USA; jguldin@fs.fed.us; dmarshall@fs.fed.us; bpalik@fs.fed.us*).

This paper reviews experience and research findings from select large-scale, long-term silvicultural experiments in four regions of the United States: the Northeast, the Lake States, the mid-South, and the Pacific Northwest. As early as the 1930s, when there was nationwide interest in multi-aged silviculture, researchers recognized that silvicultural systems involving within-stand variation in age and size structure could not be tested effectively on small (< 1ha) plots, and began installation of compartment-scale (10–20 ha) trials in many experimental forests throughout the United States. Such large-scale trials have experienced a revival in the past decade, partly in response to renewed interest in managing for within-stand structural complexity, and partly to test various hypotheses about aspects of biodiversity that are large-area dependent (e.g., effect on avian communities). Large-scale experiments are difficult and expensive to install, properly replicate, monitor, and maintain over time. However, they have three benefits: 1) scientists learn to appreciate operational realities of forest managers, such as limitations of harvesting systems, 2) study sites provide ‘life-size’, realistic examples of innovative silvicultural systems, and 3) installations offer great field laboratories to study a wide range of questions including small-scale phenomena, such as salamander dispersal and seedling development.

## Sub-theme: Utilizing Genetic Resources to Further Sustainable Forestry

### Utilizing genetic resources to further sustainable forestry

Session organizer: Eric Teissier du Cros *INRA, France*; [eric.teissierducros@avignon.inra.fr](mailto:eric.teissierducros@avignon.inra.fr)

#### **Genetic conservation for trees and people: Old problems and new challenges from a European perspective.**

Geburek, T. (*Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW), Austria*; [thomas.geburek@bfw.gv.at](mailto:thomas.geburek@bfw.gv.at)).

Genetic diversity is the ultimate source of biological diversity at all levels: genes, species, and ecosystems. Genetic resources should be conserved for the future, both to secure the width of the gene pools and to allow the utilization of best origins of forest productive material. A loss of genetic diversity may have negative consequences for fitness and forest production and may prevent necessary evolutionary changes to environmental changes. Although genetic insights into several forest trees species have been significant in recent years, we still do not know 'how much' and 'where' genetic resources should be sampled and conserved. While different concepts (e.g., Evolutionary Significant Unit) have been used in other biological sectors, helpful tools to prioritize conservation activities in forest trees are mainly missing. Moreover, genetic management units based solely on scientific grounds will not work. Genetic conservation must merge science and politics into a sound technical management of resources. Europe harbours as a fine-grained mosaic of countries with differing significance of the forestry sector, forest history, way of thinking, ownership pattern, etc. This entails that common action plans are impeded. It is advocated that genetic conservation must be an integrated part of nature conservation and regular forest management. Action to be taken should be triggered by an appropriate monitoring system (adaptive management), which should be part of the national biodiversity monitoring systems.

#### **Historical imprints of postglacial invasion on genetic diversity in European oaks.** Kremer, A., Petit, R. (*INRA, France*; [antoine@pierroton.inra.fr](mailto:antoine@pierroton.inra.fr)).

A continental wide inventory of chloroplast DNA (cpDNA) polymorphism, fossil pollen deposits and trait variation was conducted in European oaks in order to infer historical imprints on the extant distribution of genetic diversity. A strong east-west pattern was apparent in cpDNA diversity. Two maternal lineages have only a western distribution whereas two others are restricted to eastern regions and the last two are distributed in the central part of Europe. Pollen sequences were used to reconstruct the location of refugia of the deciduous oak species, and the migration from these refugia into their current ranges. Three areas have been identified as refugia: the southern Iberian peninsula, the southern Italian peninsula and the southern Balkan peninsula. By approximately 6 ka BP, the deciduous oaks had reached their maximum extension in Europe. The distribution of haplotypes and the palynological information available were used to infer colonization routes out of the ice-age refugia. There was no association between chloroplast DNA variation and nuclear controlled traits (phenotypic traits and gene markers). These results suggest that local selection pressures acting on the installed populations and pollen flow erased progressively the initial differentiation that existed among the three refugial zones after the last glaciation.

#### ***Eucalyptus globulus*: A model species for eucalypt genetic research.** Potts, B., McKinnon, G., Steane, D., Jones, T., McGowen, M., Foster, S., Dutkowski, G., Vaillancourt, R. (*School of Plant Science and CRC for Sustainable Production Forestry, Australia*; [b.m.potts@utas.edu.au](mailto:b.m.potts@utas.edu.au)).

*Eucalyptus globulus* was discovered in 1792 by French explorers on the island of Tasmania, Australia. It was rapidly spread throughout the world in the 19<sup>th</sup> century and it was the species by which much of the world first knew the genus. *Eucalyptus globulus* is now amongst the most widely planted forest tree species in the world due to its fast growth and superior pulp qualities. Formal breeding commenced in 1965 in Portugal and in the late 1980s large base population trials from native stand seed collections were established in many countries. These trials have provided unprecedented insights into the quantitative genetic control of numerous traits and how these traits genetically vary across the native range of the species. In addition, with the rapidly expanding knowledge of DNA sequence variation, we are now at the threshold of a new understanding of the genetic architecture of this important eucalypt gene pool.

#### **Growth control of woody plants through genetic engineering.** Shinohara, K. (*Forestry and Forest Products Research Institute, Japan*; [kenjis@ffpri.affrc.go.jp](mailto:kenjis@ffpri.affrc.go.jp)).

Poplar, whose genome is the first to be sequenced among woody plants, is a favorable model for plant biologists. We generated a full-length enriched cDNA library of poplar (*Populus nigra* var. *italica*) and consequently collected over

10,000 non-redundant clones. Full-length cDNA resources are also extremely useful, not only for the genetic engineering of woody plants, but for comprehensive annotations of the poplar genome. We are interested in the growth control of woody plants by genetic engineering with the above cDNA resources. It is possible to genetically engineer trees that grow faster and produce more biomass than the wild type, simply by the down-regulation or the constitutive expression of genes for the biosynthesis of ethylene or gibberellin. We also isolated one cDNA clone encoding the poplar terminal flower 1 (PnTFL1) ortholog that acts as a repressor of flowering in vegetative tissues. An early flowering variety of transgenic poplar was generated by the down-regulation of the PnTFL1 gene. However, the growth of transgenic poplar was drastically inhibited. Therefore, the suppression of flowering will lead to the enhanced productivity.

## Threats to forest genetic resources and approaches for gene conservation

Organizer: Judy Loo *Natural Resources Canada, Canada; jloo@nrcan.gc.ca*

**A multiple-species participatory domestication program in the Peruvian Amazon: experiences and results to date.** Cornelius, J.P. (*World Agroforestry Centre, Peru; J.Cornelius@cgiar.org*), Sotelo-Montes, C. (*Université Laval, Canada; alcira-del-carmen.sotelo-montes.1@ulaval.ca*), Ugarte-Guerra, L.J. (*World Agroforestry Centre, Peru; JUgarte@cgiar.org*), Weber, J.C. (*formerly with World Agroforestry Centre*), Ricse, A. (*Institución Nacional de Investigación Agraria, Peru*).

In 1995, the World Agroforestry Centre and partners initiated a participatory agroforestry domestication program in the Aguaytía watershed and Alto Amazonas province (Peruvian Amazon). The program, aimed primarily at conservation-through-use of genetic diversity, began with formal, participatory prioritization, leading to selection of four species: bolaina blanca (*Guazuma crinita* Martius: Sterculiaceae), capirona (*Calycophyllum spruceanum* [Benth] Hooker f. Ex Schumann), guaba (*Inga edulis* C. Martius: Leguminosae [Mimosoideae]), and peach palm (*Bactris gasipaes* Kunth: Palmae). Open-pollinated seed of each was collected from farmer-selected mother trees, and used in the establishment of a series of seedling seed orchards / progeny tests, the individual blocks of which were dispersed on lands of individual collaborating farmers. Almost ten years later these trials are beginning to produce seed, the Aguaytían farmers have organized themselves into a wood and seed producers' cooperative, the technology developed is being adopted more widely, and genetic results are becoming available. We describe the program and its results in detail, with special emphasis on its innovative features. Subsequently, we evaluate success to date in relation both to initial objectives and the program's response to the evolving local forestry and development environment. We conclude with a series of recommendations based on lessons learnt.

**Do near-to-nature forests provide conservation of genetic resources against pests?** Glen, M., Tommerup, I., Mohammed, C. (*CSIRO Forestry and Forest Products, Australia; Morag.Glen@csiro.au; Inez.Tommerup@csiro.au; Caroline.Mohammed@csiro.au*).

Climate change, particularly temperature and rainfall distribution, will potentially have a direct impact on aggressiveness of severe pathogens and host capacity to respond and therefore current resistance may not be durable. Conservation of natural eucalypt populations is of high value to breeding programs in forest industries. Genetic variation in disease resistance/susceptibility and other desirable traits is greater in natural populations, even in provenances, compared to seed orchards. In addition to land-base protection, natural populations require protection from introduced diseases, against which little inherent resistance may exist. World-wide movement of germplasm increases the risk of spreading pathogens from plantations or related plants in natural vegetation in other continents or regions. For example, guava rust, a devastating disease of major plantation eucalypt species, could have dire economic consequences if introduced from Central-South America to other eucalypt-growing countries. But introduction to Australia would have greater impact, as it would put at risk much of the world's key genetic resources. Critically high industry standards need to be practiced to protect forest resources from new pest threats. New molecular detection methods for pine and eucalypt pathogens of concern can facilitate the safe germplasm movement while reducing the risk of an unwanted incursion in genetic resource-bases.

**Threatened forest genetic resources and strategies for conservation in Bangladesh.** Hossain, M.K. (*Chittagong University, Bangladesh; hossainmk2001@yahoo.com*).

The natural forests of Bangladesh, one of the richest and biologically diverse forest resources are facing severe threats recently. An estimated 5700 species of angiosperms and more than 1500 species of fauna are believed to have been present. But, the natural forests of the country are declining at an alarming rate. Forest genetic resources are disappearing due to clearing land for agriculture, shifting cultivation, construction of roads, habitation, logging for

timber, fuelwood collection, encroachment, and conversion of forest lands for other uses. The physical, demographic, and economic pressures are also altering the natural environment rapidly. In this way many plant and animal species, widely distributed in the past, have either become extinct or can only be found in low densities in localized areas. The issues of conservation and protection of biological diversity have had a low priority in the past. However, very recently, conservation efforts through in situ and ex situ programs are gaining priority in both public and private levels. Conservation and utilization of forest genetic resources are given emphasis with an aim of improving forest products as well as collection and supply of improved materials from the genetic resources. The paper describes some of the recent strategies for the conservation of genetic resources of the country.

**Conservation strategies for rare dipterocarps: autecology and genetics of *Shorea lumutensis* in Peninsular Malaysia.** Lee, S.-L., Ng, K.K.-S., Saw, L.-G., Lee, C.-T., Muhammad, N. (*Forest Research Institute Malaysia; Malaysia; leesl@frim.gov.my; kevin@frim.gov.my; sawlg@frim.gov.my; leechait@frim.gov.my; norwati@frim.gov.my*), Koskela, J., Luoma-aho, T. (*International Plant Genetic Resources Institute; j.koskela@cgiar.org; t.luoma-aho@cgiar.org*).

*Shorea lumutensis* is a rare and endemic dipterocarp in Peninsular Malaysia, restricted to five forest reserves. An 8-ha plot in Sungai Pinang FR recorded 416 individuals > 1 cm diameter at breast height; demographic structure analysis showed that tree sizes displayed an inverse J-shape distribution. The species exhibits clear microhabitat preferences: prominent in ridge and upper slope, and absent in lower slope and valley. Spatial distribution pattern analysis showed spatial aggregation in four diameter-classes—explained by limited seed dispersal and self-thinning. Periodic phenological surveillance showed that the duration of flowering bloom is approximately two weeks and the period from the budding stage to mature fruit fall was approximately 16 weeks. Seed germination and seedling performance is poor in nursery and in natural habitat. Genetic diversity study showed that *S. lumutensis* supports a large amount of genetic diversity, of which majority is partitioned within population. However, significant levels of spatial genetic structure were detected within population in four diameter-classes. Mating system study inferred the species to follow the mixed-mating model. Paternity analysis showed that the pollen flow is moderately extensive, ranging from 122.0–220.3 m. This study is the first attempt applying both ecological and genetic information in the formulation of conservation strategy for a rare dipterocarp.

**Habitat loss and threats to Afromontane rainforests of Ethiopia: Implications on genetic diversity of wild *Coffea arabica* L. populations.** Senbeta, F., Denich, M. (*University of Bonn, Germany; feyeras@yahoo.com*), Demissew, S. (*Addis Ababa University, Ethiopia*), Woldemariam, T. (*University of Bonn, Germany*).

A study was carried out to assess the magnitude of human pressures on Afromontane rainforests of Ethiopia, which harbour over 650 taxa (10 % of total flora of the country) including the wild populations of *Coffea arabica*, one of the world's most important plant species. Biodiversity in these rainforests is, however, under increasing threat from deforestation owing to subsistence-driven encroachment and/or development projects. The present study indicated that when habitats of these rainforests are converted into semi-managed, forest coffee systems or farmlands, 50% and 100% loss of vascular plant species were observed, respectively. The diversity and gene pools of wild coffee populations were also threatened by the introduction of improved coffee cultivators and habitat loss. Predictions of species- and habitat loss in the Afromontane rainforests of Ethiopia indicate that the potential impacts of forest conversion may be substantial and extend well beyond the forested regions. Conservation of these rainforests and their wild coffee populations can actually be a complementary strategy for economic growth or development. Therefore, conserving and/or maintaining the great genetic diversity and variability of wild coffee found in the Afromontane rainforests with associated ecosystems must become a strategy of the highest priority.

**Effects of forest management on forest genetic resources in tropical Asia.** Wickneswari, R. (*Universiti Kebangsaan Malaysia, Malaysia; wicki@pkrisc.cc.ukm.my*).

This study investigated the genetic effects of selective logging on seven commercial tree species in Peninsular Malaysia. Seven populations of *Shorea leprosula* and five populations of *Dryobalanops aromatica* showed high genetic diversities and low genetic differentiation, indicating the presence of large forested areas with good gene flow. Logging reduced basal area of different size classes from 43–100% in *Shorea curtisii*, *Dryobalanops aromatica*, and *Scaphium macropodium*, with trees >45 cm dbh being absent. In recently logged areas, recruitment of seedlings and presence of saplings was high for the non-dipterocarp species, *S. macropodium* but low for the dipterocarp species, *D. aromatica* and *S. curtisii*. Changes in population structure of some tree species can persist in regenerated forests for 50 years. High heterogeneity in genetic diversity parameters was observed for seedlings and adults of *S. curtisii* from logged sites compared to saplings in unlogged forests. Comparison of genetic structure of *S. curtisii* of different age cohorts before and after logging indicated loss of heterogeneity after logging. No significant change in genetic diversity was observed for adults of *S. macropodium* and saplings of *D. aromatica* and *S. curtisii* immediately after logging. Species' vulnerability to the threat of genetic erosion posed by logging was highly correlated with its early growth requirements and abundance.

## Forest biotechnology

Organizer: Yousry A. El-Kassaby *The University of British Columbia, Canada; y.el-kassaby@ubc.ca*

**Genetic components of four wood chemical traits assessed by NIRS in *Eucalyptus urophylla* x *E. grandis* full sib families.** Baillères, H., Vigneron, P., Giordanengo, T. (*CIRAD-Forêt, France; henri.bailleres@cirad.fr*), Ognouabi, N. (*UR2PI, Republic of Congo*), Gion, J.M., Chaix, G. (*CIRAD-Forêt, France*).

Wood chemistry properties are assessed by near infrared diffuse reflectance spectroscopy (NIRS), a rapid prediction measurements technique, on *Eucalyptus urophylla* x *Eucalyptus* hybrids in order to analyse a Congolese progeny test. Calibrations are set for lignin content, syringyl / guaiacyl monolignol ratio, extracts contents and total phenols content. A second aim of this work is to test NIRS efficiency to predict total phenols content, which is correlated with heartwood formation and natural durability. Different spectrum pre-processing and a wavelength selection by genetic algorithm are used to improve calibration quality. The best calibrations have sufficient predictability to assess wood chemistry traits. Moreover, total phenol content calibration is the most efficient. The four properties are predicted for the samples of the half progeny test. A genetic analysis gives the heritability values, the phenotypic, genetic and environmental correlations and the genetic gain from direct and indirect selection.

**Forest tree biotechnology: Applications.** El-Kassaby, Y.A., Wheeler, N. (*University of British Columbia, Canada, and Molecular Tree Breeding Services, USA; y.el-kassaby@ubc.ca*).

Forest biotechnology encompasses a broad spectrum of modern tools that aid and facilitate our understanding of tree biology and genetics. Common biotechnology categories include micropropagation, molecular markers, marker assisted selection, genomics and genetic engineering. Increasingly, biotechnologies are finding applications in operational forestry and are dominating forestry research and development in areas such as genetics and tree improvement.

**Regional and habitat differences in homoharringtonine content of Korean native Plumyew (*Cephalotaxus koreana*).** Jung, M.-S., Hyun, J.O. (*Seoul National University, Republic of Korea; jmsk0614@hotmail.com; junghyun@snu.ac.kr*), Lee, J.H., Lee, W.Y.

The relationship between natural population properties and homoharringtonine (HHT) content of Korean native plumyew (*Cephalotaxus koreana*) had been carried out over seven regions of South Korea. This study also analyzed homoharringtonine (HHT) contents of individual tree parts in three populations which exhibited high growth rate and good condition. The contents of homoharringtonine known as a good effect on Chronic Myeloid Leukemia were determined by high performance liquid chromatography (methanol: 0.1 M ammonium formate = 20:80, flow rate = 0.8 ml/min). The contents of homoharringtonine (HHT) varied with the site of location and the part of plant. The contents of homoharringtonine (HHT) was the highest in needles (46.6%, 668.7µg/g), and followed roots (24.8%, 356.3µg/g), barks (15.4%, 220.8µg/g) and stems (13.3%, 190.7µg/g) in a row. Homoharringtonine contents in needles in the South area (Mt. Obong, Mt. Duryun and Mt. Baekun) were higher than in the middle area ( Mt. Gyeryong, Mt. South Dukyu and Mt. Jiri). A correlation analysis between tree biomass and homoharringtonine content showed a positive relationship of these parameters. Variation between annual temperature in the amount of homoharringtonine was significant in different populations of Korean native plumyew leaves. The variation between soil moisture and the production of homoharringtonine was more significant.

**Somatic embryogenesis by developmental stages of seeds in Japanese red pine (*Pinus densiflora* Sieb. ET Zucc.).** Kim, Y.W., Jeong, J.H., Shin, H.N., Moon, H.K. (*Korea Forest Research Institute, Republic of Korea; dragonkim@foa.go.kr; biojeong@empal.com; hkmoon@foa.go.kr*).

Zygotic embryos of *Pinus densiflora* at different developmental stages were tested for their potential in the initiation of embryogenic tissue lines, using immature seeds (female megagametophyte including zygotic embryo) collected during the period of May 31 to July 23. From over 5700 seeds cultured, only 10 embryogenic tissue lines (0.17%) were obtained. However, only six (0.10%) survived on maintenance medium. Among several different media tested, only the P6 medium produced embryogenic tissue lines. The highest tissue initiation (0.36%) was observed with the seeds collected on July 5. Histological observation revealed that those seeds were at the transition from proembryo to precotyledonary stages with the majority showing the former stage. Out of 10 embryogenic tissue lines initiated, seven were produced from the seeds collected in July 5. The dates correspond to late cleavage polyembryony and early proembryo stages, respectively. However, the seeds collected during the period of May 31 to June 7 did not produce any embryogenic tissue lines. Those seeds did not have zygotic embryos yet but showed archegonia. No embryogenic tissue lines were obtained with the seeds collected on June 14 or July 13 either. The seeds collected on June 14 showed a zygotic embryo.

**A molecular technique to analyze genetic variability of Norway Spruce populations.** La Porta, N., Muccinelli, I., Passerotti, S., Valgimigli, M.C. (IASMA, Italy; nicola.laporta@iasma.it; ivan.muccinelli@libero.it; passer8@yahoo.com; chiara.valgimigli@iasma.it).

Monitoring biodiversity and the conservation of genetic resources is an important goal in forest practices. Variation of quantitative phenotypical traits is a prerequisite in establishing future heterogeneity, while distribution of genetic variability between and within populations is investigated to a lesser degree. In this context, it is important to acquire reliable, polymorphic and informative primer sets that are useful to evaluate genetic variability of the populations and to identify the geographical source of propagative material. The material for the study was obtained from commercial samples of Norway Spruce (*Picea abies* Karst.) collected by Seed Agencies and International Forest Services. The samples, covering the entire natural area of this species, came from each one of the three macro-areas which forms the entire European natural area: Alpine, Carpathic, Baltic. The samples were characterized with three VNTRs mitochondrial primer sets. Two of these primers, namely nad-1a/b and mh44, gave reliable and polymorphic patterns of amplification. These patterns could then be used to evaluate the degree of variability within and between the considered populations. Moreover, they have proved useful in order to characterize the populations on the basis of the macro-area.

**Clonal and population structure in a *Hydrangea macrophylla* population inferred from amplified fragment length polymorphism (AFLP) markers.** Lee, J.H., Hyun, J.O. (Seoul National University, Republic of Korea, rattus73@hotmail.com; junghyun@snu.ac.kr), Choi, H.S., Jung, M.-S. (Seoul National University, Republic of Korea; jmsk0614@hotmail.com).

Amplified fragment length polymorphism (AFLP) markers were used to reveal clonal and population structure of *Hydrangea macrophylla* populations. Using a dense population of hydrangea in a 30m x 30m study plot at Jeju island, Korea, we generated AFLP fingerprints for 380 samples, collected at 1m intervals, using three selective primer pairs. Our results demonstrate that the largest single clone occurs over a distance of about 16m and hydrangea propagates sexually and asexually in a small patch. We also undertook a large-scale assessment of genetic population structure and diversity in *Hydrangea macrophylla*, using the same primer pairs. A total of 15 populations were sampled from Korea (10 populations) and Japan (5 populations). Populations in the Korean peninsula show low levels of genetic variation in terms of average number of alleles and degree of heterozygosity. Differentiation was positively correlated with geographical distance.

**Preliminary tests for the *in vitro* induction of morphogenesis with *Acacia caven* (Mol.) Mol.** Marinucci, L., Abedini, W., Pariani, S., Villarreal, B., Bisio, C., Sharry, S. (National University of La Plata, Argentina; cprove@ceres.agro.unlp.edu.ar).

*Acacia caven* Mol. (Fabaceae) is a native tree of South America. Its propagation and conservation are of interest with because of its wood quality, its capacity for fixing nitrogen in the soil, and its ornamental and medicinal characteristics. The aim of this study was induction of *in vitro* morphogenesis of *Acacia caven*, starting with cotyledons. Immature cotyledons were cultivated in a medium of Murashige-Skoog (MS) at half strength and complemented with saccharose and agar. Four treatments were carried out with 25 repetitions each, in light and in darkness, adding casein (1g/l), ammonium nitrate (3.3g/l), 2,4-D (0.1ppm and 1ppm) or BAP (0.1ppm). In all treatments, a formation of callus of variable size and appearance was observed. Light, casein, and ammonium nitrate concentration influenced the number of cotyledons that formed callus. Portions of callus were sub-cultivated in a medium MS/2 with different concentrations and types of PGR in order to induce somatic embryogenesis. Fourteen treatments, each with 15 repetitions, were carried out. Somatic embryos were obtained in a medium MS/2 with AG3 (0.2ppm), and shoots in a medium MS/2 with BAP (0.1ppm).

**Controlling endogenous bacterial contamination of *in vitro* cultures of *Populus deltoides* cv. Catfish clones.** Marinucci, L., Abedini, W.I., Villarreal, B., Bisio, C., Pariani, S., Sharry, S. (National University of La Plata, Argentina; cprove@ceres.agro.unlp.edu.ar).

Controlling *in vitro* fungal and bacterial contamination of woody species is extremely difficult. Endogenous bacteria cause the death of the explants due to competition, colonization of their tissues, or release of toxic metabolites to the medium. This study aimed at eliminating endogenous bacterial contamination of explants (leaves and nodal sections) of *Populus deltoides* (cv. catfish 2 and cv. catfish 5) with the help of antibiotic agents. Three treatments of the antibiotic, norfloxacin, were tested at 0, 200, and 400mg/l. It was applied to the culture medium, after which the plant material was either rinsed with antibiotic solutions for 30 minutes, or immersed in antibiotic solution for 48 hours. The results showed that a concentration of 400mg/l of the antibiotic agent was the most effective; the explants survived (80% of the leaves and 100% of the nodal sections) and looked normal and healthy. At the remaining two concentrations, the material died within 30 days due to either the phytotoxic effect of the antibiotic agent or oxidation. Purity of the donor material of the explants will determine the optimization of tissue culture of this species.

**Isolation of phosphate transporters from Hoop Pine (*Araucaria cunninghamii*) trees.** Medraj, I. (*Griffith University, Australia; i.medraj@griffith.edu.au*), Smith, F. (*CSIRO Australia; Frank.Smith@csiro.au*), Hughes, J., Xu, Z.H. (*Griffith University; Jane.Hughes@griffith.edu.au; zhihong.xu@griffith.edu.au*).

The application of molecular techniques in recent years has improved our understanding of phosphate transport in plants. Genes encoding phosphate transporters have been isolated from a number of plant species. Both high-affinity and low-affinity types have been identified. It has been reported that transgenic *Arabidopsis* with promoter drives symbiotic species to produce an alternative source of P for *Arabidopsis* when grown in low P medium. In this study, different combinations of four degenerated primers designed from high homology regions of 18 phosphate transporters representing different plant genera were used to amplify fragments of hoop pine genomic DNA extracted from old leaves, young leaves, and from roots using PCR. Six sequences with homology to known plant phosphate transporters have been identified. So far, one distinct cDNA (AcPht1) encoding a phosphate transporter has been isolated from hoop pine roots indicating the expression of this gene in roots and its involvement in P uptake. The effects of phosphate and nitrogen on the level of gene (AcPht1) expression were studied using real time PCR.

**A biotechnological approach to developing mahogany trees resistant to mahogany shoot borer, *Hypsipyla* spp.**

Opuni-Frimpong, E., Karnosky, D.F., Thakur, R., Storer, A. (*Michigan Technological University, USA; eopunifr@mtu.edu*), Cobbinah, J.R. (*Forestry Research Institute of Ghana, Ghana*).

Continuous supply and conservation of African mahogany is threatened by overexploitation of natural forests and infestation of plantations by the mahogany pest, *Hypsipyla*. A sustainable supply of mahogany is vital to the timber industry and the economic development in most tropical countries in Africa, Asia and Central America. To date, suitable control methods for the Meliaceae shoot borer have not been found. The objective of this study was to develop techniques for micropropagation of African mahogany, *Khaya* species. In vitro propagation could be used for large scale clonal propagation and conservation of selected clones of resistance genotypes. Explants (shoot tips) were collected from one-year-old greenhouse-grown *Khaya anthotheca* and *K. ivorensis*. Sterilized mahogany tissues were cultured on woody plant media supplemented with growth regulators. Auxins such as NAA and IBA were used to encourage rooting and cytokinins such as benzol-aldehyde (BA) and zeatin were used for shoot multiplication and elongation. Rooting of 50 to 70% for *K. ivorensis* and 40–60% for *K. anthotheca* were recorded for 1ml of NAA per liter. 100% percent survival was recorded for rooted plantlets. Successful micropropagation of *Khaya* could provide a platform for genetic engineering to transfer lepidopteran resistance genes into mahogany to control *Hypsipyla*.

**In vitro propagation of recalcitrant tropical forest trees through organogenesis and somatic embryogenesis.** Roy, S.K., Debnath, R.K. (*Jahangirnagar University, Bangladesh; shkmroy@yahoo.com*).

For mass propagation by in vitro organogenesis and somatic embryogenesis, we have established protocols for some tropical trees. The techniques consisted of four major steps: 1) establishment of in vitro cultures from rejuvenated tissues, 2) induction of multiple shoots from individual explants, 3) rooting, and 4) acclimatization. For culture establishment, multiplication, and rooting, Murashige and Skoog's (MS) nutrient medium was used. Explants of different species showed different responses when cultured on MS medium supplemented with various concentrations and combinations of cytokinin, auxins, casein hydrolysate and coconut milk. Depending on species, 65–85% cultures produced shoots. For multiplication, newly formed shoots were subcultured to fresh medium designed for each plant species and 15–20 shoots per subculture were obtained. Shoots rooted on root induction medium and regeneration was also obtained through somatic embryogenesis. For acclimatization, rooted shoots were transplanted onto sterilized soil and compost and misted. After 3–4 weeks, the plantlets were transplanted in polyethylene bags containing sand, soil and compost. After 8–10 months, they were transplanted in the field where 70–85% plants survived. The technique is feasible for the continuous supply of planting material for recalcitrant trees as well as for the conservation of forest gene resources.

**Molecular cloning and characterization of caffeoyl-coenzyme-A O-methyltransferase cDNA from interspecific hybrid *Acacia mangium* x *Acacia auriculiformis*.** Shek, L.P., Chee, Y.C., Wickneswari, R., Zamri, Z. (*Universiti Kebangsaan Malaysia; xiaopoh@yahoo.com; cychoong@pkrisc.cc.ukm.my; wicki@pkrisc.cc.ukm.my; zz@pkrisc.cc.ukm.my*).

Caffeoyl-CoA O-methyltransferase (CCoAOMT, EC 2.1.1.104) is involved in lignification in zinnia, tobacco, tomato, soybean, alfalfa and forsythia. This enzyme methylates both caffeoyl-CoA and 5-hydroxyferuloyl-CoA during monolignol biosynthesis. In this study, the full length cDNA sequence of CCoAOMT from inner bark tissue of interspecific hybrid *Acacia mangium* x *Acacia auriculiformis* was obtained by rapid amplification of cDNA ends (RACE). The full length cDNA of CCoAOMT was 1087 bp and contained a 750-bp open reading frame (ORF) encoding a protein of 249 amino acids. The deduced protein had a calculated molecular weight of about 28.2 kDa and an isoelectric point of 5.46. The encoded polypeptide exhibits sequence similarity to CCoAOMTs from different

plants, the highest identities being to CCoAOMTs from *Broussonetia papyrifera* (89 %) and *Medicago sativa* (86 %). A domain, methyltransf\_3, which is a member of the O-methyltransferases family, is conserved in the encoded CCoAOMT amino acids sequence.

**Assessing and sustaining bamboo resources of Himachal Pradesh for sustainable development through techniques of biotechnology.** Sood, A., Bhattacharya, A., Sharma, M., Sharma, R.K., Ahuja, P.S. (*Institute of Himalayan Bioresource Technology, India; kukisood@yahoo.co.in*).

Bamboos are perhaps the most important forest species of the tropics and sub-tropics and are aptly called the 'green gold of forests', on account of their fast growth, low maintenance following establishment, and wide utility. They are used for house building, paper manufacture, soil conservation, fodder, and food and provide a livelihood for millions of rural people in India. Natural stands are decreasing because of exploitation and commercial plantations are uncommon because of the difficulty of extracting propagules. It was important, therefore, to regenerate and multiply the different bamboo germplasm through macro- and micropropagation, for which standardized protocols have been developed. For macropropagation, single node cuttings from primary and secondary cuttings of field-grown plants were used with more than 85% success. Seed nurseries are also being raised on a regular basis to avoid monoculture. Nodal explants of field-selected superior seedlings of known physiological age were used in vitro for multiple shoot proliferation. These micro-shoots could be successfully rooted, hardened and transferred to the field in large numbers. The data on field performance of tissue culture raised plants versus nodal cuttings was generated over a period of six years and established superiority of tissue culture-raised plants in the long run.

**Genetic transformation of *Pinus radiata* D. Don to confer resistance to fungal diseases.** Triviño, C., Sabja, A.M., Moynihan, M.R., Carmona, J.C. (*GenFor S.A. and Fundación Chile, Chile; asabja@uach.cl*).

Radiata pine (*Pinus radiata* D. Don) is one of the main species in commercial forestry in Chile. A major factor in phytosanitary protection of radiata pine is the need to prevent damage over the 25 year growth cycle. Plantations are threatened by several fungal diseases. The development of radiata pine with reduced susceptibility to losses due to fungal pests can be carried out using conventional breeding. However, given the long generation time and interest in reducing susceptibility to several different fungal pathogens, genetic engineering of broad fungal resistance may be a useful strategy. *P. radiata* embryogenic cultures have been transformed using particle bombardment with combinations of three vectors that contain genes encoding antifungal proteins and peptides. Plants were regenerated from six stable transgenic lines from three genotypes. Transformation was confirmed by PCR amplification of the antifungal protein genes. Plants are being evaluated in laboratory bioassays.

**Application of *Trichoderma harzianum*, *Trichoderma viride*, and *Gliocladium deliquescens* in the biocontrol of *Rhizoctonia solani*.** Yeh, Y.-J., Liu, Y.-Y., Lee, M.-J. (*National Chiayi University, Chinese Taipei; mjlee@mail.ncyu.edu.tw*).

Taiwan, with high temperatures and a humid climate, is ideal for producing plant pathogens, and soil-borne diseases are prevalent. This study was designed to investigate the effect of antagonistic fungi (*Trichoderma harzianum*, *Trichoderma viride* and *Gliocladium deliquescens*) to *Rhizoctonia solani*. Three antagonistic fungi and *Rhizoctonia solani* were cultured with PDA to study the optimum growth temperature and pH. The result indicated that the optimum temperature and pH ranged from 20°C–32°C and pH 4–7. Three antagonistic fungi could effectively inhibit *Rhizoctonia solani* at 24°C. Observation with a scanning electron microscope revealed that three antagonistic fungi interacted with *Rhizoctonia solani*. Seedlings of *Chamaecyparis obtusa* var. *formosana* were inoculated with the antagonistic fungi, and one week later the seedlings were inoculated with *Rhizoctonia solani* to test the effectiveness of biological control. The results showed that controls inoculated with three antagonistic fungi had survival rates of 100%. However, the survival rates of seedlings inoculated with *T. harzianum*, *T. viride*, *G. deliquescens*, were 85%, 82.5%, and 92.5%, respectively. The ones inoculated with *Rhizoctonia solani* only had a survival rate of 27.5%. The results indicated that *T. harzianum*, *T. viride*, and *G. deliquescens* could inhibit *Rhizoctonia solani* effectively and achieve the goal of biological control.

**Micropropagation of Siberian Ginseng (*Eleutherococcus senticosus*) through in vitro stem nodal culture.** You, X.L., Choi, Y.E., Yi, J.-S. (*Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr*).

Zygotic embryos of *Pinus densiflora* at different developmental stages were tested for their potential in the initiation of embryogenic tissue lines, using immature seeds (female megagametophyte including zygotic embryo) collected during the period of May 31 to July 23. From over 5700 seeds cultured, only 10 embryogenic tissue lines (0.17%) were obtained. However, only six (0.10%) survived on maintenance medium. Among several different media tested, only the P6 medium produced embryogenic tissue lines. The highest tissue initiation (0.36%) was observed with the seeds collected on July 5.



Histological observation revealed that those seeds were at the transition from proembryo to precotyledonary stages with the majority showing the former stage. Out of 10 embryogenic tissue lines initiated, seven were produced from the seeds collected in July 5. The dates correspond to late cleavage polyembryony and early proembryo stages, respectively. However, the seeds collected during the period of May 31 to June 7 did not produce any embryogenic tissue lines. Those seeds did not have zygotic embryos yet but showed archegonia. No embryogenic tissue lines were obtained with the seeds collected on June 14 or July 13 either. The seeds collected on June 14 showed a zygotic embryo.

### **Using genetics and silviculture to manage multiple stress complexes in planted forests**

Organizers: Daniel Robison *North Carolina State University, USA*; [dan\\_robison@ncsu.edu](mailto:dan_robison@ncsu.edu), Michael Wingfield *University of Pretoria, South Africa*; [mike.wingfield@fab.up.ac.za](mailto:mike.wingfield@fab.up.ac.za), and Kier Klepzig *USDA Forest Service, USA*; [kklepzig@fs.fed.us](mailto:kklepzig@fs.fed.us)

**Detection of relative susceptibility of Sitka spruce clones to infection by *Heterobasidion annosum*.** Bodles, B.J.A., Woodward, S. (*University of Aberdeen, UK*; [s.woodward@abdn.ac.uk](mailto:s.woodward@abdn.ac.uk)).

*Heterobasidion annosum* causes root and butt rot of coniferous and broadleaf trees throughout the north temperate zone, leading to high economic losses. In the UK, Sitka spruce (*Picea sitchensis*) is very susceptible to decay and in severe infestations, death results. A Sitka spruce breeding program undertaken in the UK has released various clones for field planting, giving an opportunity to examine the trees for relative resistance to *H. annosum* infection and the inheritance of resistance. Forty, 2-year old clones of *P. sitchensis*, from 3 half-sib families were inoculated with an aggressive isolate of *H. annosum* through wounds at the stem base. The length of the lesion developing on the inner bark from the point of inoculation was measured 35 days after inoculation. There was no significant effect of relatedness within the half-sib family on lesion length in response to inoculation or pseudo-inoculation. From the 40 clones initially investigated, two clones with significantly shorter lesions and two with significantly longer lesions than the mean were selected for further work to determine underlying mechanisms of resistance. The results strongly indicate that there are differences in susceptibility of different Sitka spruce genotypes to infection by *H. annosum*.

**Conservation genetics of *Milicia* species in humid West Africa.** Cobbinah, J.R., Ofori, D.A. (*Forestry Research Institute of Ghana, Ghana*; [jacobbinah@forig.org](mailto:jcobbinah@forig.org); [dofori@forig.org](mailto:dofori@forig.org)).

*Milicia* spp. (*M. excelsa* and *M. regia*, the Irokos) of the Moraceae family are highly rated among the indigenous rainforest African timber species. The high economic importance of the species warrants their establishment in commercial forest plantations. However plantations of this species have been constrained by the attack of a psyllid (*Phytolyma lata*). *Phytolyma* attack leads to gall formation on the soft and succulent tissues which eventually decay and result in dieback of the shoots, growth reduction or death of seedlings. This poster reports on the efforts and achievements made towards conservation and sustained production of the species. Analysis of genetic diversity using both morphological and molecular traits showed large genetic differences among populations and individuals within same population. Individuals with genetic resistance to the pest were identified and reproduced, using vegetative propagation. Both macro-propagation and micro-propagation methods were successful in mass production of the species. Heritability of 0.83 for height growth suggests that phenotypic resistance was genetically controlled. Selection for genetic resistance coupled with large genetic diversity among selected resistant lines could enhance the success of plantation development of this species.

**The role of genetics in minimizing the risk of crop loss and maximizing plantation productivity.** Dvorak, W.S. (*North Carolina State University, USA*; [dvorak@unity.ncsu.edu](mailto:dvorak@unity.ncsu.edu)).

Tree breeding programs are an integral part of successful plantation development. Many metric traits like volume production and stem form are under control of alleles that act additively and genetic gains of 15% to 20% have often been realized through tree selection and progeny testing in each of the first several cycles of forest tree breeding. An important component in all tree improvement programs is understanding the magnitude of provenance variation in a species with respect to adaptability (survival) and growth. Because more marginal sites are being used for plantation forestry, genetic bases need to include selections from at least six to eight populations across a species natural range to ensure broad adaptability. Selection for trees with more cold hardiness, more drought tolerance or better disease resistance has resulted in new races of plantation forests that can withstand great environmental stresses. Deployment of well-tested families or clones can minimize crop losses and maximize plantation productivity if correct species/site matching has been done. Artificial inter-specific hybridization in forest trees has produced new genetic packages that are better adapted to survive extreme conditions. Examples of advances in tree breeding are given as a means of producing more healthy plantations.

**The effects of soil and fertilizer treatments on the growth of selected timber species grown on a former tin mine in Bidor, Malaysia.** Ho, W.M., Lee, D.K. (*Seoul National University, Republic of Korea; waimun\_ho@hotmail.com; leedk@plaza.snu.ac.kr*), Krishnapillay, B., Ang, L.H. (*Forest Research Institute Malaysia; baskaran@frim.gov.my; anglh@frim.gov.my*).

Former tin mines in Malaysia are characterized by sand and slime tailings interspersed with mining pools. Natural regeneration on such areas can be hindered by various factors associated with unfavorable soil properties and harsh microclimate. This study was initiated by the mutual interest of Korea and Malaysia through the ASEAN-Korea Environmental Co-operation Project as part of its efforts to rehabilitate degraded forest ecosystems. Rehabilitation of these unproductive areas requires development of cost-effective techniques and that is the objective of this paper. Three common plantation species, *Acacia* hybrid (*Acacia auriculiformis* x *Acacia mangium*), Mahogany (*Swietenia macrophylla*) and Khaya (*Khaya ivorensis*), were chosen and grown in an experimental plot established on sand tailings. The experiment was conducted using a factorial design with 3 species, two levels of soil enrichment, and three levels of fertilizer. Two years after planting, the results show that *Acacia* hybrid performed best, in survival and growth. Addition of garden soil resulted in significant ( $P < 0.05$ ) increase of height and total leaf area, irrespective of species. Meanwhile, application of chicken manure and empty fruit bunch has proven beneficial for better growth of timber species on such infertile soil.

**The effect of mixed species stands on *Hypsipyla* attack on mahogany trees in the moist semi-deciduous forest of Ghana.** Opuni-Frimpong, E. (*Michigan Technological University, USA, and Forestry Research Institute of Ghana, Ghana; eopunifr@mtu.edu*), Karnosky, D.F., Storer, A. (*Michigan Technological University, USA; karnosky@mtu.edu*), Cobbinah, J.R. (*Forestry Research Institute of Ghana, Ghana; jcobbinah@forig.org*).

Infestation of *Hypsipyla* shoot borer on mahogany trees leads to death of the young terminal shoots, growth retardation, and formation of numerous secondary shoots. This condition encourages the production of poorly formed trees, unsuitable for timber. Although attacks do not normally cause death, repeated attacks can kill the tree. Young trees are particularly affected by the shoot borer because of destruction of the apical meristem. Attacks up to the pole stage are most critical from a silvicultural point of view. Interplanting mahogany trees with other trees or shrubs is considered a management tool for minimizing the effect of *Hypsipyla* infestation in mahogany plantations. *Hypsipyla*, like most oligophagous insects, primarily locate their host trees by olfaction. It is therefore believed that in mixed stands, chemical signals given off by non-Meliaceae species in or around a stand may act as repellents thus preventing the pest from locating the mahogany tree. A study involving two varieties of mahogany and four interplanted shrub species was established to examine the effect of interplanting on the impact of *Hypsipyla*. The results showed that *K. ivorensis* was more resistant to *Hypsipyla* attack than *K. anthotheca*. An interplanting rate of 50% offered the best resistance to attack.

**The role of silviculture in reducing the risk of crop loss and increasing plantation productivity.** Pallett, R.N. (*Sappi Forests Research, South Africa; rob.pallett@sappi.com*).

Increasing yield per unit area in plantation forests is significant to meeting increased demand for roundwood and maintaining or lowering the unit costs of production. In addition, production levels must be sustained over successive crop rotations within the context of the triple bottom line, concerned with economic value, social acceptability and environmental responsibility. In Southern Africa, multiple stress complexes can significantly reduce plantation productivity, either before canopy closure or during stand development. In plantations grown for pulpwood, inherent site productivity and stand tree density significantly influence final yield. Abiotic factors such as frost, inter-specific competition for moisture, light and nutrients and biotic factors such as small mammal and insect damage or disease prevalence, influence post planting survival and hence stand productivity. In older stands, physical damage to trees due to hail, snow or insect attack, or intra-specific competition for resources, particularly moisture in times of drought, can result in disease development and mortality. Examples of management regimes that integrate species (or genotype) selection and silvicultural practices to avoid stress complexes and minimize crop losses are presented for both pines and eucalypts.

***Botryosphaeria* spp. that co-infect native *Syzygium* and introduced *Eucalyptus* trees in South Africa: implications for disease management.** Pavlic, D., Slippers, B. (*Swedish University of Agricultural Science, Sweden; draginja.pavlic@fabi.up.ac.za*), Coutinho, T.A., Wingfield, M.J. (*University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za*).

*Botryosphaeria* spp. are common opportunistic and latent pathogens on introduced *Eucalyptus* spp. (Myrtaceae) in South Africa. These fungi have also recently been reported from native South African trees closely related to *Eucalyptus*, such as *Syzygium cordatum* (Myrtaceae). In this study the *Botryosphaeria* communities on *Eucalyptus* and *S. cordatum* in South Africa are compared, to assess the potential cross influence of introduced and native fungi on the respective host groups. Isolates were collected from stem cankers, dying twigs, as well as asymptomatic twigs and leaves. Identifications were based on anamorph morphology after isolates were induced to sporulate in culture. In this study eight *Botryosphaeria* spp. were identified from *Syzygium*; three species commonly occurred on *Eucalyptus*, namely *B. parva*, *B. eucalyptorum* and *B.*

*eucalypticola*. *Botryosphaeria rhodina* is also known to infect *Eucalyptus*, but was not isolated from this tree in South Africa during the current study. Some of the potentially cross infecting species, such as *B. ribis* and *B. rhodina*, were amongst the most pathogenic on both hosts. It is clearly important for control programs to consider the potential impact of pathogens, such as *Botryosphaeria*, that can cross-infect native and introduced tree species.

**Blight resistance influences herbivore pressure: Interactions among stressors in the Chestnut system.** Rieske-Kinney, L. (*University of Kentucky, USA*).

Chestnut, *Castanea* spp., hybrids are a novel system in which to study the interaction of plant genotype, fungal pathogen resistance, and herbivore susceptibility in woody plants. These hybrids are well characterized with regard to resistance to the chestnut blight fungus, *Cryphonectria parasitica*, and variability is present. Blight-resistance is not straightforward, however, and can be adversely affected by biotic and abiotic agents. Additionally, resistance to one stressing agent may affect susceptibility to a second stressor, suggesting that blight-resistance could alter susceptibility of herbivory. A series of experiments were conducted utilizing groups of resistance-rated backcross chestnut and F1 hybrids, as well as blight susceptible American, *C. dentate*, and blight resistant Chinese, *C. mollissima*, chestnuts. Foliage was sampled for use in feeding bioassays utilizing polyphagous herbivores, including gypsy moth larvae, adult Japanese beetles, and fall webworm larvae. Foliar analyses were performed concurrently and included carbohydrate, tannin, and nitrogen content, and leaf toughness and density. Herbivore preference and foliar characteristics varied among the chestnuts tested, and there was temporal variation in the foliar characteristics. No clear pattern emerges with respect to the relationship between plant genotype, chestnut blight resistance, and susceptibility to generalist herbivores, and more research is needed to separate these effects.

**Development of early-rapid screening techniques for trees for selection for resilience to biotic and abiotic stress.**

Robison, D.J. (*North Carolina State University, USA; dan\_robison@ncsu.edu*).

The success of trees in planted forests is a consequence of the quality of the environment, silviculture, and multiple stress agents acting on them throughout the years of their growth. Thus techniques commonly used to screen tree genetic entities for resilience to stress and response to silvicultural techniques generally take many years to accomplish. This timeframe, often half of the anticipated rotation length, slows progeny and clonal testing, and can be cumbersome when great numbers of families or especially clones require evaluation. Further, field tests that are not subjected to particular stress events during their development will not reveal the coping capacity of the genetic entities being tested. Opportunities to use intensive greenhouse and small field plot testing to screen large numbers of genetic entities rapidly, could help to alleviate some of these constraints. The artificial application of abiotic and biotic stress to such tests, evaluation of the correlations in tree response to multiple stresses, and use of multivariate techniques may provide for efficient early-rapid screening.

**Distribution and importance of *Botryosphaeria* spp. on native and introduced *Eucalyptus* trees in Australia, Africa and South America.**

Slippers, B. (*Swedish University of Agricultural Science, Sweden; bernard.slippers@fabi.up.ac.za*), Ahumada, R., Gzaghne, A., Mohali, S., Nkabonga, G., Rodas, C., Roux, J., Coutinho, T.A., Wingfield, B.D., Wingfield, M.J. (*University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za*).

*Eucalyptus* represents a very large genus of trees, mainly native to Australia but various *Eucalyptus* spp. have been used to establish large plantation programs in Africa and South America. *Botryosphaeria* spp. are canker and die-back pathogens that affect the growth potential of *Eucalyptus* and they can also exist in healthy trees as latent pathogens. Taxonomic problems, however, have made it difficult to evaluate the role of different of *Botryosphaeria* spp. on *Eucalyptus* forestry and natural ecosystems. Here, we assess the distribution and impact of *Botryosphaeria* spp. on *Eucalyptus* from Australia, and various countries in Africa and South America, based on 300 isolates. Results of this study emphasize the general importance of *Botryosphaeria* on *Eucalyptus*, the need for effective identification and screening in different regions, the potential influence of native fungi on introduced hosts and the need for quarantine regulations to consider latent pathogens.

**Genetic variation in resistance traits of loblolly pine and its potential use for mitigating damage caused by**

*Dendroctonus frontalis*. Strom, B., Roberds, J. (*USDA Forest Service, USA; brianstrom@fs.fed.us; jroberds@fs.fed.us*).

The ability of a population of trees to resist attack by pests is affected by the level of genetic variation in its resistance traits. Trees in the genus *Pinus* respond to bole invasion by exuding oleoresin, which acts quantitatively to resist attacks by bark beetles. In the southern United States, loblolly pine, *Pinus taeda* L., is the most prevalent species in planted forests and is a preferred host of *Dendroctonus frontalis* Zimmermann. Resistance in *P. taeda* to *D. frontalis* is thought to be primarily the result of high oleoresin flow. It is therefore likely that the genetic structure of this trait in *P. taeda* populations influences the pattern of mortality caused by *D. frontalis*. This provides both opportunities and risks

for planted forests. Tree defensive traits are known to be heritable and may be impacted by directional selection for increased growth. In a series of experiments we have described the patterns of genetic variation existing for resistance traits in populations of loblolly pine and have studied their correlations with growth traits. Understanding these patterns is important for unraveling the evolutionary relationships between insects and tree species, and for developing methods to mitigate damage by these pests in the future.

**Achievements and development strategy of poplar genetic improvement in China.** Su, X.-H., Huang, Q.J., Zhang, B.-Y., Zhang, X.-H. (*Chinese Academy of Forestry, China; Suxh@caf.ac.cn*).

Genetic improvement of *Populus* in China was started in the 1940s. The objectives of poplar breeding have been shifted from general to more specific uses. Target traits have been changed from productivity traits to include property and adaptability traits, intending to achieve the best combinations of breeding, environment, tree species, and timber quality. Many new varieties, developed in the last twenty years, are significantly different from those bred earlier; there is an average volume increase of 10–20%, wood density increase of more than 3%, and fiber content of more than 2%. A number of new varieties/clones have been successively applied in practice. Supported by government funding, *Populus nigra* and *P. deltoides* were introduced into China. The study of genetic engineering of *Populus* has also progressed. Target genes that cause resistance to leaf- and trunk insects have been incorporated into *Populus*, successfully. With the use of molecular technologies, many molecular markers that are tightly linked with disease resistance were detected, and these will be helpful to locate and clone disease-resistant genes. Studies on mapping QTLs of many important traits, which control the growth, phenology and wood properties, have been carried out, making it possible for early selection of these traits.

**Pathogen management as a driver in *Eucalyptus* genetic management and deployment strategies.** Wingfield, M.J., Roux, J., Wingfield, B.D. (*University of Pretoria, South Africa; Mike.Wingfield@fabi.up.ac.za*).

Plantation forestry based on exotic *Eucalyptus* species expanded dramatically during the latter half of the 20th Century. This is attributable to many factors, including the great diversity of ecological niches in which these trees are found. The ease with which they hybridize and adapt to new environments and opportunities arising from vegetative propagation, are also factors accounting for the success of eucalyptus plantations. In our view, one of the more important factors associated with the tremendous growth and productivity of exotic eucalypts, is the separation of these trees from pests and pathogens that damage them in their native range. However, new pests and pathogens are continuously appearing in eucalypt plantations throughout the tropics and southern hemisphere. Consequently, plantations have failed in some areas and the difficulty with which healthy trees can be grown is increasing. Thus, breeding and selection of species and hybrids for disease resistance is becoming increasingly important. More importantly, new strategies, including those using DNA technologies are beginning to determine success or failure. This is a trend that is likely to increase in the future. We predict that companies that choose not to invest in technologies enabling disease resistance are doomed to failure.

## Genomics: Present status and progress

Organizer: Giovanni G. Vendramin, *Institute of Plant Genetics – CNR, Italy; giovanni.vendramin@igv.cnr.it*

**Imprint of natural selection in forest trees at the genome and gene level.** Kremer, A. (*INRA, France; antoine@pierroton.inra.fr*).

It is known from provenance and progeny tests that most phenotypic traits exhibit large within and between population diversity, resulting from diversifying selection pressures. With the availability of genes related to these traits, the question raises on the signature of these pressures at the DNA level. Expected signatures will be outlined based on simulations studies and supported by experimental data of nucleotide diversity in natural populations. The following potential signatures will be tracked and compared under different selection scenarios: allelic association between genes at the within and between population level, differentiation and diversity profiles along linkage groups, and clinal response of nucleotide frequencies.

**Pathway analysis of phytohormones in trees using a bioinformatics tool.** Kushida, T., Yamamoto, S., Yamagata, Y., Asanuma, T., Sakai, N. (*Japan Science and Technology Agency, Japan; kushida-tatsuya@aist.go.jp; yamagata-yuki@aist.go.jp; yamamoto-satoko@aist.go.jp; asanuma-takao@aist.go.jp; sakai-noriko@aist.go.jp*), Hattori, E.

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Research on molecular biology of tree growth and development is progressing rapidly. Bioinformatics proves essential in the analysis of such data. The bioinformatics tool: INOH (<http://www.inoh.org/>) is a cellular pathway database system that houses data of biological events such as those involved in wood formation. In this paper, the data models of biosynthesis and the regulatory pathways of plant hormones are described. Subsequently, their possibilities in contributing to the advancement of molecular biology in tree physiology are discussed. The pathway information was manually curated from scientific articles. This includes information on genes, gene products, chemicals, environmental factors, and organisms. Each biological event is represented by a pathway graph in which genes, gene products, chemicals, and environmental factors are described by nodes, and the relationships (e.g., activate) among them are described by the edges. The curated pathways included biosynthesis and response pathways of cytokinin, ABA, etc., as well as their sub-pathways (e.g., 'binding of calcineurin and calcium ion' in ABA response pathway). Availability of information on curated cellular pathways of plant hormones has enabled the comparison and analysis of the relationship between biological events and the cellular pathways under various conditions (e.g., environmental factors).

**Population and evolutionary genomics of adaptation in forest trees.** Neale, D.B. (*USDA Forest Service, USA, and University of California at Davis, USA*), Ersoz, E. (*University of California at Davis, USA*), Krutovsky, K. (*USDA Forest Service, USA*), Gonzalez-Martinez, S.C. (*CIFOR-INIA, Spain*), Wheeler, N.C. (*North Carolina State University, USA*).

Population and evolutionary genomic studies in forest trees is leading to an understanding of the molecular basis of adaptation. The association genetics approach is used to discover relationships between naturally occurring allelic variation and phenotypic variation for a suite of adaptive and economic traits. This approach has been pioneered in human genetics and is leading to the discovery of genetic variation causing complex and common disease. To begin, direct DNA sequencing of candidate genes in a small sample of pine megagametophytes provides measures on nucleotide diversity, haplotype (allele) diversity, and linkage disequilibrium. Conifers appear to have intermediate levels of nucleotide diversity, but significant haplotype diversity, in part due to very low linkage disequilibrium. These factors combine to increase power of a candidate gene association genetics approach. This approach has now been used to show associations between allelic diversity in candidate genes involved in adaptive traits such as drought tolerance and cold hardiness, and phenotypic diversity for these complex adaptive traits. It will soon be possible to perform genetic selection for desirable adaptive and economic traits directly on DNA sequence and thus fully realizing the potential of marker-based breeding and conservation.

**Detecting adaptation in patterns of sequence variation with population genetic and molecular evolutionary methods.** Savolainen, O. (*University of Oulu, Finland; outi.savolainen@oulu.fi*).

Natural selection leaves its signal on sequence polymorphism, influencing levels of diversity, frequency spectra, linkage disequilibrium, and other aspects. However, these signals are embedded among the joint effects of stochastic variation and demographic effects, such as migrations, colonizations, and bottlenecks. We used population genetics and molecular evolutionary methods to examine the genome of *Pinus sylvestris* (and some other plant species) for traces of selection, with special interest in signs of local adaptation, and demography.

**Low nucleotide diversity in populations of a Mediterranean conifer species, *Pinus halepensis* Mill.** Sebastiani, F., Buonamici A., Racchi, M.L. (*Università degli Studi di Firenze, Italy*), Neale, D.B. (*USDA Forest Service, USA*), Gonzalez-Martinez, S.C. (*CIFOR-INIA, Spain*), Plomion, C. (*INRA, France*), Vendramin, G.G. (*IGV-CNR, Italy; giovanni.vendramin@igv.cnr.it*).

Aleppo pine (*Pinus halepensis*) is an outcrossing highly heterozygous species, with very large effective population sizes. Based on isozymes, nuclear, and chloroplast microsatellite data it appears to carry high levels of variability, most of which (>85%) resides within populations. Single-nucleotide polymorphisms (SNPs) provide an abundant source of DNA polymorphisms and, if detected in candidate genes, may allow gathering information about adaptive variation. The objectives of this work are: 1) to determine SNP frequency in coding and non coding DNA sequence amplified from genomic DNA using PCR primers designed to complete genes, 2) to characterize haplotype variation in these sequences, 3) to estimate the partitioning of variation within and among natural populations, and 4) to compare these results with those obtained using other molecular markers. Ten candidate genes, involved in the drought stress tolerance, were analyzed. Six natural populations of Aleppo pine were sampled along a geographical and ecological gradient. The frequency of SNPs and nucleotide diversity are on average lower than that observed in other conifer species. Tests for genetic differentiation among populations revealed a significantly high  $F_{st}$  value for some candidate

genes, much higher than those estimated in Aleppo pine for neutral markers (isozymes and chloroplast microsatellites). The genetic differentiation among populations was higher than that estimated using neutral marker. Possible implications of these results in conservation genetics and marker-assisted selection will be presented and discussed.

## Interspecific hybridization for sustainable forestry: Breeding and deployment

Organizer: Baillian Li *North Carolina State University, USA; baillian@unity.ncsu.edu*

**Current status of breeding and deployment for clonal forestry with tropical eucalypt hybrids in Brazil.** de Assis, T.F., Rezende, G.D.S.P., Aguiar, A.M. (*Aracruz Celulose S.A., Brazil; gdr@aracruz.com.br*).

The development of the concept of clonal forestry in Brazil was based on both spontaneous and natural hybrids. Trees manifesting high level of heterosis for growth and also resistance to diseases, especially to the eucalypt canker, were used to establish the first clonal plantations in Aracruz, located on the coast of Espírito Santo State. Since the recognition of its importance, hybridization has become the dominant eucalypt breeding strategy in the country, being adopted by the main companies, for many different purposes. The most popular hybrid combination is *Eucalyptus grandis* x *E. urophylla*. However, after the preliminary success of *E. globulus* hybrids in Southern Brazil, with expected gains in wood quality for pulp production, the majority of the pulp companies became interested in this genetic background. The use of clonal forests of eucalyptus is currently widespread among Brazilian companies that use this genus for industrial purposes. Mini-cutting, using propagules produced in hydroponic mini-hedges is the preferred cloning technique to establish clonal forests. The total area planted with clones is over 1 million ha. The annual rhythm of new clonal plantations, to support expansion projects of forest-based industries, is near 238,000 ha, 80% being *E. europilia* hybrid clones.

**Genetic improvement strategy for the *Pinus elliottii* *P. caribaea* var. *hondurensis* hybrid in Queensland.** Dieters, M.J. (*University of Queensland and Cooperative Research Centre for Sustainable Production Forestry, Australia; m.dieters@uq.edu.au*), Brawner, J. (*Horticulture and Forestry Science Queensland, and CRC-SPF, Australia; Jeremy.Brawner@dpi.qld.gov.au*), Last, I. (*Department of Primary Industries and Fisheries, Queensland, Australia; Ian.Last@dpi.qld.gov.au*).

The genetic improvement of *P. elliottii* var. *elliottii* (PEE), *P. caribaea* var. *hondurensis* (PCH), and their hybrid in Queensland has relied primarily on genetic improvement within the pure species, and intensive testing and selection of elite F<sub>1</sub> hybrid families. The use of advanced hybrid generations had been considered a non-viable breeding method because: 1) the genetic causes of hybrid superiority were not well understood, 2) the possibility of segregation back to the parental types; and 3) possible hybrid breakdown. However, over the last six years, work conducted in association with the CRC-SPF has demonstrated that: 1) F<sub>1</sub> and F<sub>2</sub> populations are comparable in both mean and variance for growth traits, 2) the genetic control of most traits in the hybrid populations is largely due to additive or additive × additive epistatic genetic effects, 3) F<sub>1</sub> hybrid performance is difficult to predict from pure-species performance without the use of reciprocal hybrid testing, and 4) optimal gains can be obtained using a strategy that seeks to develop a stabilized, advanced generation synthetic hybrid. These results have led to radical changes in the direction and strategy applied to the breeding of PEE × PCH in Queensland, i.e. to produce a synthetic hybrid between these two species, creating synergies with the clonal program and reducing the total resources required.

**Eucalypt and pine hybrid breeding and deployment in South Africa.** Kain, D., Verry, S.D. (*Environmentek, CSIR, South Africa; SVerry@CSIR.co.za*).

In the diverse planted forests of South Africa, hybrids fulfil specific purposes. Historically in eucalypts, hybrids involving the favoured species *Eucalyptus grandis* have been deployed to pioneer marginal bio-climatic regions, in particular, dry and cold sites. Recently, there has been growing interest in hybridization as a means to improve wood properties. Several new hybrids of *E. grandis* under test aim to combine adaptation to marginal environments with superior pulping properties; others have been used to improve wood colour. Hybridization is increasingly being used in both eucalypts and pines to add disease resistance to species that are well regarded but susceptible on some sites. Work is underway to identify the most economic ways of breeding hybrids in South Africa. Given the large number of species and hybrids deployed, it is not economical to pursue separate breeding strategies for each of the hybrids using conventional intensive strategies developed in crop breeding. An approach under investigation is the combination of data from pure species progeny and from one or more hybrid taxa in an optimal manner using multi-species BLUP with appropriate economic weightings. This approach makes best use of the available correlated information in the various species and their hybrids, maximizing the total economic gain from breeding across the entire forest estate.

**A selective review of hybrid breeding in plants and implications for efficient breeding of *Corymbia* (ex *Eucalyptus*, Myrtaceae) interspecific hybrids for industrial plantations.** Lee, D.J., Nikles, D.G. (*Department of Primary Industries and Fisheries, Queensland, Australia; David.Lee@dpi.qld.gov.au; Garth.Nikles@dpi.qld.gov.au*).

The practical utility of intra-specific ('wide-cross') and inter-specific hybrids often depends on their expressing high-parent heterosis (HPH), i.e., significant superiority for performance, usually in yield, over that of the better parent under cultivation. Such superiority has been demonstrated and used advantageously in many plants, e.g. some crop, pasture, horticultural, vegetable, and hardwood and softwood forest tree species. Partial understandings, for example of the bases of HPH and the potential role of genomics as an aid to hybrid breeding, are still emerging in many cases. To benefit from the knowledge gained already about hybrid breeding of plants, the recent literature is reviewed selectively to identify relevant elements that might have implications for efficient breeding of some *Corymbia* inter-specific hybrids. An overview of the results of preliminary studies of *Corymbia* hybrids in tests in Queensland is also given, along with postulations of gene action for important traits in the parents and hybrids, and likely options for efficient hybrid breeding. As well, consideration is given to the definition of research and development work considered necessary for progressing the breeding of *Corymbia* hybrids efficiently, in order to deliver improved hybrid families and clones over time for sustainable industrial use.

**Adaptation trials of interspecific elm hybrids to different environment.** Santini, A., Mittempergher, L. (*CNR, Italy; a.santini@ipp.cnr.it*), La Porta, N. (*IASMA, Italy; nicola.laporta@iasma.it*).

Dutch elm disease (DED) is the most devastating pandemic tree disease of last century. Millions of stately elm trees have been lost across Europe and North America. Breeding projects aiming to introgress resistance genes in the European and American elm species from Asian species have delivered several hybrid clones that present a good/high level of DED resistance. Unfortunately, many of these hybrids showed low adaptability to hot and dry conditions. The Italian elm breeding project has the aim to develop resistant elms more adapted to the Mediterranean environment. Crossing trials were carried out among 11 Italian and Asian elm species. Crossability barriers among elm species were found rather limited. Hybrid seed production was generally related to the taxonomic affinity of parental species. Percentage of success was variable depending on male-female interaction and parental individuals. Several F<sub>1</sub> offsprings were selected from the crosses and, after clonal propagation, were planted in different stands in Italy. An artificial inoculation program was carried out for several years, routinely with backcrosses, to test the introgression of the resistance and to select at the same time the best adaptability to Italian climatic conditions. Data are given on the resistance and growth of hybrid elms (mainly *Ulmus pumila* X *U. minor*) involving *U. pumila* trees that have proven resistant to repeated inoculation with DED.

## Genomics and tree breeding for sustainable forestry

Organizer: Bailian Li *North Carolina State University, USA; bailian@unity.ncsu.edu*

**Selection and breeding of *Lespedeza* for feedstock.** Chen, X., Jia, L., Shen, Y. (*Beijing Forestry University, China; xychen@bjfu.edu.cn*).

*Lespedeza* is a shrub with the advantages of fast growth, high-yield forage, rich nutritive value, and drought and barren tolerance, which are suitable for feedstock, water and soil conservation, and soil improvement. We collected different species and seed resources of *Lespedeza* throughout China and introduced *L. cyrtobotrya*, *L. thunbergii* and *L. japonica* from U.S., Korea and Japan since 2001, and planted them in 11 locations in the semi-arid area of northern China, for selecting species and seed resources as feedstock. The phenological spectrum, growth rhythm, biomass nutrient content, drought- and salt-resistance were studied. The provenance from Georgia, USA, was the best among seven provenances of *Lespedeza cyrtobotrya*. Its leaf biomass in vegetative stages, flowering period and fruiting period were 39.4 g, 59.3 g and 48.6 g, respectively, which were 25–220% more than other provenances. Its crude protein content and energy per stem were 11.4 g and 1.04 MJ, respectively, and were two times more than other provenances. The leaf biomass, crude protein content, and energy of the Guandishan in Shanxi province of China were the highest among six provenances of *Lespedeza bicolor*. Its leaf biomass in vegetative, flowering and bearing pod stage were about 101–121% more than the poor provenance.

**The result of the IUFRO Douglas Fir (*Pseudotsuga menziesii* (Mirb.) Franco.) provenance trial at the age of 32 at three trial sites in Bosnia and Herzegovina.** Dalibor, B., Mekic, F. (*University of Sarajevo, Bosnia and Herzegovina; balliand@bih.net.ba; fatidzej@epn.ba*).

In 1972, three studies were initiated in diverse ecologic conditions within IUFRO program involving Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco.). The heights, the DBH, the survival rate, and the total volume per hectare at

the age of 32 have been researched. For the heights and changes we obtained statistically significant difference between the provenance at the trial site Gostovič and Crna Lokva, we only determined differences in the diameter, whereas in the Blinje site, no differences were reported. The average mid-height in the trial site was between 18.65 m up to 21.5 m, and the diameters varied between 24.2 cm and 26.7 cm. We cannot report significant differences in the survival trials, and between the trials, the survival varied from 22.3 % to 42.18 %. The volume per hectare did not show significant differences between the provenances in the trial sites. The mid-range volume per hectare in the trial sites varied between 117 m<sup>3</sup>/ha and 222 m<sup>3</sup>/ha. The results showed that there were differences between the provenance in the trial sites and between the trial. The results of the investigation point at the type of provenance that need to be used for introduction into previously defined sites.

**Genetic improvement of *P. caribaea* in Queensland.** Dieters, M.J. (*University of Queensland and Cooperative Research Centre for Sustainable Production Forestry, Australia; m.dieters@uq.edu.au*), Brawner, J. (*Horticulture and Forestry Science Queensland and CRC-SPF, Australia; Jeremy.Brawner@dpi.qld.gov.au*), Last, I. (*Department of Primary Industries and Fisheries, Queensland, Australia; Ian.Last@dpi.qld.gov.au*).

Significant resources have been devoted to the genetic improvement of *P. caribaea* (chiefly var. *hondurensis*, PCH) in Queensland for deployment both as a pure species and as a parent of the F<sub>1</sub> hybrid with *P. elliottii* (PEE). However new plans to develop a stable synthetic hybrid between PCH and PEE now mean that *P. caribaea* is only required for deployment as a pure species across approximately 25,000 ha in north and central Queensland. Breeding activities must therefore provide material for reforestation in these regions at a relatively low cost. The wide variety of sites where tropical pines may be planted and some uncertainty regarding what will be the best taxon, requires a diverse range of germplasm be maintained for the future. The breeding strategy adopted will involve genetic improvement within four small subpopulations of *P. caribaea* – two derived from the Mountain Pine Ridge provenance of PCH, one from the coastal and Guanaja provenances of PCH, and the last from *P. caribaea* var. *caribaea*. Small populations of some species of minor importance (including *P. oocarpa* and *P. tecunumanii*) will also be maintained. A broad range of crosses will be produced and evaluated prior to deployment in family blocks.

**Fertility variation and effective number in a clonal seed orchard of *Cryptomeria japonica* in Korea.** Kang, K.-S., Kim, C.S., Kang, Y.J., Kang, B.S. (*Korea Forest Research Institute, Republic of Korea; kangks@foa.go.kr*), Chung, M.S. (*Kyungpook National University, Republic of Korea*).

Clonal differences in the number of female and male strobili were determined for three consecutive years in a clonal seed orchard of *Cryptomeria japonica* in Korea. The strobilus production varied among clones and years. On an average of three years, each clone produced 196 female strobili and 652 male strobili, respectively. The correlation coefficient between female- and male strobilus production was positive for the three consecutive years. Based on the fertility estimated by variation on female- and male strobilus production, the status numbers (Ns) were calculated and Ns varied from 25.6 to 31.7 for the three consecutive years. On average (pooled), Ns was 86% of the census number (N). Female fertility variation was consistently higher than male fertility variation; also, female effective number was lower than male effective number. The Ns, when data were pooled, was higher than when a single year was analyzed, implying that gene diversity could increase when seeds collected from different years are pooled.

**Genetic gain and diversity of orchard crops under alternative management options.** Kang, K.S. (*Korea Forest Research Institute, Republic of Korea; kangks@foa.go.kr*), Lindgren, D. (*Swedish University of Agricultural Sciences, Sweden; dag.lindgren@genfys.slu.se*), Mullin, T.J. (*North Carolina State University, USA; tim\_mullin@ncsu.edu*), Choi, W.-Y., Han, S.-U. (*Korea Forest Research Institute, Republic of Korea*).

Genetic gain and diversity of seed crops from a clonal seed orchard of *Pinus thunbergii* were estimated considering selection, fertility variation and pollen contamination, and compared for different management alternatives (selective harvest, genetic thinning and combination of both options). Management variables included the proportion of clones left after selective harvest and/or genetic thinning. The impact on genetic gain and diversity of seed crops was quantified as a function of the quantity and quality of gene flow from outside the seed orchard. Selective seed harvest, genetic thinning and the combination of both options increased genetic gain over the initial orchard condition (i.e., before thinning). Genetic gain varied with the proportion of selected or thinned clones. Genetic thinning by means of truncation selection of clones resulted in a large decrease in status number, which was accompanied by greater genetic gain than achieved by selective harvest alone. Gene flow from outside the seed orchard greatly increased status number of the seed crop at higher rates of pollen contamination under all management options. The formulae and results of the present study could be used for identifying favorable selection intensity and alternatives for orchard management.



**Super high-density, complete genetic maps of black spruce and black x red spruce hybrid, and QTL mapping of traits related to productivity and adaptation to climate change.** Rajora, O.P. (*University of New Brunswick, Canada; orajora@unb.ca; Om.Rajora@dal.ca*), Mann, I.K., Kang, B.-Y. (*Dalhousie University, Canada; imann@dal.ca; Bum-yong.Kang@dal.ca*), Major, J.E., Mosseler, A. (*Natural Resources Canada, Canada; jmajor@nrca.gc.ca; amossele@nrca.gc.ca*).

Black spruce (*Picea mariana*) and red spruce (*P. rubens*) provide an ideal species pair for conifer genomics work. One of the objectives of our comparative structural and functional spruce genomics program is to construct high density to saturated genetic maps of black spruce and black spruce x red spruce hybrids, and to map genetic factors controlling traits related to growth and adaptation to climate change. We have developed a super high-density and complete genetic linkage map of black spruce using a three-generation outbred pedigree and that of black x red spruce hybrid using an inter-specific BC1 pedigree. The black spruce map has 941 markers distributed over 12 linkage groups (*Picea*,  $n = 12$ ), and covers 1898 cM of the map length, with an average of 1 marker every about 2 cM. The black x red spruce hybrid map has 1216 markers distributed over 12 linkage groups, covering 1865 cM, with an average distance of 1.5 cM between adjacent markers. The estimated genome size of black spruce is approximately 1900 cM. We are mapping candidate genes and QTLs for growth, adaptation to elevated CO<sub>2</sub> levels, water use efficiency, and other ecophysiological adaptive traits using replicated clonal genetic tests under different abiotic stress conditions.

**Selection of both high-growth and anti-snow damage trees of Japanese cedar.** Sasaki, Y., Yatabe, T., Sasaki, A. (*Akita Prefecture Forest Technical Center, Japan*).

Selection both high growth and anti snow damage trees of Japanese cedar (*Cryptomeria japonica* D. DON) was examined. For selection, 4 tree characteristics of height (H), diameter at breast height (DBH), horizontal length from breast height to the slanted section of the trunk (BHLH) which is an index of curvature, and ratio of survival (RS) were assessed. Seven of F<sub>1</sub> families were classified both high growth and little snow damage from 24 families with specific combinations, using five high-growth elite trees and five anti snow damage trees. Furthermore, by using the BHLH / H ratio, seven trees were found to rank highly with respect to high growth, and four were resistant to snow damage. Five snow-resistant trees were female and five elite trees were male. The results showed that 1) H, RS, and BHLH / H were significant with both snow damage resistance trees and high growth elite trees, 2) BDH was significant only in high growth elite trees, 3) BHLH was significant only for snow damage resistance. Those alternate actions of the female and male were significant with all four characteristics.

**The influence of stem pruning on seed component of Korean white pine.** Song, J.-M., Shim, T.-H., Kim, C.-W., Yi, J.-S. (*Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr*).

In order to investigate the influence of increased seed production of Korean white pine (*Pinus koraiensis* S. et Z.) by stem pruning, seeds produced from stem-pruned trees, in the seed orchard in 2000, 2001 and 2002, were analyzed. There were no significant differences in the seed with respect to moisture, ash, crude lipid, crude protein and carbohydrate, in all three years between stem-pruned and untreated trees. Thus stem pruning, in general, does not seem to influence seed constituents. However, there were significant differences in fatty acid, being 16:1 and 20:3 in 2000, and 18:3( $\alpha$ ) and 18:3( $\alpha$ ) in 2001. The quantity of fatty acid was similar to that reported by other researchers. Also, most of the fatty acid consisted of 18:2, 18:1 and 16:0; the values showed no significant difference between stem-pruned and untreated trees. The content of fatty acid may differ, depending on the researcher and the methodology used. Stem pruning did not seem to influence either the kind or amount of fatty acid produced in seed.

**Study on chloroplast DNA inheritance of hybrid of *Acacia mangium* and *A. auriculiformis* using Single Strand Conformation Polymorphism (SSCP) (Preliminary Study).** Widyatmoko, A.Y.P.B.C. (*Centre for Forest Biotechnology and Tree Improvement/CFBTI, Indonesia; aviwicaksono@yahoo.com*), Rimbawanto, A. (*CFBTI, Indonesia; rimba@indo.net.id*), Sunarti, S. (*CFBTI, Indonesia; narti\_nirz@yahoo.com*).

Chloroplast inheritance in angiosperms can vary among and within species. A number of studies reported the inheritance of chloroplast DNA in pure species or hybrids. Most angiosperm species display maternal inheritance of the chloroplast genome. However, chloroplast DNA (cpDNA) can also be biparentally inherited or paternally inherited. The cpDNA, which, based on knowledge of its mode of inheritance, can be used either as molecular marker for genetic studies or as a potential tool for genetic manipulation. In this study, single strand conformation polymorphism (SSCP) of chloroplast non-coding regions was used to determine chloroplast DNA heritability in hybrid between, *Acacia mangium* and *A. auriculiformis*. Controlled pollination seedlings between the two species were used. In order to be certain that the materials were hybrid, SSR markers and species-specific RAPD markers were used. Several candidate full-sib hybrid seedlings were checked by SSR and RAPD marker; however, some of them were not full-sib hybrids. Only full-sib hybrid seedlings were used as materials for cpDNA inheritance study using SSCP.

**Somatic embryogenesis and plant regeneration from mature zygotic embryo of *Diospyros discolor* Willd.** Wu, Z.-X., Wang, Y.-N. (National Taiwan University, Chinese Taipei; m627@ntu.edu.tw).

We established a plant regeneration system for *Diospyros discolor* Willd. (Ebenaceae) via somatic embryogenesis. Direct embryogenesis was successfully induced on mature zygotic embryos cultured on modified MS medium with 0.1 mg l<sup>-1</sup> 2,4-D and 0.05 mg l<sup>-1</sup> TDZ. For somatic embryo maturation, the mass of globular embryos were transferred to 1/2MS medium without plant growth regulators. After 20 days culture, the elongated somatic embryos were separated from explants and subcultured on WPM medium with 0.5 mg l<sup>-1</sup> IBA and 1 mg l<sup>-1</sup> GA3 for germination. The germination frequency of mature somatic embryos germinated was approximately 30%. This is the first report on plant regeneration of *Diospyros discolor* via somatic embryogenesis.

**Study of *Trichilia pallida* Swartz populations and subpopulations genetic structure.** Zimback, L. (Instituto Florestal, Avaré, São Paulo State, Brazil; nativas@fca.unesp.br), Mori, E.S. (São Paulo State University, Brazil; esmori@fca.unesp.br), Kageyama, P.Y. (Escola Superior de Agricultura "Luiz de Queirós", Brazil; kageyama@carpa.ciagri.usp.br), Aoki, H. (Instituto Florestal, Avaré, São Paulo State, Brazil; hideyo@iflorest.sp.gov.br).

*Trichilia pallida* Swartz is a climax tree species of the Meliaceae family, and of interest to forest users because of its insecticidal properties. Forty plants per population were collected from two subpopulations in Bofete County, three subpopulations in Campinas County, and two subpopulations in Gália County, all in São Paulo State, Brazil. Using the RAPD method, leaf DNA analysis showed 10 highly polymorphic primers, with 72 dominant markers, and was used to estimate genetic diversity within and among populations. Total gene diversity ( $H_t = 0.33$ ) among populations was high. The principal component was gene diversity within whole populations ( $H_s = 0.29$ ), but gene differentiation between populations ( $G_{st} = 0.13$ ) was considered moderate. In subpopulations total gene diversity  $H_t$ , the gene diversity within  $H_c$  increased and  $G_{st}$  decreased; the Campinas populations and subpopulations showed greater diversity. Low gene flow ( $N_m = 0.78$ ) indicated that genetic drift between populations, and among subpopulations was moderate (1.43 to 3.52). The genetic distances were low among populations (0.06 to 0.17) although they were superior to those of subpopulations within populations (0.02 to 0.05).

## Progress in tree breeding for tropics and subtropics

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### Production of improved planting stocks of *Tectona philippinensis* and *Intsia bijuga* using stem cuttings.

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Studies were conducted to identify an alternative propagation technique for mass production of improved planting stock of the endangered Philippine teak (*Tectona philippinensis*) and ipil (*Intsia bijuga*). Macropropagation technique using stem cuttings was investigated, utilizing stem cuttings collected from seedlings. Successful rooting of stem cuttings of the two species was achieved. Cuttings were cut into two-nodes and soak in Benlate solution (fungicide). Rooting hormones such as indolebutyric acid, naphthalene acetic acid were used. Treated cuttings were planted in Hiko trays filled with coconut coir dust, sand and garden soil in a 2:1:1 ratio. The rooting media/potting media was sundried for three days. The planted cuttings were placed in a large plastic chamber for one month, then, rooted cuttings were transferred to individual 5 x 8 cm black polyethylene bags filled with the sundried pottings media and returned to the plastic chamber for another month. The chamber was gradually open for acclimatization of seedlings for another month. Seedlings of Philippine teak were fertilized with 20 g of Biocore, and ipil were fertilized with 0.50 g of complete fertilizer for healthy and vigorous seedlings and maintained in the nursery for eight months prior to field planting.

### Breeding of *Pinus taeda* in the southeastern USA.

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The North Carolina State University–Industry Cooperative Tree Improvement Program is celebrating 50 years of operation since it was founded by Bruce Zobel in 1956. It has had a greater impact on planted forests than any other tree improvement programs in the world. Today, over 1 billion genetically improved loblolly pine seedlings are planted annually on approximately 600,000 hectares in the southern United States of America. The planting stocks from progeny of second generation orchards produced 15 and 35% over wild stands. Family block planting with open-pollinated and controlled pollinated seedlings are now used by many cooperators to achieve additional gains in productivity, rust resistance, and stem quality. With the advances in rooted cutting techniques and somatic embryogenesis, some industry members are testing and deploying

vegetative propagules and somatic seedlings to capture even higher returns from the breeding efforts. As we are moving into the third cycle breeding program, new genomics tools will be used to accelerate the breeding and deployment progress.

**Distribution of *Azadirachta excelsa* land race in Peninsular Malaysia.** Mahat, M.N., Ghani, A.R.A., Abdullah, M.Z. (*Forest Research Institute Malaysia, Malaysia; mohdnoor@frim.gov.my*).

Although sentang is native to Malaysia, it is not native to Peninsular Malaysia. It has been reported to be an introduced species and was described in Penang in 1820 as *Melia excelsa*. Thereafter, sentang was found in farmland or marginal areas along the road sites or villages. The largest populations are found in four states namely Terengganu, Kelantan, Kedah, and Perak, but they are also found in Perlis, Penang, and Negeri Sembilan. A thorough survey was conducted in Terengganu and Kelantan to map the locations, and the trees were also evaluated for plus tree selection based on: diameter at breast height, total and merchantable height, crown size, branch size and angle, stem straightness, and fruiting ability. Forty-four old trees were found in Terengganu, of which 33 were located in Jertih district and 11 in Kuala Terengganu. There are 353 trees found in five districts of Kelantan. Significant variation was observed in all of these land races. Therefore, some these trees have been selected to be plus trees for future seed supply of planting stock.

**Genetic variation in growth performance and fluorescence efficiency of four selected *Acacia* progenies.** Mahat, M.N., Ghani, A.R.A. (*Forest Research Institute Malaysia, Malaysia; mohdnoor@frim.gov.my*), Ab. Shukor, N.A., Awang, K. (*University Putra Malaysia, Malaysia*).

A species/ provenance/progeny trial was established in August 1998 at Kampung Aur Gading, Kuala Lipis. The research was part of a collaborative effort between the Universiti Putra Malaysia (UPM), and the Fuelwood / Forest Research and Development Project (F/FRED) and the Australian Centre for International Agriculture Research (ACIAR) to evaluate the performances of these species /provenances in Malaysian environment and to assess the genetic worth of selected parents. The study involved the assessment of growth performance and fluorescence efficiency of three-year-old *Acacia mangium*, *A. auriculiformis*, *A. crassiparva*, and *A. aulococarpa* trial plot at Kampung Aur Gading, Kuala Lipis, Pahang. The materials used in this trial comprised 80 progenies—20 progenies from each of the four species. Significant variations were detected in the growth performance between the species, provenances as well as among progenies. However, no significant variation were found in fluorescence efficiency between the species/provenances. Morphological character, such as leaf size, was observed to have significant effect on the growth of these *Acacia*. *A. mangium* had the best growth. The result also revealed that further selection could also be done from the best progenies to form an advanced breeding population. The physiological characteristics, such as fluorescence efficiency, however, could not serve as one of the selection criteria for further improvement.

**The program for conservation and genetic improvement in the Northern Territory of Australia of the high-value, tropical hardwood timber species *Khaya senegalensis* (African mahogany) endangered in parts of its homelands.** Nikles, D.G. (*Department of Primary Industries and Fisheries, Queensland, Australia; Garth.Nikles@dpi.qld.gov.au*), Reilly, D.F., Robertson, R.M. (*Department of Business, Industry and Resource Development, Northern Territory, Australia; Don.Reilly@nt.gov.au; Beau.Robertson@nt.gov.au*).

Achievements of the program, commenced in 2001, include: 1) preparation of short- and long-term strategic plans, 2) phenotypic selection in each of 24 provenances (from 11 countries of nativity between Senegal and Uganda, one secondary) and unknown sources represented in Northern Territory (NT) stands (1970s plantings, some 20 ha), all threatened, 3) establishment of 142 grafted clones in both a 'gene recombination orchard' (GRO) and a conservation clone bank (CCB) to generate progeny with great diversity, and ensure protection of the germplasm, 4) establishment of first tests in 2005 of more than 400 clones from hedged seedlings (open pollinated from some 20 NT and Queensland select trees), 5) congregation of grafts of the seemingly-best 14/142 clones at one end of the CCB to promote production of seed from them to raise plants for new clone tests, and 6) selection of a site for a CSO needed to allow a future option of plantation establishment via seed or seedlings. Limited flowering occurred in the CCB in 2004. Planting a second-cycle, base population as open-pollinated, GRO families and infusions, to enable future selection of second-generation trees for on-going improvement, will follow procurement of seed after the first general flowering expected in 2005 or 2006.

**Radial basic density variation in different provenances of *Grevillea robusta* Cunn.** Povoá de Mattos, P., Martins, E.G. (*Embrapa Florestas, Brazil; povoa@cnpf.embrapa.br; emartins@cnpf.embrapa.br*); Brand, M.A., Bittencourt, E. (*Uniplac, Santa Catarina, Brazil; martha@uniplac.net; eduardo@uniplac.net*).

*Grevillea robusta* Cunn. was introduced in Brazil at the end of the 19<sup>th</sup> century. It has been cited in uses as wind and frost protection, energy source, and solid wood. At this stage, it is important to introduce wood quality variables in breeding programs of *G. robusta*. The aim of this work was to estimate radial basic density variation in wood samples of different prove-

nances of *G. robusta*. Samples were taken from seven-year-old trees, from a provenance test in the Itaipu Binacional area in Parana State, according to volumetric growth; considering excellent, intermediate, and slow growth. The samples were taken bark to bark from the central board, from the first log, making sub samples of 1 cm in the radial direction. Basic density was determined for each sub sample, and the radial variation percentage was established, considering the smallest and largest basic density value in the same ray. The average basic density was 0.47 g/cm<sup>3</sup>, and percentage of radial variation was 12.9%. There was variation of the radial basic density among provenances and progenies, but no correlation between radial variation of basic density and tree diameter was detected. More conclusive results should be obtained with a wider sample.

## Recent advances in Eucalyptus breeding

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**Wood density and uniformity index of Eucalyptus grandis and E. grandis x urophylla clones in Brazil.** Alzate, S.B.A. ([bibiana\\_arango@hotmail.com](mailto:bibiana_arango@hotmail.com)), Tomazello Filho, M. (University of São Paulo, Brazil), Roque, R.M. (Technology Institute of Costa Rica, Costa Rica).

In Brazil the genus *Eucalyptus* is widely used in reforestation programs and the concepts of clonal silviculture and multiple uses of the forests are intensively applied. The characterization of clones wood properties (wood density variability and uniformity) is essential to establish the possibilities of wood utilization, as ex.: solid wood, pulp and paper, boards, posts, etc. Eight years old- 10 *Eucalyptus grandis* and *E. grandis x urophylla* clones were selected from experimental plantations and collected wood samples for density uniformity research. Using the routine X-ray densitometric analysis were obtained the radial wood density profiles and the Uniformity Index-UI. The wood density and UI values were 0.46 (0.34–0.51) and 169.5 (142–206) in *E. grandis* clones, respectively, and 0.54 (0.49–0.58) g/cm<sup>3</sup> and 193 (192.2–202.7) in *E. grandis x urophylla* clones. The lower mean density values and higher uniformity presented by *Eucalyptus grandis* clones compared with *E. grandis x urophylla* clones constitutes a important wood quality parameter to be considered in eucalypts genetic programs with implication to wood properties and utilization.

**Resistance to rust (*Puccinia psidii* Winter) in Eucalyptus grandis progenies in Brazil.** Mello, E.J., da Silva, J.F., de Siqueira, L. (Suzano Bahia Sul Papel e Celulose S.A.; Brazil; [emello@suzano.com.br](mailto:emello@suzano.com.br); [jfsilva@suzano.com.br](mailto:jfsilva@suzano.com.br); [lsiqueira@suzano.com.br](mailto:lsiqueira@suzano.com.br))

Rust is one of the most damaging eucalypt diseases in Brazil. Elite hybrid clones involving *Eucalyptus grandis* are extensively used by the pulp and paper industry. However, *E. grandis* is one of the most-susceptible species to rust disease caused by *Puccinia psidii* Winter. The disease occurs on seedlings in nurseries, on young trees in the field, on coppice, and also on shoots in clonal gardens. The objective of this study was to evaluate rust resistance of 28 half-sib progenies of elite genetic material from the Suzano Pulp and Paper tree breeding program in São Paulo State and to select the best trees as clones for operational plantations. Traits assessed included: susceptibility index and total height at age six months, diameter at breast height, total height, total volume per hectare, and mean annual increment (MAI) at age seven years. Analysis showed the occurrence of variability among families for rust susceptibility at age six months, with susceptibility index ranging from 3.8–10.0. At age seven years, the Scott Knott cluster means analysis showed the existence of diversity between families. Based on this, we selected 252 best trees (30% of selection) according to the Smith and Hazel, 1943 Mass Selection Classic Index. This selection indicated a 98% gain on the MAI trait.

## Management and conservation of forest genetic resources

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**The potential uses of *Trilepisium madagascariense* DC for non-timber benefits and the need for its genetic conservation in southwest Ethiopia.** Adilo, M. (Ethiopian Agricultural Research Organization, Ethiopia; [mchilalo@yahoo.com](mailto:mchilalo@yahoo.com)), Senbeta, F. (University of Bonn, Germany), Yadessa, A. (Ethiopian Agricultural Research Organization, Ethiopia), Woldemariam, T. (University of Bonn, Germany).

Throughout human history, plants have made an important contribution to the life of local communities. They play a significant role in a wide range of socioeconomic systems as a source of foods, fuelwood, medicine, dyes, poisons, shelter, fibers and religious and cultural ceremonies. Accordingly, *T. madagascariense* is one of the economically and

ecologically important indigenous tree species occurring in the transitional montane rainforests of southwest Ethiopia. The objective of this paper is, to highlight the importance of *T. madagascariense* as source of non-timber forest products and to enhance its use and conservation. *T. madagascariense* has several uses: the fruit is edible, the bark is reported to be useful for treating stomach ulcers, rheumatism and anaemia; the roots are a remedy for impotence; the latex is used for making birdlime. However, deforestation is threatening the transitional montane rainforest of Ethiopia and the population of *T. madagascariense*. Therefore, there is a need to develop a conservation strategy *in situ* or *ex situ*, while using the tree species and its forest habitat in a sustainable way.

**Common and multiple ice-age refugia in two southern beeches (*Nothofagus* spp.).** Azpilicueta, M.M. (INTA EEA Bariloche, Argentina; [mmazpilicueta@bariloche.inta.gov.ar](mailto:mmazpilicueta@bariloche.inta.gov.ar)), Marchelli, P. (CONICET and INTA EEA Bariloche, Argentina; [pmarchelli@bariloche.inta.gov.ar](mailto:pmarchelli@bariloche.inta.gov.ar)), Gallo, L. (INTA EEA Bariloche, Argentina; [lgallo@bariloche.inta.gov.ar](mailto:lgallo@bariloche.inta.gov.ar)).

The current distribution area of southern South America Temperate Forests was highly affected during the Quaternary Age by glacial movement and climatic changes. Multiple ice-free areas, both in the Coastal and Andes regions, where species survived were selected for several recent single-specific studies. Assuming a common life history, joint analysis of two inter-fertile important species of these forests, *Nothofagus nervosa* and *N. obliqua*, was carried out. Chloroplast DNA genetic markers were analysed in 26 and 25 populations respectively through a PCR-RFLP technique (trnD-trnT/TaqI and trnF-trnV/TaqI). Six haplotypes were observed, three of them common for both species, with a coincident geographic distribution. A differentiation between Andes and Coastal Mountains was evident and higher haplotype diversity was detected in the coast. The two most frequent haplotypes had a north-south distribution pattern in the Andes. Intrapopulation variation was only detected in three populations of *N. nervosa*, east of the Andes. These results indicate the existence of at least four common ice age refugia where both species survived the glacial period. Coastal regions could have been a location for two of such refugia, being the other two located east or west of the Andes region.

**The role of CAMCORE in the *ex situ* conservation of forest trees.** Dvorak, W.S. (North Carolina State University, USA; [dvorak@unity.ncsu.edu](mailto:dvorak@unity.ncsu.edu)).

CAMCORE is an international conservation and tree domestication program located at North Carolina State University. The driving force for its formation in 1980 was private forest industry. CAMCORE has 19 industrial members located on four continents; donor countries are honorary members of the program. CAMCORE specializes in the *ex situ* conservation and tree improvement of tropical and subtropical species native to Central America, Mexico, and Southeast Asia. Since 1980, it has sampled 25 species of conifers, 366 provenances and 8506 mother trees in seven countries. During the same time period, 13 broadleaf species representing 148 provenances and 2665 mother trees were sampled in 12 countries. Participants in the program have established more than 1500 ha of provenance/progeny tests and *ex situ* conservation field plantings. In addition to tree conservation and breeding mandates, CAMCORE has expanded its research effort to include species characterization and development of pine hybrids. Species characterization includes detailed wood studies to relate wood quality to potential markets and disease resistance screening of its species for Pitch Canker. The pine hybrid program explores the potential of wide crosses between the US southern pines and the Mexican pines.

**Pollen morphology of Korean *Rosa* species.** Kim, S.-Y. (Korea National Arboretum, Republic of Korea; [rosaksy@foa.go.kr](mailto:rosaksy@foa.go.kr)), Kim, K.-H. (Chonbuk National University, Republic of Korea; [forestkk@chonbuk.ac.kr](mailto:forestkk@chonbuk.ac.kr)).

Since the genus *Rosa* exhibits severe morphological variation, the names of many species have been based on their minor differences, which have led to a great deal of controversy in delimiting taxonomic ranks and phylogenetic interpretation within the genus. This study was conducted to a) test phylogenetic utility of the pollen morphological characters in inferring phylogeny of Korean *Rosa*, and b) establish a classification system, by reviewing previous morphological classifications and using as much phylogenetic information as possible. To achieve these goals, pollen micro-morphology, one of the main phylogenetic characters, was analyzed from seven species of Korean *Rosa*. Examination of the pollen micro-morphology from eight taxa of the genus demonstrated that pollen grains were monad, tricolporate, and the sculpture pattern was striate. Two types of pollen, which differed in the height of ridge on the surface, were observed. Evolutionary direction of the observed sculpture patterns was contrary to the existing phylogenetic relationships, which suggest that the evolution of pollen characters is not consistent for all taxa and can be reversed.

**The role of regional collaboration in managing forest genetic resources in Europe.** Koskela, J., Turok, J., Bozzano, M. (International Plant Genetic Resources Institute, Italy; [j.koskela@cgiar.org](mailto:j.koskela@cgiar.org); [j.turok@cgiar.org](mailto:j.turok@cgiar.org); [m.bozzano@cgiar.org](mailto:m.bozzano@cgiar.org)).

Forest genetic resources have been on the agenda of the pan-European forest policy process since 1990. This has enabled development of strong regional collaboration through the European Forest Genetic Resources Programme (EUFORGEN),

established in 1994. First, the collaboration focused on developing *in situ* and *ex situ* conservation methods for model tree species and monitoring progress made at the national level as a response to various threats to European forests (e.g. acid rain and genetic erosion). Recently, the focus has been moving towards facilitating practical implementation of various recommendations and closer integration of gene conservation into sustainable forest management. This reflects changing needs identified by the forest policy process for managing the genetic resources. Forest genetic resources were considered only as a scientific issue while gradually it is being recognized that they are important for the whole forest sector. Subsequently, interaction between scientists, policy makers and managers, as well as collaboration between forest and others sectors, are becoming increasingly important for effective management of genetic resources. Lessons learnt during the past 10 years show clearly the benefits of keeping forest genetic resources in the political agenda and having a regional approach to promote conservation and sustainable use of these resources.

**Microsatellite mtDNA can be used to assess the genetic variability of Norway Spruce in different management systems in the Italian Alps.** La Porta, N., Muccinelli, I., Passerotti, S. (*IASMA, Italy; nicola.laporta@iasma.it; ivan.muccinelli@libero.it; passer8@yahoo.com*), Piovani, P. (*University of Parma, Italy; pio@dsa.unipr.it*).

It is important to have the right tools to monitor genetic variability in order to preserve the genetic resources and maintain the biodiversity both in natural forest populations and plantations. The choice and collection of seeds for reforestation processes can heavily affect the genetic variability of the population. Seeds collected from few mother plants or sometimes collected from adult plantations can create a dangerous genetic bottleneck to the future generations. To this purpose, we evaluated the genetic variability of different populations of Norway Spruce (*Picea abies* Karst.) coming from three different silvicultural management systems in the Eastern Italian Alps. The three analyzed systems were natural or natural-like forests, Italian plantations (aged 70–80 years), and Austrian plantations (aged 150–200 years). For each of the three systems, we obtained samples from four different management units, 50 plants/unit, for a total of 600 plants. Two different VNTRs mitochondrial primer sets were used to characterize the samples. The analysis of genetic variability in each group confirms the supposed higher biodiversity of the natural populations vs. plantations, with very few exceptions that can be explained with forest dynamic processes that took place after the original plantation. The differences between the populations are analyzed and discussed.

**Forest genetic resources conservation initiatives of the North American Forest Genetic Resources Working Group.** Loo, J.A. (*Natural Resources Canada, Canada; jloo@nrcan.gc.ca*), Vargas-Hernandez, J.J. (*Colegio de Postgraduados, Mexico*), Ledig, F.T. (*University of California, Davis, USA*).

The Forest Genetic Resources Working Group of the North American Forestry Commission has worked for more than 30 years on joint research, training and development and application of technologies to conserve and sustainably use forest genetic resources. The Working Group consists of three members from each of the countries of North America and work, focusing primarily on temperate conifers of Mexico, and is organized into tasks chaired by Working Group members. A large number of tree species and populations in Mexico are endangered by threats such as deforestation, over-exploitation, fire, grazing and climate change. Particularly at risk are small, high elevation populations of temperate conifer species that have close relatives distributed through western USA and into Canada. These populations contain unique genetic material of potential value to all three countries as climates warm and the valuable genetic resources are eroding rapidly in the face of ongoing threats. Examples of collaborative research among the three countries include genetic diversity and gene flow analyses of endangered Mexican *Picea* spp., genetic structure of isolated populations of *Pseudotsuga* and population genetics and ecology of *Pinus pinceana*. In addition to collaborative research, each of these projects includes development of practical recommendations and strategies for long-term conservation.

**Spatial structure and genetic diversity of three tropical tree species with different habitat preferences in a hill dipterocarp forest of Peninsular Malaysia.** Ng Kit-Siong, K., Lee, S.-L., Saw, L.-G., Lee, C.-T. (*Forest Research Institute Malaysia, Malaysia; kevin@frim.gov.my; leesl@frim.gov.my; sawlg@frim.gov.my; leechait@frim.gov.my*), Plotkin, J. (*Harvard University, USA; plotkin@ias.edu*), Koh, C.-L. (*University of Malaya, Malaysia; kohcl@um.edu.my*).

Analyses of the spatial distribution pattern and spatial genetic structure were conducted, using a 33-ha plot in a hill dipterocarp forest in Peninsular Malaysia. The trial involved *Shorea curtisii* (dominant on the ridges), *S. leprosula* (common in well-drained and swampy sites), and *S. macroptera* (abundant in hilly and lower parts of the forest). The estimated levels of genetic diversity, based on five microsatellite loci were high in all three species. The spatial distribution pattern analyses showed a random distribution pattern only in the large-diameter trees of *S. macroptera*. The significant spatial aggregation observed in all diameter classes of *S. curtisii* and *S. leprosula* was further proof that these species are habitat specific. Significant spatial genetic structure was observed for *S. curtisii* at short distances in both diameter classes, with the magnitude of spatial genetic structure increasing from small- to large-diameter trees.

For *S. macroptera* and *S. leprosula*, the significant spatial genetic structure was observed only in large-diameter trees. Given that high degree of micro-environmental heterogeneity does not directly affect *S. macroptera*, other ecological and evolutionary processes, such as intra- and inter-specific competitions, herbivores and plant diseases might shape the spatial genetic structure in the large-diameter trees.

**Relevance of marginal populations for breeding and conservation strategies in Patagonian Cypress.** Pastorino, M., Sá, M., Gallo, L. (INTA EEA Bariloche, Argentina; [mpastorino@bariloche.inta.gov.ar](mailto:mpastorino@bariloche.inta.gov.ar); [msa@bariloche.inta.gov.ar](mailto:msa@bariloche.inta.gov.ar); [lgallo@bariloche.inta.gov.ar](mailto:lgallo@bariloche.inta.gov.ar)).

*Austrocedrus chilensis* is the forest tree species that most penetrates into the Patagonian steppe, even surpassing the ecotonal line in sites with mean annual precipitation below 600 mm. Most marginal populations have been ignored until now because of their reduced size (patches of some 100 trees) and their poor forestry phenotypes. The aim of the present study is to evaluate their genetic resources in comparison with those of wetter conspicuous forests. Seeds of 310 trees from 11 marginal populations from the whole Argentinian range of the species were collected. Individuals were genotyped at 12 isozyme loci by subjecting at least six endosperms to horizontal starch gel electrophoresis. Intrapopulation variation was characterized through several classic parameters, which showed that marginal populations are more variable than non-marginal ones. In order to test adaptive characters as well, a germination trial was carried out in a greenhouse. Seeds from 194 progenies from the harvested populations were sown in a randomized complete block design, with three repetitions. The germination capacity and energy were high (73% and 34% respectively), compared to those reported for non-marginal populations. From the results, it seems evident that marginal populations from the steppe harbour valuable genetic resources of Patagonian Cypress.

**Ex-situ conservation of *Khaya madagascariensis*.** Ramamonjisoa, L. (National Tree Seed Centre, Madagascar; [lolona.sngf@wanadoo.mg](mailto:lolona.sngf@wanadoo.mg)).

A National Strategic Plan of Forest Genetic Resources Management was established for Madagascar in 2000; its purpose was to promote a new orientation in research on indigenous species. The aim of research on artificial regeneration was *ex situ* conservation. Criteria for choosing species are: threat, and social and economic value at the local, regional and international levels. *Khaya madagascariensis* (Acajou de Madagascar), included in Meliaceae family, is one of the species that merits priority. It comes from a small specific region in the north-west within a humid tropical climate and grows in alluvial forests. The *Khaya* population is fragmented, and the genetic pool is declining along with the capacity for natural regeneration. Fragmentation of the species is due to overexploitation by local communities for timber, and for medical and aromatic usage. Objectives of the research on *ex-situ* conservation of *Khaya madagascariensis* are a) determination of the effect of seed storage factors such as humidity rate, containers, and temperature on seed viability, and b) establishment of *ex-situ* protective plantations. Provenances located nearest to plantation sites were more adapted than those further away

**Analysis of genetic diversity of Oriental beech (*Fagus orientalis* Lipsky) populations as the basis for development of gene conservation strategy in Hyrcanian forests, Iran.** Salehi Shanjani, P. (Research Institute of Forests and Rangelands, Iran; [psalehi@rifr-ac.ir](mailto:psalehi@rifr-ac.ir)), Vendramin, G.G. (CNR, Italy; [giovanni.vendramin@igv.cnr.it](mailto:giovanni.vendramin@igv.cnr.it)).

The Hyrcanian forests in Iran represent the most preserved forest ecosystems that have remained from the Tertiary period and are considered to be relic ecosystems. Pure and mixed beech (*Fagus orientalis* Lipsky) stands are the most important forests in the Caspian zone. Beech forests cover around 17.6 % of Hyrcanian forests surface and represent about 25 % of forest trees volume in Iran. In this study, we analyzed 13 beech populations along an east-west gradient within the Hyrcanian forests, using polymorphic nuclear- and chloroplast simple sequence repeats, nSSRs and cpSSRs, respectively. Chloroplast markers revealed a very strong differentiation among populations (Fst 80%). The analysis of molecular variance (AMOVA) showed that 52% of the total cpSSR variation was attributable to differences among regions, 28% to differences among populations within regions and 20% to differences within populations. Nuclear SSRs confirmed the presence of significant differentiation among populations and among geographic regions, even if, as expected, less pronounced than using cpSSRs (4% and 3% of total nSSR variance due to differences among regions and among populations within regions, respectively). Possible applications of these results for the certification of provenances and/or seed lots and for designing conservation programs are presented and discussed.

**Conservation of forest genetic resources on farms: Diversity makes a difference.** Simons, A.J. (World Agroforestry Centre, Kenya; [t.simons@cgiar.org](mailto:t.simons@cgiar.org)), Kindt, R., Lengkeek, A., Boffa, J.M., Tchoundjeu, Z., Akinnifesi, F., Roshetko, J., Cornelius, J.P., Jamnadass, R., Kalinganire, A.

Forest and agricultural farms both account for approximately 38% of tropical land area, each dwarfing forest plantation area more than twenty-fold. Whilst natural forests contain ten times as many species and ten times as many individual

trees as agricultural land, they face enormous pressures from agricultural expansion, extractive production and climate change. Although trees on farms are largely viewed for their productive functions, they also present opportunities for conservation of tree genetic resources on farm. Moreover, they provide ecological and genetic buffering capacity for integrated approaches to landscape level conservation. Data from tree diversity studies of farms in Africa, Latin America and Asia highlight the interspecific and intraspecific conservation role of trees on farms. More worryingly, the data also reveal the bottlenecks associated with remnant trees and natural regeneration as founder populations. In addition, dangers for some taxa are indicated following unstrategized introduction, selection and diffusion of tree germplasm. The prospects for varietal, population, species and landscape level conservation are discussed against the background for the need for productive diversity on farms to contribute to attainment of the millennium development goals.

**Role of sengon (*Paraserianthes falcataria*) genetic diversity in sustainability of community forest in Java, Indonesia.** Siregar, U.J., Wulan, R., Siregar, I.Z. (*Bogor Agricultural University, Indonesia; ulfahjsiregar@yahoo.com; isirega@gwdg.de*), Sunarya, S. (*Winaya Mukti University, Indonesia; sopandies@yahoo.com*), Winarni, I. (*R&D Centre for Forest Product, Indonesia; inawinarni2003@yahoo.com*).

Sengon (*Paraserianthes falcataria*) community forestry in Java has a long history, but efforts to establish pure sengon plantations have been hampered by attack of the stem borer (*Xystrocera festiva*). This study investigated genetic diversity presence in a sengon community forest that might have an important role in its sustainability. Using isozyme 9, sengon populations in West, Central and East Java were investigated for 14 loci of 7 enzyme systems. Polymorphism was found in 7 loci, with average number of allele 1.54. Expected heterozygosity was 0.172, indicating relatively high diversity, due to a high outcrossing rate (81%). In order to find diversity in plant resistance to the stem borer, investigation of the activity of trypsin inhibitor in the stem was done. Variation on trypsin inhibitor activity was found across 3 different age classes and 3 populations, ranging from 5.28 to 9.70 units/mg of sample. The finding of high trypsin inhibitor activity in 10-year old trees from Sukabumi is of interest for the tree improvement program; the stem borer is reported to attack trees older than 4 years old, when trypsin inhibitor activity is assumed to have decreased.

**Global state of research on forest tree genetic diversity.** Ståhl, P.H. (*The Forestry Research Institute of Sweden, Sweden; per.stahl@skogforsk.se*)

IUFRO Task Force 4, Management and Conservation of Forest Genetic Resources, was established in January, 1998. The Task Force was asked to gather and synthesize information and detect knowledge gaps. A questionnaire was developed and distributed to IUFRO members in 2000 to determine the state of research on forest genetic resources and its relation to various disciplines: policy, behaviour and society, economy, management and operations, ecology and environment, and biology. The initial response was poor so the questionnaire was sent a second time in 2002. A total of 88 replies were received and more than half of them were from Europe. Respondents were asked to rate the state of the knowledge of the relationship between forest genetic resources and each of the disciplines for major and minor forest tree species. In general the knowledge concerning management, ecology and biology aspects is more complete than policy, societal and economic aspects, though there are serious knowledge/research gaps, with respect to genetics, in all disciplines and in all areas of the world. The relatively poor response to the questionnaire from IUFRO members may signal that little attention is paid to genetic resources in many areas of forest research.



## Sub-theme: Meeting the Challenge of Climate Change

### Meeting the challenge of climate change

Organizer: Lauri Valsta University of Helsinki, Finland; [valsta@helsinki.fi](mailto:valsta@helsinki.fi)

**Monitoring and baseline methodologies for carbon sequestration in forests.** Brown, S. (*Winrock International, USA; [sbrown@winrock.org](mailto:sbrown@winrock.org)*).

Now that the Kyoto Protocol has been ratified, interest in forest-based carbon sequestration CDM projects is increasing. Various 'players' are engaging in carbon sequestration CDM projects, and they will need to prepare project design documents (PDDs). These PDDs require the documentation of baseline and monitoring methodologies. The IPCC Good Practice Guidance provides guidance for monitoring methodologies but little guidance on baselines. There are currently no standard practices for developing baselines and most pilot project baselines have been produced on a case-by-case basis. I will present examples of approaches used to develop baselines for several existing projects. The carbon benefits for afforestation/reforestation (A/R) projects have been shown to be easier to measure and monitor than national inventories, partly because not all pools need measuring: a selective accounting system can be used that must include all pools expected to decrease and choice of pools expected to increase as a result of the project. Such a system allows for trade-offs between expected carbon benefits, costs, and desired precision. Techniques and methods for accurately and precisely measuring individual carbon pools in forestry projects exist, and have been well tested in many part of the world. I will present our experience with several forestry projects that demonstrate that the use of these techniques can readily estimate carbon stocks to be within less than  $\pm 10\%$  of the mean at modest cost. Satellite remote sensing technology may be useful for monitoring forestry projects in the future, though at present it has met with limited success at the accuracy and precision needed for A/R projects. I will present some promising techniques using airborne systems that are developing that can provide cost-effective means for monitoring changes in carbon stocks to known levels of precision for complex forests.

**Forests and forest products in climate change mitigation.** Valsta, L. (*University of Helsinki, Finland; [lauri.valsta@helsinki.fi](mailto:lauri.valsta@helsinki.fi)*), Sedjo, R.A. (*Resources for the Future, USA; [sedjo@rff.org](mailto:sedjo@rff.org)*), Pingoud, K. (*Finnish Forest Research Institute, Finland; [kim.pingoud@metla.fi](mailto:kim.pingoud@metla.fi)*), Gustavsson, L. (*Mid-Sweden University, Sweden; [leif.gustavsson@miun.se](mailto:leif.gustavsson@miun.se)*).

Forests and forest products have a wide-ranging impact on the carbon dioxide concentration of the atmosphere. The annual increase in atmospheric carbon (ca. 3 GtC) amounts to less than 0.3 % of carbon stored in forest vegetation and soils. Hence, modest changes in this storage are influential. Recent studies estimate the terrestrial net sink to be from 0.7 to 1.4 GtC. The global annual carbon flow through forest harvests is estimated to be 1–1.5 Gt, of which 0.35 Gt is in industrially-processed wood. Aside of land use change, forest management practices and the use patterns of forest products significantly influence the amount of the mitigation effect of the whole forest sector. We analyze the tradeoffs between economic goals of forest management and the objective of maximizing carbon storage in forests as well as the carbon flow from forests. To obtain the total forest-based impact, we then add the effects of energy and material substitution based on the use of forest products. The magnitude of the substitution effect is variable across world regions and technologies. We provide updated estimates for current and potential effects based on case studies and large-scale statistics.

**Prospects for markets for carbon offsets from forests.** Brand, D. (*Hancock Natural Resource Group, Australia; [dbrand@hnrng.com.au](mailto:dbrand@hnrng.com.au)*).

Despite the accepted importance of forest ecosystems as a key part of the global carbon cycle and an important reservoir or pool of carbon, the integration of forests into greenhouse gas emissions trading has been slow to develop. While emissions trading seeks to find the lowest cost solution to reducing net greenhouse gas emissions, the use of forestry offsets is questioned on the basis of permanence and accounting accuracy. Over the past two years, however, substantial progress has been made in establishing forestry offsets as a 'carbon credit' in emerging carbon markets. This paper will review the status of forestry offsets in the Kyoto Protocol including the Clean Development Mechanism, the EU Emissions Trading Regime, the NSW Greenhouse Gas Abatement Scheme, and the Chicago Climate Exchange. In addition, new forestry carbon initiatives such as the California Forestry Carbon Registry and the New Zealand Permanent Forest Sinks Initiative will be reviewed. These nascent markets and regulations are generating greater confidence in the regulations and methodologies necessary to create confidence in forestry offsets as an environmental commodity.

**Widening the inclusion of forests beyond Kyoto 2012 targets: What are the options?** Schlamadinger, B. (*Joanneum Research, Austria; bernhard.schlamadinger@joanneum.at*), Kirschbaum, M.U.F., Dutschke, M., Penman, J., Trines, E., Ward, M., Freibauer, A., Brown, S., Canadell, P., Ciccacese, L., Marland, G., Michaelowa, A., Pingoud, K., Rametsteiner, E., Yamagata, Y., Somogyi, Z., Bird, N., Hoehne, N., Pena, N., Smith, P., Labat, A., Fiedler, J.

Parties to the Protocol are to initiate negotiations for commitments after 2012 in 2005, at least seven years before the end of the first commitment period (Article 3.9). In this light, this is an opportune time to revisit the inclusion of forestry: What it aims to achieve and how climate policy post-2012 could be designed to reach these goals. This presentation will summarize the findings of a workshop that will take place in May 2005 and is designed to bring together experts on issues surrounding land use, land-use change and forestry (LULUCF) and to allow them to discuss and formulate options for inclusion of LULUCF in an international climate change agreement beyond 2012.

In particular, the presentation will: a) assess and discuss the benefits and difficulties of LULUCF within the Kyoto Protocol; b) discuss the objectives for LULUCF in a post-2012 international climate change agreement; c) discuss improvements to the current modalities, new activities for inclusion within a post-2012 international climate change agreement (such as deforestation in developing countries); and alternative architectures for consideration of LULUCF; and d) evaluate the options identified.

## **Tree rings as indicators of the impact of environmental changes on forest growth**

Organizer: Paolo Cherubini *WSL, Switzerland; paolo.cherubini@wsl.ch*

### **Indirect human-induced effects promote carbon pools in temperate forest chronosequences.**

Bascietto, M., Matteucci, G., Scarascia-Mugnozza, G. (*University of Viterbo, Italy; giuseppe.scarascia@ibaf.cnr.it*).

Carbon sequestration and its driving variables are important in understanding the role of forest ecosystems in the global carbon cycle. Direct biomass measurements and dendroecological methods were used to assess aboveground pool (stock) and flux (stock changes) of Norway spruce stands of different ages in the Tharandter Wald (Central Europe). To evaluate whether the C sink pool has increased in younger forest stands compared to older stands we sampled pools and fluxes of four stands belonging to a chronosequence, and compared the results with a sampled external older site. A two-stage Randomized Branching Sampling was used to provide estimates for the aboveground pool, flux, and surface area of stem, branch, and needle compartments. LAI and annual carbon flux peaked in the 43-year old stand (11.8 m<sup>2</sup>/m<sup>2</sup>, 8.58 t C/ha/yr, respectively), and decreased in older stands. There was 51% (0.92 t C/ha/yr) more annual carbon growth in the middle-aged stand compared to the mature one, while differences between the young and the middle-aged stand, although detectable, were less significant. The constancy of forest management practices throughout the years made it possible to relate the observed carbon growth enhancement to faster tree growth caused by environmental changes.

**Periodicity and growth rate of five promising tropical tree species from semideciduous forests in southeast region of Sao Paulo State, Brazil.** Botosso, P.C. (*Embrapa Florestas, Brazil; botosso@cnpf.embrapa.br*), Tomazello Filho, M., Lisi, C.S., Maria, V.R.B. (*ESALQ/Universidade de São Paulo, Brazil; mtomazel@esalq.usp.br; cslisi@carpa.ciagri.usp.br; vivibap@ig.com.br*).

Growth rate and periodicity in girth increment were studied in five woody species that are potentially promising for restoration and silviculture, based on wood anatomy, phenology and diameter growth measurements. Permanent steel dendrometer bands were fixed in the trunks of 27 selected trees from a plantation of known age (*Tabebuia serratifolia* – Bignoniaceae; *Cedrela fissilis* – Meliaceae; *Dipteryx alata* – Papilionoideae; *Copaifera langsdorffii* – Caelsapinoideae; *Cariniana estrellensis* – Lecythidaceae) and girth increments were evaluated during 33 months. Cambium activity was reduced or ceased in the dry winter season probably due to water stress. Expressive growth rates were detected after the first rainfall, demonstrating that the largest period of wood formation corresponds to the rainy season and a longer phase of permanence of the leaves. Higher average trunk girth increments were observed in species with lower wood specific gravity (SG) and slower growth in higher wood SG species. Girth increment may be influenced by several climatic parameters, but the most important variable is the soil water deficiency, inducing leaf fall and seasonal growth behaviour. Growth rings as a source of cyclic structural change of growth periodicity were observed. This methodology is a potential tool to determine age and growth rate of tropical trees.

**Ecological trends in the wood anatomy of some trees from Atlantic rain forest in south of Brazil: Growth rings and vessels.** Botosso, P.C., Povoá de Mattos, P. (*Embrapa Florestas, Brazil; botosso@cnpf.embrapa.br; povoá@cnpf.embrapa.br*), Galvão, F., Roderjan, C.V., Kuniyoshi, Y.S. (*Departamento de Ciências Florestais, UFPR, Brazil; fgalvao@floresta.ufpr.br; roderjan@floresta.ufpr.br; yoshiko@floresta.ufpr.br*).

There is not much information on growth dynamic and ecology of tree species growing in the Brazilian Atlantic forest domain, now reduced to less than 7% of its original area. Ecological trends based on wood anatomy were observed in some representative woody species occurring within this ecosystem in the state of Paraná. Data on tree rings, qualitative and quantitative vessel features (arrangement, grouping, diameter and element length) were analyzed in tree species growing in lowlands forests, mixed forests and dense montane forests situated at 0–20m, 800–1200m and >1200m above sea level, respectively. Non-destructive small wood samples were collected and prepared for macro and microscopic observations. The presence of growth rings was associated with seasonal environments in terms of temperature, humidity and soil water balance. Preliminary results show that vessel elements seem to be smaller and occur more frequently in multiples at higher altitudes and in environments affected by thermal seasonality. The wood of species from lowland forests appears to be at least as well adapted to efficient water transport as to safety for hydraulic conduction during periods of physical or physiological drought. These results are compatible with ecological trends established by other authors for other floras and/or taxa.

**Increased productivity of old-growth baldcypress (*Taxodium distichum*) in the southern United States.** Devall, M.S., Reams, G.A. (*US Forest Service, USA; mdevall@fs.fed.us; greams@fs.fed.us*).

Baldcypress (*Taxodium distichum*) is a long-lived deciduous conifer that grows in intermittently flooded and poorly drained areas of the southeastern United States. Practically all the virgin baldcypress stands were logged during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, and most baldcypress that exists today is second growth. A few old-growth trees remain, but most are hollow. We located and cored solid baldcypress trees up to 1375 years old along the Tangipahoa and Pearl Rivers in southeastern Louisiana, and crossdated and measured the rings. We converted average ring width to basal area increment data because basal area is a better indicator than ring width of actual tree productivity. The old-growth trees (>1000 years) from both areas show increased growth since about 1950. The younger old growth (500–1000 years) from the Pearl River demonstrate less accelerated growth during the same period and those from the Tangipahoa River have maintained relatively constant basal area increment. It is surprising that very old trees are increasing in radial growth because the ratio of photosynthesis to respiration decreases in older trees. A possible explanation is that the increased growth is due to CO<sub>2</sub> enrichment.

**Ring growth of *Quercus liaotungensis* on the Chinese loess plateau in relation to climatic factors.** Du, S., Yamanaka, N., Yamamoto, F. (*Tottori University, Japan; shengdu@alrc.tottori-u.ac.jp, yamanaka@alrc.tottori-u.ac.jp, fukuju@muses.tottori-u.ac.jp*), Otsuki, K. (*Kyushu University, Japan; otsuki@forest.kyushu-u.ac.jp*), Wang, S.Q., Hou, Q.C. (*Chinese Academy of Sciences, China; shengqi\_wang@yahoo.com.cn, houqch@ms.iswc.ac.cn*).

Annual ring growth of a natural *Quercus liaotungensis* forest bounded by a desertified region in the loess plateau of China was investigated for evidence of environmental influence. Increment cores of 120 trees were sampled from six stands about 500 m apart from each other. The sampled trees were growing in the middle part of moderate slopes facing north, north-east or north-west, and climatological data were obtained from the nearest meteorological station of Yan'an city, Shaanxi province. The results of correlation analyses between standardized data of annual ring growth and climatic factors showed that ring growth variability is correlated with both inter- and intra-annual climate variation. Ring growth was positively correlated not only with annual precipitation, but also with high precipitation in early summer and the previous autumn. Summer high temperatures negatively affected ring growth, while a mild temperature in late autumn of the previous year showed a positive effect. The extent of growth reduction and release varied spatially, probably as a result of microenvironment and the resulting soil water condition.

**Correlation between weather conditions and tree growth for Scots pine and Norway spruce in northern Sweden.** Elfving, B., Freeman, M., Mörling, T. (*Swedish University of Agricultural Sciences (SLU), Sweden; michael.freeman@spek.slu.se; tommy.morling@ssko.slu.se*).

Correlation between estimated stem biomass growth according to a process-based model and observed growth on increment cores for Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst) was analysed under boreal conditions. Continuous observations on radiation, temperature and precipitation were used to estimate annual stem biomass growth in the period 1980–2001, using the model, Biomass, adapted to boreal conditions. In autumn 2001, 180 increment cores from 90 trees were gathered within 2 km from the site of climatic measurements from three undisturbed stands of each species. Measurement of annual ring characters was made with a flat beam x-ray wood scanner. Species mean index series were used to relate observed and predicted annual growth. Ring width indices correlated well with the official species-wise series for the region but the correlation between indices for pine and spruce was low. Wood density

indices for the species had a higher correlation. Estimated biomass growth was not significantly correlated with ring width indices but the correlation with ring wood density indices was significant for both species. The results indicate that ring wood density, but not ring width, is related to the annual variation in general growing conditions.

**Tree-ring variability of *Araucaria columnaris* (Forster) Hook trees in São Paulo State, Brazil.** Medeiros, J.G.S., Tomazello Filho, M. (*Department of Forest Sciences/University of São Paulo, Brazil; jeangm@esalq.usp.br*).

*Araucaria columnaris* trees, originated from New Caledonia, an island group in the Pacific Ocean, and are widely planted in parks and green areas of Brazilian cities, due to their crown size and architecture. In urban areas, this species is exposed to anthropogenic factors and is useful in dendrochronological research for analyzing the growth effects of environmental quality. Wood cores were extracted by an increment borer from 12 *A. columnaris* trees and the tree rings were characterized by applying anatomical and X-ray densitometry methodologies. The results showed radial variability in tree rings. Juvenile wood (central core) presented growth rings that were light coloured, with distinct boundaries that changed, gradually, from earlywood to latewood. Mature wood had distinct tree rings but with an abrupt transition from latewood to earlywood. These features were related to tracheid dimensions, and wood density. The annual and accumulative tree-growth increments of *A. columnaris* trees were discussed as an index of environmental effects.

**Influence of climate, soil and stand variables on cork growth.** Paulo, J.A., Tomé, M. (*Instituto Superior de Agronomia, Portugal; joanaap@isa.utl.pt; magatome@isa.utl.pt*).

Samples from mature cork of *Quercus suber* L. extracted in the period from 1996 to 2003 in sites distributed around Portugal were used for this investigation. Growth trends of the width of respective cork rings after 8 to 10 years of growth were analyzed and compared with the prediction from an existing cork growth model, only dependent from individual tree variables. The residuals produced in this comparison were used to investigate the relationship between cork growth and climate (temperature and precipitation), soil, and stand variables. The considered model was then refitted by incorporating climate variables, which proved to be related with cork growth. This model was then used to evaluate the consequence of climatic changes on cork growth, based on climate scenarios specific for Portugal.

**Growth periodicity of *Ocotea porosa* and *Araucaria angustifolia* from plantation in the southern Brazil.** Pova de Mattos, P., Botosso, P.C., Carvalho, P.E.R. (*Embrapa Florestas, Brazil; povoa@cnpf.embrapa.br; botosso@cnpf.embrapa.br; ernani@cnpf.embrapa.br*), Tomazello Filho, M. (*ESALQ-USP, Brazil; mtomazel@esalq.usp.br*).

*Ocotea porosa* (Nees) Angely and *Araucaria angustifolia* Kuntze are very important commercial tree species in Brazil but they are being threatened by natural exploitation. Silvicultural studies were conducted to overcome this problem. It was also necessary to understand their growth behaviour in plantations, and under different regimes of precipitation and temperature. This work aimed to study radial growth by analyzing the growth rings of 13-year old trees, (three of *A. angustifolia* and two of *Ocotea porosa*), from an experimental plantation in the Giacomet Marodin Company area of Quedas do Iguaçu, Paraná State. Wood samples were taken from breast height level, and were prepared for microscopic analysis and measurement of the growth rings. Growth rings were distinct in both species, and their identification was more difficult in the earlier years. It was possible to verify the tendency of growth variation related to precipitation. On average, *O. porosa* had an annual growth increment of 4.6 mm and *A. angustifolia*, 7.0 mm. For both species, growth rate was higher in the earlier years, and average increment decreased in the last five years. This effect was more evident in *A. angustifolia*.

**High resolution records of temperature change during the last millennia in high latitudes of Siberia, Russia.** Sidorova, O.V., Vaganov, E.A., Naurzbaev, M.M. (*Russian Academy of Sciences, Russian Federation; ovsidorova@forest.akadem.ru*).

The local tree-ring chronologies from Siberian dendroclimatic network and millennia tree-ring chronologies from northern Eurasia were developed. The analysis of long-term climatic changes in Siberian sub-Arctic for the last 400 years showed a high correlation between local chronologies and the earlier summer temperature ( $R = 0.69-0.84$ ), and thus, allowed one to apply this chronology for temperature reconstruction. Combined north Siberian chronologies were compared with the other climate proxies of the circumpolar Northern Hemisphere, which showed significant correlation for the pre-industrial- and industrial periods, as well. The correlation analysis was applied to evaluate the influence of the main climatic forcing factors (solar radiation, volcanic activity, increase of CO<sub>2</sub> concentration) on combined tree-ring series. It was shown that solar radiation and volcanic activity explained more of the common variability in temperature changes than the CO<sub>2</sub> concentration.

**Growth trends in European forests and their potential causes.** Spiecker, H. (*Albert-Ludwigs-University, Germany; instww@uni-freiburg.de*).

Forest growth changes are observed in various time scales. Year-specific growth variations are well known to dendrochronologists. Medium-term growth fluctuations often are observed when permanent research plot data, repeated forest inventory data series or tree analysis data are evaluated. In addition, long-term growth trends may occur in several decade-long observation periods. Various factors are affecting forest growth. This presentation intends to exclude effects of management on growth such as effects of weed control, regeneration techniques, initial spacing, tending, thinning, species selection, species mixture and stand structure, genetic improvement, and age structure. The study also tries to discriminate between the effects of planned fertilization, liming, drainage, effects of insect and fungi attacks, effects of storm, snow and fire and the effects of other factors which determine forest growth. The analysis concentrates on site-induced changes in forest growth, evolving from possible changes in air temperature, precipitation, nitrogen input, elevated CO<sub>2</sub> and from past litter racking. The study is based on empirical observations from stem analysis of dominant trees. Growth variations and growth trends are described and possible causes identified.

**Effects of atmospheric nitrogen deposition on tree growth in temperate forests in Switzerland.** Waldner, P., Cherubini, P., Stähli, M., Thimonier, A., Schmitt, M. (*WSL, Switzerland; peter.waldner@wsl.ch, paolo.cherubini@wsl.ch, manfred.staehli@wsl.ch, anne.thimonier@wsl.ch, maria.schmitt@wsl.ch*).

Human activities such as burning of fossil fuels have affected the atmosphere. As a consequence, natural ecosystems in central Europe have been exposed to i) a four-fold increase in nitrogen deposition, ii) an increase in carbon dioxide concentration of more than 50 ppm, and iii) an increase in temperatures of about 1.5 °C during the last century. Tree ring widths and long temperature records have largely been used to show the impact of increased temperature on tree growth and net primary production. However, long records of atmospheric nitrogen deposition are scarce and have rarely been correlated with tree ring widths. In this study, we used climate and deposition records and tree core samples from Swiss Long-Term Forest Ecosystem Research (LWF) plots at various environmental conditions to investigate the effect of nitrogen deposition on tree radial growth. Temperature and CO<sub>2</sub> increased globally, but a rise of tree radial growth was only found at sites that now have a high nitrogen deposition. This indicates that net primary production was strongly influenced by nitrogen deposition. Results from correlation analyses of more than 20 years of monthly nitrogen deposition, other climatic parameters and tree ring data will also be presented.

**Use of tree ring data to test a broad-scale model of forest productivity in Australia.** Waterworth, R., Brookhouse, M., Kesteven, J. (*Australian National University, Australia; robert.waterworth@anu.edu.au*).

Australia's National Carbon Accounting System (NCAS) has developed a continental Forest Productivity Index (FPI) which estimates monthly productivity at 1km resolution from 1970–2003, using a simple process-based model. Good agreement has been found between the long-term average FPI and aboveground biomass at or near maturity in native forests, allowing broad-scale modelling of biomass stocks. However little work has been conducted on testing the FPI over short time periods. Few long-term growth experiments exist in Australia's less commercially productive native forests, leading to a paucity of data for testing the FPI. The majority of Australia's forests are dominated by eucalypts. Eucalypts have typically been characterized as unsuitable for tree-ring analysis due to difficulty of identifying annual rings, relatively short life-spans and the impacts of insect defoliation. Hence, eucalypt tree-ring data have been under-utilized in Australia. However, sufficient tree-ring measurements have been successfully carried out in eucalypt species to allow comparison with the FPI. This presentation will discuss the development of the FPI, eucalypt tree-ring sampling and measurement, and the value of broad-scale hybrid growth models. Application to plantation systems and limitations of tree-ring measurements in testing models of biomass production will also be discussed.

**Effect of boron, genotype and site conditions on intra-ring checking in radiata pine.** Xue, J.M., Clinton, P.W., Beets, P.N., Kimberley, M., Graham, D., Leckie, A., Payn, T.W. (*New Zealand Forest Research, New Zealand; jianming.xue@forestresearch.co.nz*).

Intra-ring checking in radiata pine is a significant concern to New Zealand wood processors. Intra-ring checking appears to arise following collapse of cells with insufficient cell wall strength to withstand tension forces associated with wood drying. Boron (B) plays an important role in improving cell wall integrity and growth and wood quality by linking to the rhamnogalacturonan II fraction of pectic polysaccharides and other vital cell activities. Site factors (mainly soil moisture) are also assumed to affect intra-ring checking in radiata pine. This study, consisting of 5 genotypes 5 rates of boron fertilizer (0, 4, 8, 16, 32 kg B/ha) 2 weed treatments at each of two sites, was carried out to investigate the extent and patterns of the interactions between the tested factors in relation to the intra-ring checking in radiata pine. The links between the intra-ring checking and boron concentration and the C isotope ratio in the wood were also examined.

## Global fire trends and climate change

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**Estimating annual carbon emissions from Canadian wildland fires.** de Groot, W.J., Landry, R., Banfield, E., Peters, V., Anderson, K.R., Kurz, W.A., Hall, R.J., Lynham, T.J., Fraser, R.H., Englefield, P., Jin, J.-Z., Carr, R., Pritchard, J. (*Natural Resources Canada, Canada*; [bill.degroot@nrcan.gc.ca](mailto:bill.degroot@nrcan.gc.ca)).

Wildland fires burn an average of 2 million ha of forest annually in Canada. A wide range of fuel types and burning conditions contribute to large inter-annual variability in area burned and carbon emissions. In support of Canada's national forest carbon monitoring, accounting, and reporting system, a fire and carbon emissions project was initiated using a boreal pilot study to develop and test a method to provide annual estimates of national carbon emissions from fires. The Project is housed within the Canadian Wildland Fire Information System (CWFIS) which integrates multi-source data for national-level products. Area burned and daily fire spread are derived from satellite products. Spatially and temporally explicit burning conditions for each fire are determined using fire weather data from the CWFIS. The Carbon Budget Model for the Canadian Forest Sector (CBM-CFS) provides detailed fuel type and pre-fire fuel load data. The CWFIS calculates the fuel consumption for different biomass pools in each burned cell based on fuel type, fuel load, burning conditions, and fire behaviour using a fire effects model. Carbon emissions are calculated from fuel consumption. The CWFIS performs the fire-initiated transfer of biomass between pools, and the CBM-CFS uses the new pool data to calculate post-fire carbon dynamics.

**Fire and climate change in boreal forests.** Flannigan, M.D., Logan, K.A., Stocks, B.J., Wotton, B.M., Todd, J.B. (*Natural Resources Canada, Canada*; [kimlogan@nrcan.gc.ca](mailto:kimlogan@nrcan.gc.ca), [bstocks@nrcan.gc.ca](mailto:bstocks@nrcan.gc.ca), [mike.wotton@utoronto.ca](mailto:mike.wotton@utoronto.ca), [btodd@nrcan.gc.ca](mailto:btodd@nrcan.gc.ca)).

Fire is the major stand-renewing agent for much of the circum-boreal forest, and greatly influences the structure and function of boreal ecosystems from regeneration through mortality. Current estimates are that an average of 5–15 million ha burn annually in boreal forests, almost exclusively in Siberia, Canada, and Alaska. There is a growing global awareness of the importance and vulnerability of the boreal region to projected future climate change. Fire activity is strongly influenced by four factors: weather/climate, fuels, natural ignition agents, and humans. Climate and weather are strongly linked to fire activity which suggests the fire regime will respond rapidly to changes in climate. Recently, the climate of the northern hemisphere has been warming due to an influx of radiatively active gases (carbon dioxide, methane etc.) resulting from human activities. This altered climate, modeled by General Circulation Models (GCMs), indicates a profound impact on fire activity in the circum-boreal forest. Recent results using GCMs suggest that in many regions, fire weather/fire danger conditions will be more severe, with longer fire seasons and increases in: area burned, people-caused and lightning-caused ignitions, and the intensity and severity of fires. Ongoing fire/climate change research is designed to determine the impact of a climate change altered fire-regime on the landscape and develop options for future adaptation and mitigation strategies.

**Application and development of forest fire danger rating system in Korea.** Lee, S.I., Won, M.S., Lee, M.B., An, S.-H., Kim, D.H. (*Korea Forest Research Institute, Republic of Korea*; [LSY925@foa.go.kr](mailto:LSY925@foa.go.kr); [mswon@foa.go.kr](mailto:mswon@foa.go.kr); [mblee@foa.go.kr](mailto:mblee@foa.go.kr); [shan508@daum.net](mailto:shan508@daum.net); [k3d2h1@foa.go.kr](mailto:k3d2h1@foa.go.kr)).

The objective of this project was to develop the Korean Forest Fire Danger Rating Index (KFFDRI) to forecast the danger of forest fire occurrence for the reduction of forest fires. The KFFDRI consists three indices, each with a scale of 1–10: daily weather (DWI), fuel model (FMI), and topography model (TMI). DWI uses meteorological characteristics such as effective humidity, temperature, and wind speed, and is adapted to local conditions using one of eight logistic regression models. Both FMI and TMI were derived from analysis of forest type and site features of 126 forest fires. In addition to the modeling and analysis, various factors affecting forest fire occurrence were analyzed with a thematic map based on forest type, topography, administrative units, and meteorological data. The forest fire hazard index is used to produce hazard indices on the web in real-time. The system uses a Windows 2000 NT Server as the platform, with ArcGIS 8.3 as the analysis tool, and Arc IMS as internet map server. VB.NET and Avenue were used for programming. The web-based forest fire danger rating system is updated hourly, providing Koreans with real-time information on actual fire hazards.

**Temporal analysis of the Keetch-Byram Drought Index of selected stations in Malaysia: implications for forest fire management.** Nuruddin, A.A., Ampun, J., Yusof, M.S.M. (*Universiti Putra Malaysia, Malaysia*; [ainuddin@forr.upm.edu.my](mailto:ainuddin@forr.upm.edu.my)).

Keetch-Byram drought index (KBDI) is used by forest fire managers to integrate weather elements into a numerical index for risk of fire, and is used for allocating resources and preparedness. In the study, daily KBDI values were calculated and

temporal trends were studied at four selected stations in Malaysia for the period 1990–1995. KBDI software was used to determine KBDI values. Three fire danger categories were established; low (LFD) (0–1000), moderate (MFD) (1001–1500), and high (HFD) (1501–2000). Kota Bharu had the highest maximum daily KBDI (1982), while Kuching had the lowest maximum (1769). The highest monthly mean KBDI value at Kota Bharu was 1550 in February, and the lowest was 350 in November. The highest value at Kuching was 1120 in July, and the lowest was 240 in January. At Sandakan, the highest monthly KBDI mean was 1355 in April, and the lowest was 380 in December. The highest monthly KBDI mean at Subang was 1370 in July, and the lowest was 680 in December. In the frequency analysis, Kota Bharu had 773 MFD days and 684 LFD days. Kuching had 1497 LFD days and 120 HFD days. Sandakan had 1056 LFD days and 424 HFD days. Subang had 926 MFD days and 366 HFD days. Implications on fire management activities are discussed.

**Wildfire in forests of Greek fir.** Raftoyannis, Y. (*TEI Lamias, Greece; rafto@teilam.gr*), Spanos, I. (*Forest Research Institute, Greece; ispanos@fri.gr*).

Greek fir (*Abies cephalonica* Loudon) is a dominant tree species in the mountainous Greece and it forms productive forests. In the past, wildfires in fir forests were not considered a major threat, but in the last decades, fir forests in Greece have experienced large crown fires with subsequent ecological and economical losses. Thin-barked and resin blistered, with a moderately shallow rooting system, the Greek fir is susceptible to fire. Additionally, young trees have low-growing branches that can easily ignite from burning undergrowth, providing a fuel ladder into the crown. Past burn mosaics tended to increase the probability that subsequent fires would also burn in a mixed pattern. However, after decades of fire exclusion and silvicultural management, patches of late succession forests with large accumulations of dead and living fuels have coalesced, increasing likelihood of fires of unusual size and severity. Severe crown fires may knock succession back to herbs and shrubs, or replace fir forests with the fire tolerant oak forests. In our contribution, we present data on wildfires in fir forests in Greece and their relationships with climatic data.

## Experimental manipulations of forest ecosystems: hints on global change

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**Changes in temperature sum and frost damage risk at the beginning of growing season in Finland over the last 100 years.** Häkkinen, R., Heinonen, J. (*Forest Research Institute, Finland; risto.hakkinen@metla.fi; jaakko.heinonen@metla.fi*).

The timing of leaf unfolding and flowering of boreal trees can reasonably be predicted with temperature dependent bud development models, e.g. the simple temperature sum. The predicted bud burst takes place when the species-specific threshold value of temperature sum has been attained. We analyzed the changes and trends of different values of bud burst threshold utilizing temperature records of the Finnish Meteorological Institute covering the 20<sup>th</sup> century from different locations in Finland. The frost damage risk is highest during the two-week period after bud burst. The variations in frost damage risks were studied by analyzing the conditional distribution of minimum temperatures after bud burst threshold values had been reached. We found that the rate of temperature accumulation has increased over the last century. The bud burst thresholds towards the end of the study period were achieved about one week earlier than at the start. In general, the earlier the buds burst the greater the danger of frost damage. However, due to the increasing spring temperatures there was no significant trend in frost damage risks of boreal trees over the last 100 years.

**Oak forest responses to chronic precipitation change over one decade.** Hanson, P.J. (*Oak Ridge National Laboratory, USA; hansonpj@ornl.gov*), Johnson, D.W. (*University of Nevada, USA; dwj@cabnr.unr.edu*), Wullschleger, S.D. (*Oak Ridge National Laboratory, USA; wullschlegel@ornl.gov*).

Changes in regional precipitation expected to result from increasing global temperatures are predicted to have a major effect on the composition, structure and productivity of forest ecosystems. Since 1993, catchment-scale manipulations of precipitation inputs (-33 or +33% throughfall) to an upland oak forest have been conducted. Photosynthesis, conductance, and canopy water use can be reduced from 30 to 50% under soil water deficits, and dormant season carbohydrate storage pools dropped below 10% following severe droughts. However, evidence for the translation of such physiological responses to change in tree basal area growth is lacking for trees greater than 20 cm diameter. This resilience results from an observed disconnect between early-summer tree growth phenology and late-season drought occurrence. Contrary to our expectation, long-term annual leaf production for the dry treatment exceeded that of the

wet and ambient treatment plots by 20%. This difference is hypothesized to result from excessive leaching of beneficial plant elements, and is supported by measured increases in cation concentrations in the soil solution leaching from plots with elevated acidic precipitation. Finally, reduced and increased seedling survival associated with dry versus wet precipitation regimes has been observed and has implications for the long-term diversity of eastern forest systems.

**Demonstration of the direct importance of plant photosynthates for soil processes.** Högberg, P. (*SLU, Sweden; Peter.Hogberg@sek.slu.se*), Högberg, M.N. (*Sweden*).

Large-scale forest girdling reveals the close and immediate link between soil processes and recent plant photosynthates. In boreal forests, summer-time soil respiration rates have been reduced by up to 50–65% shortly (weeks-months) after girdling. These figures represent underestimates of the autotrophic soil respiratory pathway, since girdled trees consume root sugars and starch at an accelerated rate. Girdling also causes an accelerated supply of substrates like dead roots and mycorrhizal fungal mycelium to heterotrophs. Fertilized forests and forests in region with higher natural nutrient supply and/or significant N deposition show a smaller response to girdling. This is in accordance with plant allocation theory, which predicts reduced partitioning to roots and mycorrhizal fungi under such conditions. The few studies of broad-leaved forest indicate that these may be less responsive to girdling, possibly because they store more non-structural C in their roots. In boreal and temperate coniferous forests a number of studies report 50% reductions in dissolved C, an important source of labile C for the soil microbial community. The drastic decline in soil activity after girdling also supports the argument that rates of fine root turnover may previously have been over-estimated, as suggested by recent large-scale C isotope labelling experiments.

**Effects of management on carbon fluxes: Results from a chronosequence study using eddy covariance measurements.** Lindroth, A. (*Lund University, Sweden*), Grelle, A. (*SLU, Sweden*), Lankreijer, H., Lagergren, F., Mölder, M. (*Lund University, Sweden*).

The effect of management on carbon fluxes was studied by measuring net ecosystem exchange by eddy covariance in a chronosequence of four different coniferous stands in central Sweden. The stands were of age 30, 60 and 100 years. The clear-cut was harvested in the winter just before the first measurements began. The 30- and 60-year old stands showed the largest net uptake rates of C, the clear-cut released intermediate amounts, and the 100-year old stand was least. The 30- and 100-year old stands showed the highest gross primary production (GPP), followed by the 60 years-old stand and the clear-cut. The reason for the lower productivity in the 60 years-old stand was probably because of lower nutrient availability in the soil manifested through a slightly higher C/N ratio. The total ecosystem respiration was highest in the 100-year old stand. The relationship between total biomass increment and GPP was linear with a regression coefficient of 0.2. The results clearly show a very large impact of management on the carbon balance and the conclusion is that for up-scaling and for estimation of total carbon balance of the whole rotation, the age effect must be considered.

**Experimental soil warming effects on forest soil CO<sub>2</sub> release: A new measuring system with high temporal resolution.** Schindlbacher, A., Zechmeister-Boltenstern, S., Jandl, R. (*University of Natural Resources and Applied Life Sciences, Austria; andreas.schindlbacher@bfw.gv.at*).

Global Warming is predicted to increase soil respiration and may thereby lead to positive feedback effects through additional CO<sub>2</sub> emissions from soils. Experimental soil warming is an approach to investigate whether the respiration increase lasts only short term or causes long term changes in soil CO<sub>2</sub> emissions. For this purpose we installed a fully automated soil warming (+ 3 °C topsoil) and CO<sub>2</sub> flux (15 closed dynamic chambers) measuring system in a mixed forest stand in the Austrian limestone Alps. Heating cables were installed in the topsoil using special developed tools to minimize soil disturbance. Soil CO<sub>2</sub> fluxes are measured on heated and control plots. To estimate the contribution of root respiration some heated and control plots were trenched (roots were cut). Soil respiration is measured continuously over 24 hours in the snow free season and biweekly during wintertime. This high temporal resolution allows us to investigate the effects of rapid changes in soil temperature, moisture and aeration on CO<sub>2</sub> emissions. Rapid changes can be caused by rainfall events that often occur in this area. The high temporal resolution should also result in a better annual estimate of soil CO<sub>2</sub> emissions for our site.

**The “timeless field experiment.” Can we design studies that will endure?** Schoenholtz, S., Powers, R.F. (*USDA Forest Service, USA; rpowers@c-zone.net*).

Long-term field studies in agronomy date to the 1800s and are world treasures. Yet, forestry lacks a strong parallel. Despite the value of forests, much of our theory on how they behave rests on retrospective and chronosequence studies, not on experiments lasting decades. Such studies can only address a narrow set of issues that may not be relevant today or tomorrow. Furthermore, projections from such studies have unknown variance and lack portability. Experiments have failed for many reasons. Plots often are small and edge effects soon become great; replication is not adequate to deal with catastrophe; treatments are too limited to address many issues; the study may not attract other disciplines. To



endure, plots and treatments must be large enough to address multiple issues now and in the future, replication must be sufficient to handle 'demonic intrusion,' multiple disciplines should be involved in both planning and research, and commitment must be passed through generations. Several examples are given from the United States.

**Predicting time-since-fire using forest inventory data: A case study in the boreal forest of Saskatchewan, Canada.** Schulz, R., Marshall, P., LeMay, V. (*University of British Columbia, Canada; rschulz@interchange.ubc.ca; peter.marshall@ubc.ca; valerie.lemay@ubc.ca*).

Traditional approaches to determining time-since-fire in forest landscapes require interpretation of aerial photographs and dedicated field sampling. Time-since-fire data are used to calculate disturbance patterns and other metrics (e.g., fire frequency) required by landscape ecologists. If other sources of information, such as forest inventories, could be used to predict reliable time-since-fire data, it could greatly reduce the cost of acquiring these data. This paper presents the results of a case study applying spatially-explicit modelling techniques, together with forest inventory data, to predict and evaluate time-since-fire data for a boreal mixed-wood forest in northwest Saskatchewan. The results appear promising, but as of yet are not sufficiently precise to replace traditional, field-intensive approaches to obtaining time-since-fire data.

## Climate change and tree resistance to insects and pathogens

Organizers: Francois Lieutier *Université d'Orléans, France; francois.lieutier@univ-orleans.fr*, and Mike Wagner *North Arizona University, USA; mike.wagner@nau.edu*

**Regeneration after clear-felling *Pinus sylvestris* stands infected by *Gremmeniella abietina*.** Bernhold, A., Hansson, P., Witzell, J. (*Swedish University of Agricultural Sciences, Sweden; Andreas.Bernhold@sso.slu.se*).

The pathogen *Gremmeniella abietina* is the causal agent of Scleroderris canker on *Pinus sylvestris*. Recently, Sweden has suffered the greatest epidemic ever recorded, with more than 450 000 ha infected pine stands. No general guidelines on management of infected slash or on regeneration after sanitation felling have been made. Two studies concerning management of *P. sylvestris* stands infected by *G. abietina* have, however, been initiated in 2001–2004. In the first study, vitality and survival of *G. abietina* on slash after clear-felling was studied in middle-aged *P. sylvestris* stands. Shoots were collected from infected slash at regular intervals after sanitation felling. Vitality was then tested by studying spore (conidia) germination rate. The preliminary results show that *Gremmeniella abietina* remain viable (98–100% germination after 72 h on fruit juice agar at 15 °C) up to 18 months in slash on the ground. In the second study, infection rate of *P. sylvestris* seedlings planted after clear-felling *Gremmeniella*-infected *P. sylvestris* is studied in plantations with and without removal of infected slash. The results of these studies will be important in developing management guidelines for Fennoscandian forest owners in the future.

**Environmental stresses and tree resistance to defoliators.** Björkman, C., Larsson, S. (*Swedish University of Agricultural Sciences, Sweden; christer.bjorkman@entom.slu.se*).

Raising temperatures and other environmental changes, as an effect of a presumed global change, will affect all biological organisms, including trees. Depending on the present conditions, such environmental changes may result in trees that are more or less stressed. The stress level of trees affects their quality as food for defoliators. If the quality improves and defoliators are affected positively, it may be due to a decrease in tree resistance. Here, I briefly review how different environmental changes (e.g., temperature, precipitation) may affect the resistance of trees against defoliation. Different types of tree resistance mechanisms will be covered. A complicating factor when trying to predict how defoliators are affected by environmental changes is that many factors interact with each other. For example, different plant resistance traits may respond differently to the same environmental stress and natural enemies of the defoliators may be oppositely affected. Acknowledgement of these interactions and identification of the most significant ones will be important steps when choosing pathways for future research.

**Factors associated with the susceptibility of elms (*Ulmus* spp) to the elm leaf beetle.** Bosu, P.P. (*Forestry Research Institute of Ghana, Ghana; pbosu@forig.org*), Wagner, M.R. (*Northern Arizona University, USA; mike.wagner@nau.edu*).

Siberian elms (*Ulmus pumila*) are extensively planted as shade trees in the dry and windy urban environments of northern Arizona. However, Siberian elms are highly susceptible to defoliation by the elm leaf beetle (*Pyrrhalta luteola* Müller). In order to provide alternatives to the planting of Siberian elms 32 elm species, cultivars or hybrids were evaluated in an experimental elm plantation established in the city of Holbrook, Arizona, during 1999–2001. Species or

hybrids that sustained higher mean overall defoliation (15–46%) included *U. pumila*, *U. glabra*, ‘Regal’, ‘Sapporo Autumn Gold’, ‘New Horizon’, ‘Charisma’, ‘W2115-1’ elm, and ‘Homestead’. Chinese elms (*U. parvifolia*) and the American elm (*U. americana*) cultivar Valley Forge were much less susceptible to elm leaf beetle defoliation than Siberian elm. The remaining elm taxa were intermediately susceptible. Analyses of leaf anatomical and nutritional traits indicated that trichome density as well as concentrations of iron, phosphorus, manganese and soluble nitrogen might be involved in elm resistance to elm leaf beetle defoliation.

**Drought and tree resistance to insects and pathogens: general concepts and illustration with results from experiments with the complex pine-bark beetles-associated fungi.** Dreyer, E., Guerard, N., Croise, L. (INRA, France; [dreyer@nancy.inra.fr](mailto:dreyer@nancy.inra.fr)), Lieutier, F. (Université d’Orléans, France; [francois.lieutier@univ-orleans.fr](mailto:francois.lieutier@univ-orleans.fr)).

Drought has long been considered as a major predisposing factor able to increase the susceptibility of trees to attacks by insects or to fungal diseases. Such assumptions are based mainly on observations in forest stands, where dry years are frequently followed by large damage to the trees by insects or fungi, due to either increased insect populations or inoculum in the environment, and or to decreased resistance of the trees. While a large bundle of data supports the occurrence of increased insect populations after dry years, there is still no clear-cut experimental evidence for drought induced-changes in the susceptibility of the trees. Moreover, we do not yet have a clear view of the physiological basis for such potential changes. During this presentation, several conceptual models predicting a modulation of tree resistance by water availability will be briefly addressed. The discussion will be based on results from several long term experiments with Scots pine trees submitted to controlled constraints, and inoculated with a range of fungi associated to bark beetles.

**Evaluation of long term performance of 3-PG.** Fontes, L., Tomé, M., (Universidade Técnica de Lisboa, Portugal; [luisfontes@isa.utl.pt](mailto:luisfontes@isa.utl.pt); [magatome@isa.utl.pt](mailto:magatome@isa.utl.pt)), Pretzsch, H., Roetzer, T., Landsberg, J.J. (Technische Universität München, Germany; [H.Pretzsch@lrz.tum.de](mailto:H.Pretzsch@lrz.tum.de); [Thomas.Roetzer@lrz.tu-muenchen.de](mailto:Thomas.Roetzer@lrz.tu-muenchen.de)).

Process-based models (PBMs) are based on the physiological processes that determine tree growth and can, in theory, provide estimates of the potential productivity for sites with no previous mensurational data. In addition, PBMs can evaluate the effects of fertilization or thinning, or the impact of pests and diseases or provide information to evaluate the probable effects of climate change on forest growth. The model developed by Landsberg and Waring 3-PG (Physiological Principles Predicting Growth) has been used for a wide range of species and sites worldwide. However information on the performance of the model using long climate and growth data series is scarce. Available data for *Picea abies* with more than 100 years of growth in Bavaria were used to evaluate long term performance of 3-PG. Calibration was based on sites with the highest and lowest productivity existing in the available data set. Long term monthly climate data series from conventional meteorological stations was used. Long term performance of the model through the predicted growth, based on climate evolution, is an attempt to produce better knowledge of the ability of 3-PG to predict the impact of climate on forest growth.

**Role of temperature and host association in shaping the distribution range of two closely related species of bark beetles.** Horn, A. (Université d’Orléans, France; [Agnes.Horn@univ-orleans.fr](mailto:Agnes.Horn@univ-orleans.fr)), Kerdelhué, C., Sauvard, D. (INRA, France; [Carole.Kerdelhue@pierroton.inra.fr](mailto:Carole.Kerdelhue@pierroton.inra.fr); [Daniel.Sauvard@orleans.inra.fr](mailto:Daniel.Sauvard@orleans.inra.fr)), Lieutier, F. (Université d’Orléans, France; [Francois.Lieutier@univ-orleans.fr](mailto:Francois.Lieutier@univ-orleans.fr)).

*Tomicus piniperda* and *Tomicus destruens* are closely related bark beetle species that weaken various pine species, through maturation feeding in the shoots. Trunk attacks by the Mediterranean *T. destruens* are responsible for heavy damage, while the Palaearctic *T. piniperda* seldom kills trees. Because of climatic changes, *T. destruens* could increase its range further north, thereby threatening non-Mediterranean pines. However, little is known about the distribution, host range and ecological characteristics of both species. Our goals were to (i) determine the distribution range and host spectrum of *T. piniperda* and *T. destruens*, using systematic sampling and molecular identification; (ii) assess their development capacities at different temperatures, to understand how their distribution ranges could be affected by global warming; and (iii) test their development capacities on different hosts, to assess if they could attack new pines if their distribution range changed. We found parapatric distributions of the beetles, with few sympatric populations on *Pinus pinaster*. The survival rates of both species at low temperatures were significantly different. Low temperatures could thus be a factor limiting the spread of *T. destruens*. Moreover, this latter species could develop on non-Mediterranean pines. Its progression further north could thus be a threat for pine forests.

**Fungi associated with bark beetles (Coleoptera: Scolytidae) on Norway spruce in Slovenia.** Jurc, M. (University of Ljubljana, Slovenia; [maja.jurc@bf.uni-lj.si](mailto:maja.jurc@bf.uni-lj.si)).

The results of research on fungal populations associated with four bark beetles species (*Ips typographus*, *Pityogenes chalcographus*, *Dryocoetes autographus*, and *Orthotomicus laricis*) colonizing Norway spruce (*Picea abies*) are

presented. The bark beetles were collected in autochthonous stands of Norway spruce: *I. typographus* from under the trunk bark, *P. chalcographus* from the branches, and the latter two species from under the bark of stumps. For each of the four bark beetles, two logs of uninfested trees were inoculated with a total of 36 randomly chosen, live and crushed beetles (18 per log), and with four control inoculations without insects. After three weeks of incubation, tissue samples were removed from each inoculation point and 35 different taxa of fungi were isolated on MEA. Most of the fungi were from the group Deuteromycota and were not pathogenic. The role of particular fungal species in host-beetle-fungi complexes is discussed. The results demonstrate the role of such relationships in nature and that they should be taken into account in forest management practices.

**Ecological assessment and sustainable management of cypress under climate change conditions in the Italian Alps.** La Porta, N. (*IASMA, Italy; nicola.laporta@iasma.it*), Battisti, A. (*University of Padua, Italy; andrea.battisti@unipd.it*), Raddi, P. (*CNR, Italy; paolo.raddi@ipp.cnr.it*).

Cypress is one of the major tree species that emphasizes the landscape component of a territory. Cypress canker caused severe damage in Italy, and in the Alps, and for a long time prevented the use of this species in forestry and as an ornamental planting. The main point of this work is to study the potential of cypress cultivation at the northern end of the range of this species, under conditions of continuous climatic change, which may favour the spread of this Mediterranean conifer. The objective was to maintain and protect standing cypress populations and increase dispersion of this species in suitable Alpine environments. The work is based on three key points, 1) phytosanitary assessment of the cypress and evaluation of genetic variability in the local fungus/host system, 2) understanding the dynamics of the spread of disease by insects and the causative factors, and 3) adapting resistant clones that were patented in previous research programs. Such clones were developed under Alpine environmental conditions, and were selected for canker resistance, cold tolerance, insect attractiveness, and ecological sustainability in plantations.

**Living on the edge: Eucalypt resistance to stem borer attack in subtropical Australia.** Lawson, S., McDonald, J., Aigner, R. (*Department of Primary Industries and Fisheries, Queensland, Australia; simon.lawson@dpi.qld.gov.au; janet.mcdonald@dpi.qld.gov.au; rebeccah.aigner@dpi.qld.gov.au*), Carnegie, A.J. (*Department of Primary Industries, New South Wales, Australia; angusc@sf.nsw.gov.au*).

Plantations of *Eucalyptus* spp. in subtropical eastern Australia are subject to damage by a wide range of insect pests. Increased stress, particularly through drought, predisposes trees to higher risk of insect damage. Stem-boring insects, such as longicorn beetles and cossid wood moths, have potentially severe impacts on plantation productivity through their negative effects on establishment and wood quality. These stem borers are regarded as one of the key pests of eucalypt plantations established in northern New South Wales and southeastern Queensland since the mid 1990s. This region of Australia has been severely impacted by widespread and long-lasting drought in recent years, and climate change models have suggested that the trend toward more frequent and longer episodes will continue. The biology of these borers appear to be well synchronized to successfully colonize trees by utilizing periods when trees are under greatest moisture stress, and the incidence and severity of attack has increased under these conditions. The relationship between climate change, tree response to stress and future management options for these insects will be discussed in terms of the expansion of eucalypt plantations in subtropical Queensland and New South Wales.

**Environmental stresses and tree resistance to bark beetles.** Lieutier, F. (*University of Orleans, France; francois.lieutier@univ-orleans.fr*).

A review is presented on the proven effects that various climatic factors have on conifer resistance to bark beetles. The considered factors include water stress and nutrient availability, as well as other environmentally damaging agents such as wind, lightning, fire, and pollution. For some of them, the level of stress is also taken into account. Comments are made on the validity of certain parameters as indicators of tree resistance or efficacy of its mechanisms. Then, all reliable results are synthesized in a table where effects on tree susceptibility and resistance level to bark beetle attacks are presented, in parallel to effects on tree resistance mechanisms themselves, while separating the preformed from the induced defences. Coherence of the results, gaps and particularities are discussed. General trends are presented, especially regarding dose effects of stresses and possible interactions between factors.

**Diversity of environmental effects on tree resistance to insects and pathogens.** Niemelä, P. (*University of Joensuu, Finland; pekka.niemela@joensuu.fi*).

Environmental effects on tree resistance to insects and pathogens exhibit highly diverse and conflicting patterns. Among insect herbivores the strength and direction of the effect depends on the type of environmental factor (drought, shading, pollution, N-enrichment, CO<sub>2</sub>-enrichment, etc.), tissue type, tree species studied and on the feeding of the

herbivore. Although there are fewer studies on the environmental effects of tree resistance against pathogens, relationships between environmental factor, tissue type, and pathogen species seem to exist. Several factors may explain the high diversity of effects. Response curves are not linear and, consequently, the strength of the effect varies depending on the location on response curve. Changes in the secondary chemistry of trees depend on the functional and hierarchical levels of plant metabolic pathways and on what kind of trade-off situations the environmental factors create. In addition, high variation in responses to environmental factors may simply implicate conflicting pressures of natural selection, maintaining high variation in tree resistance to herbivores and pathogens. Thus we can 'turn the coin around' and interpret the variation in responses as an adaptation to changing and unpredictable environments.

**Potential impact of climate change on plantation pest and disease problems in southern Africa.** Roux, J., Wingfield, M.J. (*Tree Protection Co-operative Programme (TPCP), University of Pretoria, South Africa; jolanda.roux@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za*).

Together with host resistance and the pathogen, environmental conditions represent a key component of the so-called disease triangle. Changes in any of these factors may result in disease. Increased temperatures can lead to extended periods of drought and thus increased stress on trees. In Southern Africa, this results in increased mortality in *Pinus* spp. due to infection by the opportunistic pathogen, *Diplodia pinea*, as well as the wood wasp, *Sirex noctilio*. In *Eucalyptus* plantations under stress, increased attacks of standing trees by the wood borer, *Phoracantha semipunctata*, and the pathogen *Botryosphaeria* sp. can result in substantial loss. Changes in climate may also result in an increase in areas conducive to the biology of certain pests and pathogens. For example, the *Eucalyptus* canker pathogen, *Cryphonectria cubensis* in South Africa is mostly restricted to a small area along the east coast of the country. Climate change predictions, have, however, shown that an increase in temperature will increase the possible areas of occurrence of this pathogen. In the future, it will become increasingly important to consider the effects of climate change not only on the plantations but also on pests and pathogens.

**Impacts of climate fluctuations and climate changes on forest tree pathogens in Europe.** von Weissenberg, K. (*University of Helsinki, Finland; kim.vonweissenberg@helsinki.fi*), Thomsen, I.M. (*Forest and Landscape Denmark; imt@kvl.dk*), La Porta, N. (*IASMA, Italy; nicola.laporta@iasma.it*), Capretti, P. (*University of Florence, Italy; paolo.capretti@unifi.it*).

In Europe terrestrial ecosystems are being subjected to changing environmental conditions on an unprecedented scale, both in their rate and in their geographical extent. The ability of forest ecosystems to adapt to these rapid changes requires fundamental knowledge of their responses to the forces of global change. Climate changes that increase frequency and intensity of stress due to drought and higher temperatures will likely increase the frequency of several tree diseases in the future. In the past, disease epidemics in forests have drastically changed species composition over vast areas. Present trends show a decline in the health status of certain tree species such as silver fir, Norway spruce, pines, cypress, chestnut, elms, oaks, plane tree, and alder over their ranges in Europe. Several examples of decline are not due to general climate changes, but rather to man's activities, local weather, and soil conditions. However, in the most recent cases, oak- and alder decline, the contributing factors are not well understood, and changes in climate and ground water tables may be involved. Local weather conditions that are advantageous to the pathogen and disadvantageous to the host are often involved.

## **Forest insect effects on forest productivity, management decisions, and carbon sequestration**

Organizer: David MacLean *University of New Brunswick, Canada; macleand@unb.ca*

**A critical review of British Columbia's response to a major forest pest epidemic.** Adamson, D.G. (*McGregor Model Forest, Canada; dan.adamson@mcgregor.bc.ca*), Andersen, E.R. (*York University, Canada; eraconsulting@shaw.ca*).

Mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins, commonly attack and kill mature lodgepole pine, *Pinus contorta* Dougl. ex Loud. However, with recent mild winters, dry summers, and abundant stands of pine in the interior of British Columbia (BC), Canada, a significant outbreak has occurred with most age classes of pine being killed. While outbreaks have been recorded in BC since 1910, the current outbreak is the largest insect epidemic in known history, and is growing at 40% per year. It is estimated that \$20 billion in timber is at risk, and economic models forecast significant forestry job losses, with dramatic effects on rural forest-dependent communities. Issues currently being researched include: management strategies, research and management capacity, municipal and aboriginal community impacts, and forest policies and regulations. This MPB outbreak provides an excellent opportunity to evaluate the response to a major stochastic event in light of past forest management practices and policies (e.g. fire suppression). This poster focuses on the critical examination of our ability to: 1) undertake long-

range forest planning, 2) respond to socio-economic impacts of forest-dependent communities, and 3) establish research priorities and processes that guide desired future forest conditions that are challenged by climate change.

**Disturbance of the boreal forest of Canada by the spruce budworm, *Choristoneura fumiferana* (Clem.).** Alfaro, R.I. (*Natural Resources Canada; Rene.Alfaro@nrca-nrcan.gc.ca*), MacLean, D.A. (*University of New Brunswick, Canada; macleand@unb.ca*), Nealis, V., Shand, A. (*Natural Resources Canada*), Porter, K. (*University of New Brunswick, Canada*).

The study of the long term historical extent, intensity, and frequency of forest disturbances provides a baseline against which we can measure changes in current and future disturbance regimes. The spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae), is a native defoliating insect of balsam fir (*Abies balsamea* (Linnaeus) Miller and white spruce (*Picea glauca* (Moench) Voss) and a major disturbance agent of the Canadian boreal forest. Damage is caused by the mature caterpillars, which consume the current foliage year after year. The Canadian Forest Service established a network of ground plots in the Boreal forest, extending from New Brunswick to British Columbia with the purpose of monitoring forest ecosystem changes at the stand and landscape levels due to repeated defoliation by this insect. Data was collected on tree top-kill and mortality occurring as a consequence of budworm defoliation. In addition we measured stand level ecological indicators, such as understorey composition, coarse woody debris accumulation and wildlife tree population changes. Defoliation by the spruce budworm caused concern to forest managers because of growth loss, stem defects, and tree mortality resulting from defoliation. In addition, biodiversity values were affected as areas reserved for their old-growth characteristics were threatened by defoliation. Computer simulation models were developed to assist managers in decision-making. Dendrochronological studies determined that outbreaks of this insect are recurrent, however frequency and severity over the landscape were variable.

**Possum damage in *Pinus radiata* plantations in south-eastern New South Wales, Australia.** Carnegie, A.J., Griffiths, S. (*NSW Department of Primary Industries, Australia; angusc@sf.nsw.gov.au*), Winter, A. (*formerly NSW DPI, Australia*).

Forests NSW (NSW DPI) manages the largest estate of exotic *Pinus* plantations in Australia, with almost 200 000 ha of mostly *Pinus radiata*. Of this, 35 000 are situated in south-eastern New South Wales (Monaro Region). Since the mid-1990s the most significant forest health issue in this region has been damage from native marsupial possums, *Tricosurus vulpecula*. Possums climb trees and peel back the bark to feed, resulting in top death. During routine forest health surveillance from 1996–2004 the extent, incidence, and severity of possum damage in Monaro Region were recorded. The total area of damage did not change significantly during this period, with approximately 10 000 ha affected. The number of trees damaged (incidence) was similar from 1996–1999, but decreased steadily from 2000–2004. Trees 7–15 years old suffered the most severe damage, with the top 25–33% of the tree killed. Affected compartments in this age-class range averaged 10% incidence of new damage in 1996, 1997, 1998, and 1999. Older trees had less severe damage (<25% tree killed) and lower incidence. Compartments adjacent to native forest and retention strips suffered greater damage. The impact on merchantable wood and management options to reduce possum damage are discussed.

**Herbivorous insects as determinants of carbon dynamics in forests.** Carroll, A.L., Kurz, W.A. (*Natural Resources Canada, Canada; Allan.Carroll@nrca-nrcan.gc.ca; wkurz@nrca-nrcan.gc.ca*).

Herbivorous insects comprise one of the primary sources of disturbance within boreal and sub-boreal forests. Periodic epidemics, causing growth reduction and mortality of trees over large areas, influence the source-sink dynamics of forest carbon sequestration. Due to their poikilothermic nature, the life history of insects is largely defined by their thermal habitat. Warming, from climate change is expected to increase the per capita growth rate of many forest insect populations and exacerbate their impact on carbon fluxes. Given the capacity for herbivorous insects to respond rapidly to changing climates and their potential to impact forests over vast areas, there is concern of elevated herbivory causing increased release of atmospheric carbon. The influence of forest insects on carbon dynamics will only be relevant to climate change if it manifests as a net increase in insect impacts over time—an increase beyond the historic range of variability in the frequency, severity, and distribution of insect epidemics along with their interactions and feedbacks with other biotic and abiotic components of the environment. Carbon losses within the historic range are likely off-set by regrowth of forests affected in earlier years. Using examples from North America, we will discuss the potential for insect herbivory to affect carbon source-sink dynamics in forests.

**Static insect trapping system an asset to forest management.** Griffiths, M.W., Ramsden, M., Bashford, D. (*Department of Primary Industries and Fisheries, Queensland, Australia; Manon.griffiths@dpi.qld.gov.au*).

A static insect trapping program was initiated within Queensland's exotic (*Pinus*) plantation estate in 2004. Forestry Tasmania developed an urban/plantation trap design and surveillance system, which is currently in use

and expanding to all entry points in Tasmania. In Queensland, this trapping program, which complements the general forest health surveys, was set up within the Beerburum, Fraser Coast, and Ingham management areas. The system incorporates the use of one intercept panel and three Lindgren 12-funnel traps (wet type) using ethanol and alpha-pinene lures respectively, at each of five sites within the management areas. The funnel traps are set up in a triangular configuration located five meters apart, with fresh damaged timber billets placed centrally within this triangle. The intercept trap is located 30 m from the funnel traps. These traps and lures act as generalist attractants for known and previously undetected economic pest species, drawing from over a 100–200 m radius. Target captures are Scolytids, Buprestids, Cerambycids, Anobiids, Curculionids, and *Sirex*. Knowledge of known species and their population fluxes at each trap station will provide data on catch efficiency and confidence that new or unknown species will be captured. Capture data obtained from this system will assist in the sustainable management of the plantation estate.

***Sirex* wood wasp—a threat to tropical pines?** King, J. (Department of Primary Industries and Fisheries, Queensland, Australia; [judy.king@dpi.qld.gov.au](mailto:judy.king@dpi.qld.gov.au)), Kent, D. (Department of Primary Industries NSW, Australia), Fitzgerald, C.J. (Department of Primary Industries and Fisheries, Queensland, Australia).

*Sirex* wood wasp (*Sirex noctilio*) is a destructive introduced pest of *Pinus radiata*, the main exotic softwood plantation species in southern Australia—New South Wales, A.C.T., Victoria, South Australia, and Tasmania. *Sirex* was detected in mainland Australia in 1962, and posed a major threat to the softwood industry. Despite implementation of a biological control program, *Sirex* spread, and is now close to Queensland. The Queensland exotic softwood plantation estate is mainly *Pinus caribaea*, *P. elliottii*, and *P. caribaea* x *P. elliottii* F1 and F2 hybrids. The *Sirex* susceptibility of *P. caribaea* and these hybrids, and their potential to host its biological control agents were unknown, and the threat to plantations could not be assessed. We investigated the susceptibility of *P. caribaea* and the hybrids to *Sirex* infestation. Insectary experiments: billets were exposed to *Sirex* wasps and parasitoids emerging from field collected *P. radiata* billets (billets were stored until emergence). Field experiments: newly emerging mated females were caged on standing *P. caribaea* and the hybrids in a plantation (the trees were harvested after 3 months and destructively sampled). Some billets were retained in the insectary for later investigation. We discuss susceptibility, parasitoids and nematodes, development times, and implications for management.

**Western poplar clearwing moths in intensively managed hybrid poplars: effects on production and control strategies.** Kittelson, N.T., Hannon, E.R., Brown, J.J. (Washington State University, USA; [nealk@wsu.edu](mailto:nealk@wsu.edu)).

The western poplar clearwing moth (*Paranthrene robiniae* [Hy. Edwards]) (WPCM) has recently become the most economically significant pest of irrigated hybrid poplars grown in southeastern Washington and northeastern Oregon. The WPCM is a wood-boring moth that attacks all ages of poplars. Newly planted trees are the most susceptible to damage from the WPCM. Larvae bore into the base of the new trees and girdle them, weakening the base, making the trees susceptible to breakage due to wind. Portions of newly planted fields have required replanting up to three times because of WPCM. Damage from the WPCM has caused up to 25% loss of new plantings. Conventional pesticides are ineffective in controlling WPCM because most of its lifecycle is spent as larvae inside the tree. In 2003, we implemented a mating disruption control strategy, which has increased the establishment of newly planted trees and significantly reduced the amount of damage caused by the WPCM. We report on damage caused by the WPCM, the effect this damage has had on the hybrid poplar industry in this region, and the result that mating disruption has had on the WPCM and irrigated hybrid poplars.

**Carbon allocation to resin ducts or to monoterpene production?** Lamontagne, M., Abwe Wa Masabo, M. (Université de Moncton, Canada; [mlamont@umce.ca](mailto:mlamont@umce.ca)).

Monoterpenes play an important role in the defensive system of balsam fir, *Abies balsamea*, as a feeding deterrent to spruce budworm, *Choristoneura fumiferana*. The goal of this project, initiated in 2002, was to determine the anatomical causes of variation in leaf structure, photosynthesis, and monoterpenes concentrations along canopy profiles for current foliage of juvenile and mature balsam fir. Total monoterpenes (% dry weight) were not significantly correlated to maximum photosynthetic capacity. Total monoterpenes decrease significantly with increasing resin duct volume and were probably diluted in other defensive compounds such as phenol and resin. Total monoterpenes were significantly higher in mature than in juvenile trees. Resin ducts were significantly larger in juvenile than in mature trees. Moreover, for all canopy levels, resin ducts in the needles of the apical branchlet were significantly larger than in adjacent axillary branchlets of the same branch, suggesting an apical control on growth and differentiation. These results suggest that one should take into account dilution effects in resin ducts to explain the susceptibility of juvenile and vigorous trees to spruce budworm.

**Insect effects on forest management decisions: the role of Decision Support Systems.** MacLean, D.A. (*University of New Brunswick, Canada; macleand@unb.ca*), Gottschalk, K. (*USDA Forest Service, USA; kgottschalk@fs.fed.us*), Shore, T., Porter, K. (*Natural Resources Canada*).

From 1975–2000 in Canada and 1980–2000 in the United States, forest insects caused 709 million ha and 167 million ha, respectively, of moderate-to-severe defoliation or beetle-killed trees. Of the 234 million ha of commercial timber in Canada, more area is depleted by fire and insects (0.5%/yr) than is harvested (0.4%/yr). Forest managers need tools to predict insect outbreak occurrence and effects on forest development to ensure that timber supply will be present at the expected time of harvest and to utilize silviculture to reduce the severity of outbreaks. Insect Decision Support Systems (DSS) link prediction and interpretation models to GIS, under a graphical user interface. DSS assist managers to predict insect effects on forest structure and productivity, forecast sustainable harvest levels, optimize protection (biological insecticide) programs, and use silviculture and harvest scheduling to restructure forests to reduce future damage. We review effects of insects on forest management decisions and DSS for five major North American insect pests: spruce budworm (*Choristoneura fumiferana* Clem.), mountain pine beetle (*Dendroctonus ponderosae* Hopk.), jack pine budworm (*Choristoneura pinus* Freeman), forest tent caterpillar (*Malacosoma disstria* Hbn.), and gypsy moth (*Lymantria dispar* [L.]). We also discuss use of natural disturbance regimes to guide appropriate forest management.

**Development of an integrated management strategy to reduce the impact of *Hypsipyla* species (Lepidoptera: Pyralidae) on African mahogany.** Opuni-Frimpong, E., Karnosky, D.F., Storer, A. (*Michigan Technological University, USA; eopunifr@mtu.edu*), Cobbinah, J.R., Ofori, D.A. (*Forestry Research Institute of Ghana, Ghana*).

African mahogany, *Khaya ivorensis* and *K. anthotheca* (Meliaceae: Swietenoidae), is threatened because of over-exploitation and an inability to establish plantations because of *Hypsipyla* species that devastate young stands by killing main stems, causing excessive forking and branching, and in worst cases, mortality. This study was undertaken to identify tolerant provenances/genotypes to *Hypsipyla* attack and to explore different mixed planting systems to reduce the impact of *Hypsipyla*. Seeds collected from the range of distribution of mahogany in Ghana were planted in 3 different ecological regions of Ghana and monitored for response to *Hypsipyla* attack. Data were collected on tree height, diameter, height at first fork, number of branches, branches attacked, number of fresh attacks, and dead shoots, and subjected to analysis of variance and means were compared among seed sources versus ecological regions by Tukey's multiple range test. The differences in all the parameters measured were significant among the different seed sources—four genotypes were relative tolerant to persistent *Hypsipyla* attack. Mixed planting system studies indicated that a 25% mix of *K. ivorensis* with *Albizia*, *Terminalia* and *Cedrela* gave the best results with <10% *Hypsipyla* attack. Mixed stands with *K. anthotheca* showed no significant differences of *Hypsipyla* attack

**Biology and management possibilities of invasive gall wasps (Hymenoptera: Eulophidae) in eucalyptus plantations of the Mediterranean and north and central Africa.** Protasov, A. (*ARO, Israel; protasov@volcani.agri.gov.il*), Saphir, N., Brand, D. (*JNF, Israel*), Blumberg, D., Assael, F., Mendel, Z. (*ARO, Israel; zmendel@volcani.agri.gov.il*).

Within 4 years, two eucalyptus gall wasps, *Leptocybe invasa* Fisher & LaSalle and *Ophelimus* sp., have invaded large areas around the Mediterranean and Africa causing severe damage to afforestation projects and to the eucalyptus timber industry. Damage has been reported from 15 countries in the area—the wasps are free from their principal natural enemies that occur in Australia. Substantial injury caused by these species has been recorded to the principal eucalyptus species of the area: *Eucalyptus camaldulensis*, *E. globules*, and *E. grandis*. Both wasp species induce galls on the leaf blade, the petiole, and the twig. They are uniparental, displaying bivoltinuous development with a long overwintering period under cold Mediterranean climate. Among the 80 *Eucalyptus* spp. tested, only those belonging of the sections *Exsertaria*, *Latoangulata*, and *Maidenaria*, are susceptible. We discuss the life and seasonal histories of these species, their host plant range as well as the development of short-term and long-term management, which include: 1) development and evaluation of short-term management programs to protect newly established plantations and nursery stock, 2) search and selection of candidates for classic biological control, and 3) breeding *E. camaldulensis* hybrids for resistance against these gall wasps.

**Detection and control of infestation epicenters as a strategy for managing the teak defoliator, *Hyblaea puera*, at a landscape level.** Sudheendrakumar, V.V., Sajeew, T.V., Varma, R.V. (*Kerala Forest Research Institute, India; sudhi@kfri.org; tvsajeew@rediffmail.com; rvvarma@kfri.org*).

The teak defoliator moth, *Hyblaea puera*, (Lepidoptera: Hyblaeidae) is the most serious pest of teak (*Tectona grandis*). Outbreaks of this insect begin in small epicentres and spread progressively. The impact of controlling the epicentres on subsequent outbreaks was studied in 8500 ha of teak plantations in Nilambur, Kerala, in 1999 and 2000. In 1999, twenty epicentre populations ranging from 1–125 ha in area, covering a total of 375 ha were detected and controlled. Subsequent to the control operations, an area of 7532 ha was found infested. The control operation was judged unsuccessful due to the inefficiency of the sprayers used. In 2000, sixteen epicentre patches ranging from 0.12–5 ha in area, covering a total area of

18.2 ha were detected and successfully controlled. Approximately 2640 ha of teak plantations were infested subsequent to the control operations. A comparison of the area under teak defoliator infestation between years in which epicentre control was carried out and the normal years (data on spatial dynamics generated under earlier studies in 1993 and 1998) indicated that the pest incidence in 2000 was very low and significantly different from all the other years. The reduction in the area under infestation is attributed to the control of epicentre populations.

**Modeling the impact of exotic pests on the New Zealand forest sector and its major trading partners.** Turner, J.A. (*New Zealand Forest Research Institute, New Zealand; james.turner@forestresearch.co.nz*), Buongiorno, J., Zhu, S. (*University of Wisconsin-Madison, USA; jbuongio@facstaff.wisc.edu; sszhu@yahoo.com*), Prestemon, J.P. (*USDA Forest Service, USA; jprestemon@fs.fed.us*).

The New Zealand forest industry, based on highly productive plantation forests, is an important contributor to the domestic economy. A significant threat to New Zealand's forest industry is the introduction of exotic pests. As well as the direct economic impact due to forest loss, revenue declines for commercial forestry arise indirectly from reduced exports of raw logs and sawn timber due to phyto-sanitary regulations and trade bans imposed in export markets. This paper presents an economic model, the Global Forest Products Model (GFPM), which can be used to assess the impact of pests on the New Zealand forest sector and its major trading partners. The GFPM is a spatial partial-equilibrium model, which gives projections of production, consumption, and trade for 14 forest products, forest stock and forest area, and welfare for each of 180 countries. As well as assessing the impact of forest loss due to exotic pests, GFPM can also estimate the effect of measures to mitigate pest impact in New Zealand's export markets. These measures include trade bans, phytosanitary regulations, and tariffs. Comparing the projections for different scenarios made with the GFPM enables assessment of the full impact of exotic pests on the New Zealand forest sector.

## Forests between air pollution and climate change

Organizer: Elena Paoletti *National Council of Research, Italy; e.paoletti@ipp.cnr.it*

**Ecological evaluation in Alpine forest ecosystems by Integrated Monitoring: Long-term observations.** Ambrosi, P., La Porta, N., Maresi, G., Salvadori, C., Valentinotti, R. (*IASMA, Italy; paolo.ambrosi@ismaa.it; nicola.laporta@iasma.it; giorgio.maresi@iasma.it; cristina.salvadori@iasma.it; ruggero.valentinotti@iasma.it*).

Woodland protection studies in Trentino (North Italy) began at the end of the 1970s in relation with the acute emergency of forest decline. First observations concerning yellowing needles and crown transparency were carried out together with general survey of known pathologies. Since 1992 investigations were focused on the application of a forest monitoring system in two selected areas (Lavazè, Pomarolo) under the UN-ECE-ICP program. The interdisciplinary program of integrated monitoring aimed to investigate the state and the biodiversity of alpine natural-like structure forests in relation to air pollution effects, anthropogenic stresses, climate changes and trophic-energetic balances. Air pollution effects were not detected and did not influence the evolution and homeostasis in the investigated plots. Presence of pathogens and pests appeared quite constant and damages seemed to be very localized. Actually climate change could be considered as a major constraining factor for forest health, both in short- and long periods. Repeated stresses appeared very effective in conditioning wood development and stability and in enhancing the aging process in many stands.

**Integrated effects of air pollution and climate change on forests: A worldwide perspective.** Bytnerowicz, A. (*USDA Forest Service, USA; abytnrowicz@fs.fed.us*), Omasa, K. (*University of Tokyo, Japan; aomasa@mail.ecc.u-tokyo.ac.jp*), Paoletti, E. (*National Council of Research, Italy; e.paoletti@ipp.cnr.it*).

Global Change has become a decisive environmental issue in our time. Together with land use change, both air pollution and climate change are part of Global Change. The main force of climate change is the increase in atmospheric CO<sub>2</sub> concentrations. Carbon dioxide and air pollutants mostly come from the same sources. As a result, global forests are growing in a changing atmospheric environment. Approaches to understand present and future forest health should integrate the effects of air pollution and climate change on forests. Here we review the research and monitoring situation in Europe (European Union), North America (USA and Canada) and Asia (main focus on Japan and China) as far as forest response to air pollution and climate change is concerned. After reviewing present legislation, past trends and future scenarios about air pollution (tropospheric ozone, nitrogen oxides, volatile organic compounds, sulphur dioxide, acidic deposition) and climate change (CO<sub>2</sub> and other greenhouse gases), an overview of the main research projects and existing forest monitoring initiatives is provided. Our aims are: to assess the usefulness of these initiatives; to discuss the policy for funding environmental research; and to provide options for common research and monitoring approaches on a worldwide basis.



**Community characteristics and species diversity of *Cupressus funebris* community in the Three Gorges Reservoir area of China.** Cheng, R., Xiao, W.-F., Shi, Z. (*Chinese Academy of Forestry, P.R. China; chengrm@forestry.ac.cn*).

Three Gorges Reservoir Area is located in the moist sub-tropical region of China; the total area is about 54,000 km<sup>2</sup>, and *Cupressus funebris* forest is one of the main types of vegetation. According to the data from 72 plots, the forest was divided into 11 community types. The vertical structure of all community types is divided into tree layer, shrub layer and herb layer. The indices of richness, diversity, and evenness of the different layers in all community types followed the pattern of shrub layer > tree layer > herb layer. Due to the marked disturbance of human activities, no pattern was found in altitude gradient. In recent years, especially, the population in this area has been increasing heavily, but the natural resources are limited. Excessive exploitation of natural resources has resulted in degradation of forests for crop cultivation, and excessive collection of plants for herbal medicine. At the same time, environment pollution should not be overlooked; acid rain, for example, has been detected in this area and has affected the forest.

**Global change stresses in northern hardwoods of Canada.** Cox, R.M. (*Natural Resources Canada, Canada; Roger.Cox@nrca-nrcan.gc.ca*), Zhu, X.B. (*Natural Resources Canada, and University of New Brunswick, Canada*), Bourque, C.-P.A. (*University of New Brunswick, Canada*), Allen, D.J. (*Natural Resources Canada, Canada*), Arp, P.A. (*University of New Brunswick, Canada*).

Global change includes dynamics of the changing physical and chemical climate in which our forests grow, coupled with natural and man-made disturbances. These stresses or agents of change can act singularly, together, or in tandem and their interactions need to be understood to accurately forecast impacts on productivity, functioning, and composition of our forests. Experiments dealing with global change agents and their interactions will be reviewed in view of predisposition of northern hardwoods to climate extremes or insect attack. Bioclimatic analyses of current and historical declines will also be reviewed and their role in identifying and verifying key agents affecting northern hardwood resources will be discussed. Determination of key agents and their effect thresholds is essential for the mining of climatic databases for biologically relevant events that can form the basis of temporal and spatial correlation with observed dieback and decline. An example of this approach with yellow birch decline will be presented, in view of the damage caused by freeze-thaw events. The geographic extent of the most severe freeze-thaw events when compared with the extent of previously observed yellow birch decline, showed a coincidence with 83% and was 55% of the geographic range.

**Perspectives on assessing and monitoring the effects of air pollution and climate change on forests – more and reoriented science is needed.** Ferretti, M. (*Linnaeaambiente Ricerca Applicata, Italy; m.ferretti@linnaea.it*), Bastrup-Birk, A. (*Danish Centre for Forest, Landscape and Planning, Denmark*), Bytnerowicz, A. (*USDA Forest Service, USA; abytnerowicz@fs.fed.us*), Percy, K.E. (*Natural Resources Canada, Canada; Kevin.Percy@nrca-nrcan.gc.ca*).

Since the 1980s, the concern generated by the potential for air pollution effects on forests has resulted in several monitoring programs in Europe, North America and elsewhere. More recently, issues such as climate change and biodiversity loss became important on the political agenda, resulting in a demand for data and information covering these additional topics. However, reliable and scientifically defensible data can be achieved only through a robust design based on several scientific issues, including forest ecology, plant physiology, statistics, and knowledge about the physical environment. Inappropriate design may affect the credibility of the data, disrupt public confidence in forest monitoring, resulting in weakening of its role in the forest resource management system. The paper aims to i) evaluate programs designed to monitor the effects of air pollution and climate change on forests in Europe and North America, from different perspectives, ii) place this evaluation in the context of the political relevance of monitoring programs, and iii) present a theoretical and practical perspective on large-scale monitoring of the effect of air pollution and climate change on forests.

**Tree symptoms in the changing environment: Bridging stress factors to physiological responses and visible changes.** Günthardt-Goerg, M.S., Vollenweider, P. (*Swiss Federal Research Institute WSL, Switzerland; madeleine.goerg@wsl.ch; pierre.vollenweider@wsl.ch*).

Plants have evolved various biochemical and structural adaptations to biotic (parasitic, herbivory) and abiotic (nutritive, physical and geochemical) stress. In a changing environment, similar responses, but often in new combinations, are implemented with beneficial or detrimental consequences to cope with the different anthropogenic emissions and changes to natural environmental conditions. Analyzing the structural and histochemical modifications can thus indicate the stress agent itself or at least its target, defence or coping reactions, and the efficiency of the plant's response. Accelerated senescence is a general and unspecific plant reaction, whereas specific defence pathways (some of them resulting in programmed cell death) are induced by a species-specific amount of pathogens and a restricted number of abiotic stress factors. Detoxification by immobilizing contaminants away from sensitive assimilation and conducting tissues allows adapted populations to survive in contaminated environments. Indications at cell level have to be understood to interpret the

different types of visible symptoms and their localization within the tree. They will allow the observer to develop reliable diagnostic tools for survey purposes. This paper reviewed stress factors, for which reliable bioindication is currently available, and others, for which future research is needed to determine their role in environmental change.

**Forests and carbon sequestration in a polluted environment.** Jandl, R. (*Federal Office and Research Center for Forests, Austria; robert.jandl@bfw.gv.at*).

The potential of forests to sustainably bind CO<sub>2</sub> for decades both in their biomass and the soils is not disputed. Research topics are the size and stability of the involved C pools. The biomass retains C for decades and at high accumulation rates, soils sequester more C at low rates. Natural site factors and air pollutants impair the utilization of the C sequestration potential. Three pollutants, ozone, nitrogen, and soil acidification, are chosen as examples. Elevated ozone concentrations reduce the growth rate and the C transfer to the soil. Nitrogen deposition has a fertilization effect and increases the C sequestration, but emissions of N<sub>2</sub>O from N-enriched forests are high. Liming of forest soils stabilizes the chemical soil status and is beneficial for the chemical quality of drinking water from forested areas. The effect of a stimulation of the nutrient cycle is linked to a reduction in the soil C pool. The three examples highlight that C sequestration in forests not only depends on silviculture, but also on external factors (air pollution) and chosen remedies (liming).

**Causes of changes in growth of European forests: Analysis of the roles of climatic factors and nitrogen nutrition.**

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Temporal trends and spatial patterns of height growth changes of Norway spruce (*Picea abies* L. Karst.), Scots pine (*Pinus sylvestris* L.) and European beech (*Fagus sylvatica* L.) forests across Europe were analyzed in relation to changes in air temperature and precipitation, and to levels of foliar nitrogen. Results show that mean height growth rates have significantly increased during the period 1960 to 2000: 25.1% for beech, 24.8% for pine, and 22.8% for spruce. Based on yield table assumptions these changes in height growth correspond to increases in total volume production of 74.0% for beech, 44.9% for pine, and 56.4% for spruce. The level of height growth acceleration is fairly constant over the last 40 years. Mean height growth acceleration rate of beech with higher N nutrition was more than two times larger than of those with lower N. A similar tendency was indicated for pine, but not for spruce. The higher the site index, the lower the level of change in height growth of pine and beech. A spatially explicit statistical model was developed to explain a significant amount of the spatial variability in changes of mean height growth rate of spruce and pine across parts of Central and Northern Europe.

**Physiological and genetic responses to ozone in trees growing under elevated atmospheric CO<sub>2</sub>.**

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Atmospheric concentrations of CO<sub>2</sub> and O<sub>3</sub> are increasing such that large areas of the world's forests will be exposed to elevated levels of these co-occurring pollutants in the next century. Little is known as to the physiological or genetic responses of forest trees to these interacting pollutants for the long term. We have examined the responses of three northern forest tree species (*Acer saccharum*, *Betula papyrifera*, and *Populus tremuloides*) grown for their entire 7-year life history in an open-air facility under two levels of CO<sub>2</sub> (360 ppm and 560 ppm) and O<sub>3</sub> (51 ppb and 77 ppb). Results of the study showed that O<sub>3</sub> at relatively low levels offsets the increases in productivity caused by elevated CO<sub>2</sub>. Elevated CO<sub>2</sub> generally decreased the negative aspects of O<sub>3</sub>, except for sugar maple where the effects of O<sub>3</sub> were exacerbated at elevated CO<sub>2</sub>. Allometry was not affected by either greenhouse gas, and responses were highly variable by species and by clone within species (for aspen), resulting in changes in community composition. The long-term interacting effects of CO<sub>2</sub> and O<sub>3</sub> were not all predictable based on previous single gas treatment responses.

**A review of the interactive effects of nitrogen fertilization under elevated CO<sub>2</sub> concentrations, including new insights from a FACE experiment on poplars.**

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Tree plantations for biomass and energy production have the greatest potential for carbon mitigation. However, the Kyoto Protocol states that only direct human-induced changes in carbon stocks may be used as credit for the reduction of emission targets. Therefore, the direct human-induced effect by carbon management should be separated from the indirect effects due to global change (increasing CO<sub>2</sub>, nitrogen deposition). Distinguishing these effects is very difficult

with present scientific tools unless manipulative studies are conducted at the ecosystem scale as is the case of free air CO<sub>2</sub> enrichment (FACE) experiments. The present research combines a fast-growing, agro-forestry ecosystem, capable of elevated biomass production, with a large-scale FACE infrastructure (EUROFACE), the only one available in the European Union on a forest tree stand, and a differential N-fertilization treatment. Above-ground woody biomass of trees exposed to elevated CO<sub>2</sub> for three growing seasons increased by 15 to 27%, depending on species. There was greater depletion of inorganic N from the soil in elevated CO<sub>2</sub>, but no effect of CO<sub>2</sub> on stem wood density. N fertilization increased N leaf content both on mass and area basis and in both CO<sub>2</sub> treatments but did not influence the photosynthetic parameters apart from enhanced stomatal conductance.

**Defence and avoidance from ozone under global change.** Tausz, M. (*University of Melbourne, Victoria, Australia; University of Graz, Austria; Michael.tausz@unimelb.edu.au*), Wieser, G. (*Federal Office and Research Centre for Forests, Austria; gerhard.wieser@uibk.ac.at*); Grulke, N.E. (*USDA Forest Service, USA; ngrulke@fs.fed.us*).

The level II approach of critical loads, a concept adopted by the UN-ECE, aims at a flux-based evaluation. For this purpose, environmental factors (e.g., water status, ambient CO<sub>2</sub>) governing stomatal conductance are taken into account. It is widely anticipated that these factors will vary in the future due to global change. According to the flux-based concept, a decrease of stomatal conductance (e.g., due to increasing drought or elevated CO<sub>2</sub>) would protect trees from pollution effects through avoidance of uptake. In contrast to this straightforward hypothesis, experimental evidence is not always clear. There are numerous results suggesting that pollutants and factors subject to global change (drought, CO<sub>2</sub>) may interact and even exacerbate effects. The stress physiological basis thereof is that the antioxidative defence system comes into play, in protecting against pollution effects and natural stressors (e.g. drought). It has been suggested that an 'effective pollutant dose', which is weighted by physiological defence capacity, would be more appropriate to predict such effects. In this review paper, we argue that a merely flux-based approach is imperfect, because global change effects may also modify the physiological susceptibility to ozone. Instead, a flux concept weighted by defence capacity should be tested.

**Deposition monitoring in forest ecosystems in Croatia.** Vrbek, B., Benko, M., Vuletić, D., Litvay, T., Dubravac, T. (*Forest Research Institute, Croatia; borisv@sumins.hr*).

Systematic and elaborate multidisciplinary research on pedunculate oak and common hornbeam began in Croatia in 199, and the method of monitoring deposition in forest ecosystems was developed at that time. This method, which is closely related to ICP-Forest monitoring, has included several forest communities. The following ions were monitored: Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>-S, NH<sub>4</sub><sup>+</sup>-N, NO<sub>3</sub><sup>-</sup>-N, Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>. Sampling was performed at 3-month intervals by means of funnels with minimum openings of 314 cm<sup>2</sup>, and the amount of precipitation was measured in rain gauges with a surface opening of 60 cm<sup>2</sup>. Plastic lysimeters collected seepage at a depth of 10 cm or beneath the humus layer. The surface of the collector-tubs (baths) is 1093 cm<sup>2</sup>. Monitored plots were established in forest communities of beech and fir (*Abieti-Fagetum illyricum/Ht.*), submontanum beech (*Homogino-alpine-Fagetum sylvaticae*), Aleppo pine and evergreen oak (*Quercus ilicis-Pinetum halepensis*), evergreen oak (*Quercus ilicis*), and pedunculate oak and common hornbeam (*Carpino-betuli Quercetum roboris*). On experimental plots soil type was defined, and chemical and physical analyses of samples were conducted. Results showed that our forest ecosystems absorbed more deposited particles (wet and dry sedimentation) in comparison to control samples in the open area.

**Determination of present and critical loads of nitrogen and acidic deposition and levels of ozone on Swiss long-term forest ecosystem research plots.** Waldner, P., Schaub, M., Pannatier, E., Schmitt, M., Thimonier, A. (*WSL – Swiss Federal Research Institute for Forest, Snow and Landscape, Switzerland; peter.waldner@wsl.ch; marcus.schaub@wsl.ch; elisabeth.pannatier@wsl.ch; maria.schmitt@wsl.ch; anne.thimonier@wsl.ch*), Rihm, B. (*Meteotest, Switzerland; rihm@meteotest.ch*), Thöni, L. (*FUB – Forschungsstelle für Umweltbeobachtung, Switzerland; fub@fub-ag.ch*).

Air pollutants affecting forest health include increased acidic precipitation, increased atmospheric deposition of nitrogen compounds and increasing surface levels of ozone (O<sub>3</sub>). In the frame of the 1985 Convention on Long Range Transboundary Air Pollution (LRTAP) a network to monitor air pollution impacts has been established. Furthermore, various research efforts have been undertaken to define critical values below which significant harmful effects on specified elements of the forest ecosystems do not occur according to present knowledge. We compared different methods to determine the present and critical loads and levels for 13 Swiss long-term forest ecosystem research (LWF) plots. In general, a good agreement was found between an inferential and the throughfall method to determine atmospheric deposition of nitrogen and sulphur. These deposition values have been compared to empirical critical loads and also to critical loads calculated with a mass balance on the assumption of a steady state. Ozone levels during vegetation periods have been measured with passive sampler and were compared to the critical threshold of 40 ppb (AOT40). However, plant injury does not only depend on ozone concentration and we discuss the implications of exceeding the AOT40 threshold in comparison with the ozone uptake, based on the flux concept.

## Understanding linkages between climate and forest fire

Organizer: David Peterson *USDA Forest Service, USA*; [peterson@fs.fed.us](mailto:peterson@fs.fed.us)

### Correlation between meteorological data and fire occurrence in a Mediterranean area (Tuscany Region).

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This paper presents a study exploring the correlation between meteorological conditions (temperature and precipitation) and forest fire occurrences in the Mediterranean region during the high hazard period (75% of forest fires occur between June and September, with a peak in August). The first step was an investigation of the correspondence between the meteorological data trend and the fire ignitions from 1984–2002. The meteorological data were used to define a Drought and Thermal Fire Hazard Index. These indices were matched with fires events in order to test and verify their capability to define, in a forest ecosystem, the favourable conditions for fire ignition. In the second phase, the severity of the fires that occurred were analyzed and used to adjust the Canadian Fire Weather Index and Fire Potential Index so these indices would be applicable to Mediterranean conditions. The ignition risk derived from these indices was compared with the statistics for each fire event, to develop an operational tool for the Regional Fire Fighting Office. Using these tools, a retrospective prediction was undertaken for the 2002, 2003, and 2004 fire seasons.

### Characterizing wildland fire fuels and risk in the southeastern United States of America. Mickler, R.A., Bailey, A.D. (*ManTech Environmental Technology, Inc., USA*; [robert.mickler@mantech.com](mailto:robert.mickler@mantech.com); [andrew.bailey@mantech.com](mailto:andrew.bailey@mantech.com)).

Wildland fuels have been accumulating in the United States during at least the past half-century due to wildland fire management practices and policies. The additional fuels contribute to intense fire behaviour, increase the costs of wildland fire control, and contribute to ozone and particulate matter air pollutants. Wildfire risk assessments and fire behaviour, smoke, and emission models can be improved with spatially and temporally explicit estimates of vegetation cover and biomass. Additionally, land managers can identify forest units with the highest need for fuel reductions by prescribed burning. This study reports on the assessment of wildland fire risk utilizing remotely sensed vegetation maps, forest field plot data, and spatial models of live and dead vegetation fuel loading, fire behaviour, smoke dispersion, and emissions. The vegetation classes were combined with field measurements of standing live and dead trees, down deadwood, understory shrub and herbaceous vegetation, forest floor, and soil carbon biomass using the United States Forest Service Forest Inventory and Analysis protocols. Our study incorporates modified International Classification of Ecological Communities association level vegetation maps created from 3-D digital photogrammetry, disturbance history, and field plot data, to accurately capture the structural complexity of fuelbeds in US forests.

## The contributions of tree physiology to understanding the effects of climate change

Organizer: Robert Teskey *University of Georgia, USA*; [teskey@smokey.forestry.uga.edu](mailto:teskey@smokey.forestry.uga.edu)

### Annual pattern of carbohydrate accumulation in Aleppo pine under different climatic conditions in Israel.

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Understanding the ecophysiological characteristics of forest trees is an important tool for proper forest management. Sugar and starch reserves are prominent factors in tree growth and development. Storage carbohydrates may serve as osmoregulators during environmental stresses. The aim of the present study was to compare the carbohydrate accumulation in two Aleppo pine (*P. halepensis* Mill.) provenances under contrasting climatic conditions, a semi-arid zone and a typical Mediterranean zone. Soluble sugars and starch were determined monthly throughout the year in needles, stem bark and roots. The data show two peaks of carbohydrate accumulation, which was quite similar in the two climatic zones: one during the winter (soluble sugars in needles and starch in all three organs) and the second during the summer (soluble sugars in the bark and roots). Carbohydrate accumulation during the winter can be attributed to the effect of low temperature. Mediterranean species grown under low temperatures accumulate high levels of carbohydrates; in summer, high accumulation of carbohydrate was attributed to water stress. Besides the important role of carbohydrate accumulation in plant resistance to environmental stresses, the winter peak seems to be utilized for the early spring flush, which is the most prominent one in this region.

***Quercus robur* seedlings response to temporary irradiation.** Creanga, I.A., Arteni, A.A., Artenie, V. (*Territorial Forestry Office, Romania; creanga52@yahoo.com*).

Low doses of ionizing radiation (one of the so called temporal sources of pollution of our times) have been administrated to oak seedlings with uniform genophond. The acute irradiation effects on assimilatory pigments, catalase activity, and nucleic acid levels was investigated using spectrophotometric and chemical assays. In 3-month old seedlings, the assimilatory pigment level was diminished, and the chlorophyll a/b ratio decreased, which suggests an inhibitory effect on the LHC II system. The catalase activity was enhanced, revealing the plant capacity to adapt to the increased amount of hydrogen peroxide (catalase substrate) related to the radiation indirect action. In 6-month old seedlings, the chlorophyll a/b ratio was also slightly diminished. The catalase activity is linearly diminished, the biosynthesis processes being no more able to compensate for the irradiation damages. The vegetal cell ability to face the radiation impact was proved, however, by the increased level of nucleic acids (the intensification of DNA and RNA biosynthesis processes). We may conclude that temporary low doses of irradiation represents a serious perturbation in the young seedling physiology though compensatory biosynthesis mechanisms are able to repair part of the damages in the 3- and 6-month old plants.

**Climate change and water use of plants and catchments.** Eamus, D., Yanusa, I. (*University of Technology, Sydney, Australia*).

The study of climate change includes systematic examination of changes in atmospheric composition (especially CO<sub>2</sub> concentration), climate (especially rainfall, water vapour pressure and temperature), and biotic (especially vegetation) responses to these changes. Such studies can be undertaken from micro to macro-scales, both spatially and temporally. Over the past 50–100 years, global mean surface temperatures have increased by about 0.15 °C per decade. It is generally expected that this will cause increased surface evaporation. However, open-pan evaporation rates have shown relatively consistent declines over the past 50 years (the so-called ‘pan evaporation paradox’) despite increased temperatures. Potential causes of this paradox include changes in solar radiation input and cloudiness. Increased cloudiness can cause increased diffuse beam irradiance and hence NPP. Transpiration from leaves occurs predominantly through stomata, which themselves are influenced by the atmospheric concentration of CO<sub>2</sub> and transpiration rate, temperature and light flux density. This paper discusses the pan evaporation paradox, stomatal control of transpiration and rates of water use of field-grown trees under conditions of increased atmospheric concentrations of CO<sub>2</sub>.

**Influence of leaf form on photosynthetic carbon gain and growth of heteroblastic seedlings to light.** Gamage, H.K., Jesson, L.K. (*Victoria University of Wellington, New Zealand; gamagehars@student.vuw.ac.nz; linley.jesson@vuw.ac.nz*), Drake, D.R. (*University of Hawaii, Hawaii; dondrake@hawaii.edu*).

Changes in leaf morphology affect the physiological function of plants. Heteroblastic plants have fixed changes in leaf morphology between seedling and adult stages relative to homoblastic plants. We tested the prediction that heteroblastic seedlings would have higher photosynthetic carbon gain, survival, and growth than homoblastic congeners in shade. Four pairs of congeneric homoblastic and heteroblastic species in genera *Aristotelia*, *Hoheria*, *Pseudopanax*, and *Melicope* were grown for nine months in four shelters within a glasshouse. We altered light quality and quantity to simulate deep shade and full sun. Heteroblastic seedlings, which have toothed, and lobed leaves reduced leaf lobing in shade but lobing was retained in full sun. Maximum photosynthetic rate and stomatal conductance of heteroblastic species were greater than homoblastic congeners in full sun, but did not differ in shade. Seedling survival and growth measures of height, root collar diameter, and total dry mass were consistently lower for heteroblastic species relative to homoblastic congeners both in sun and shade. We conclude that changing leaf morphology in heteroblastic seedlings is not an adaptation to shade, and other functional hypotheses should be sought.

**In our elevated CO<sub>2</sub> world, is tree growth nitrogen or carbon limited?** Gifford, R.M. (*CSIRO Plant Industry, Australia*).

Although the idea of single limiting factors to productivity is well entrenched in plant science, the opposite idea of multiple co-limiting factors also receives much, and increasing, support. While the equal distribution of limitations among several co-limiting factors might be true for natural ecosystems in stable environments to which they are very well adapted, the reality for planted monocultures in environments in which they did not evolve probably falls in-between these two extreme ideas. Following several decades of globally increasing atmospheric carbon dioxide concentration and nitrogen deposition on the land, owing to expansion of fossil fuel combustion, the question takes on further complexity. Are the concurrent increases in available carbon and nitrogen complementing each other to drive forest productivity to new highs, or are other limiting factors limiting the expression of both potential global stimuli? This is a difficult problem to untangle owing to the complexity of interactions between variables and the multiplicity of concurrent environmental changes. The problem is discussed from the perspective of the N-cycle and the C-cycle interacting in different ways on different timescales.

**The effect of elevated [CO<sub>2</sub>] and temperature on respiration and photosynthesis in developing shoots of boreal Norway spruce.** Hall, M., Råntfors, M. (Göteborg University, Sweden; [marianne.hall@miljo.gu.se](mailto:marianne.hall@miljo.gu.se); [mats.rantfors@botany.gu.se](mailto:mats.rantfors@botany.gu.se)), Linder, S. (Swedish University of Agricultural Sciences, Sweden; [sune.linder@ess.slu.se](mailto:sune.linder@ess.slu.se)), Wallin, G. (Göteborg University, Sweden; [goran.wallin@miljo.gu.se](mailto:goran.wallin@miljo.gu.se)).

A cold climate with short growing seasons is one of the most limiting factors for carbon fluxes between boreal forests and the atmosphere. Increasing atmospheric CO<sub>2</sub> concentrations [CO<sub>2</sub>] and rising temperatures are thus likely to result in a higher carbon sequestration. Several ecosystem processes are involved, and in the present study the focus is on the development and carbon balance of new shoots in mature Norway spruce (*Picea abies*) trees, aiming to establish when these shoots become net providers of carbon and how this is affected by the climatic conditions. The study was performed at the Flakaliden long-term experimental site in northern Sweden (64° 07' N, 19° 27' E). Twelve 40-year-old Norway spruce trees were enclosed in temperature and CO<sub>2</sub>-controlled whole-tree chambers, and exposed to [CO<sub>2</sub>] elevated to 700 Bmol/mol, and elevated air temperature (ambient + 5 °C in winter and ambient + 3 °C in summer), treatments applied simultaneously as well as separately and combined with tracking of ambient conditions. The results indicate an impact of elevated [CO<sub>2</sub>] on the fully developed shoots by increasing the maximum net assimilation rate with 35%, although the daily mean activity was largely related to daily mean photosynthetic photon flux density.

**Evaluation of the environmental decline in the microwatershed of Escuque, State of Trujillo, Venezuela.** Jaimes C., E.J., Mendoza M., J.G., Ramos G., Y.T., Pineda C., N.M. (Los Andes University, Venezuela; [edgarja@cantv.net](mailto:edgarja@cantv.net); [josegmm@hotmail.com](mailto:josegmm@hotmail.com); [yalitzar3@hotmail.com](mailto:yalitzar3@hotmail.com); [pineida@cantv.net](mailto:pineida@cantv.net)).

A technical analysis was conducted to determine the degree of environmental decline in the Río Blanco and La Palma streams located in the microwatershed of the Escuque river. On the basis of the resulting diagnosis, the levels of decline in both sections of the microwatershed were determined using the methodological approach of the logical framework. Two matrix models were applied: cause – effect and problem – solution, for both sections. An overall analysis of the environmental decline of the watershed was carried out applying unpublished parameters defined by the authors of this evaluation. On the basis of these relations it was possible to determine that the Río Blanco stream showed a higher value of decline (VD = 678) than the La Palma stream with a VD = 572. It was concluded that the main reasons for this decline were, the absence of land management plans, and the lack of technical leadership in government agencies with regard to the identification of priorities, and the design of feasible and sustainable production projects.

**Mesoclimatic homogeneity of life zones in Venezuela.** Jaimes C., E.J., Pineda C., N.M., Mendoza M., J.G. (Los Andes University, Venezuela; [edgarja@cantv.net](mailto:edgarja@cantv.net); [pineida@cantv.net](mailto:pineida@cantv.net); [josegmm@hotmail.com](mailto:josegmm@hotmail.com)).

This presentation generally aims at analyzing the homogeneity of the mesoclimates of Venezuela using the Multiple Homogeneity Index (Índice de Homogeneidad Múltiple IHM). The methodology was based on obtaining climatic information collected by the Meteorological Service of the Venezuelan Air Force (FAV). The different life zones identified in Venezuela were grouped according to the mesoclimatic types that had been previously defined by different authors. The matrix of climatologic data was structured on the basis of three criteria of classification: 1) elements associated with the energy components of the biosphere (solar radiation, insolation and temperature), 2) elements related to humidity in the troposphere (precipitation, evaporation and relative humidity), and 3) elements linked to the general circulation of energy and humidity in the atmosphere (wind, cloudiness and atmospheric pressure). The results allowed the determination of the most homogeneous mesoclimatic types and life zones. These results are of high significance for projects related to biodiversity management in forestry and agroforestry systems that are currently being used in the various life zones of the country.

**Genetic variation in response to global change.** Karnosky, D.F. (Michigan Technological University, USA; [karnosky@mtu.edu](mailto:karnosky@mtu.edu)).

Increasing atmospheric concentrations of the two greenhouse gases, carbon dioxide (CO<sub>2</sub>) and ozone (O<sub>3</sub>), are important drivers of global change. Forest trees have a high degree of phenotypic plasticity in response to these two gases. In this presentation, I will examine genetic variation in aspen (*Populus tremuloides*) responses to elevated concentrations of atmospheric CO<sub>2</sub> and O<sub>3</sub> in two long-term studies of global change impacts in the Lake States region of the USA: the Aspen FACE open-air study of interacting CO<sub>2</sub> and O<sub>3</sub> in northern Wisconsin and the Ozone Gradient Study which includes a common set of aspen clones planted at different spacings along a natural O<sub>3</sub> gradient from northern Wisconsin to southern Wisconsin and southern Michigan. In the two studies, genetic differences in productivity, survival, and reproductive fitness linked to ambient O<sub>3</sub> have been demonstrated suggesting these two gases could be affecting natural selection for aspen via eliminating O<sub>3</sub>-sensitive genotypes from future generations. For sensitive genotypes, ambient O<sub>3</sub> was shown to induce visible foliar symptoms, alter competitive interactions, decrease flower and seed production, and reduce the capacity for vegetative reproduction.

**Ecophysiological characteristics of windward and leeward tree species in Nanjenshan, Taiwan.** Kuo, Y.-L., Hong, J.-S. (*National Pingtung University of Science and Technology, Chinese Taipei; ylkuo@mail.npust.edu.tw*).

Species compositions at windward sites and leeward sites of Nanjenshan, southern Taiwan, are distinctly different due to the differential impacts of wind stress caused by the northeasterly monsoon in winter. In order to explore the mechanisms of site differentiation between windward species and leeward species, we monitored diurnal variations in photosynthesis at upper canopy leaves of four windward species and two leeward species in monsoon and non-monsoon seasons. In addition, photosynthetic temperature responses were also determined in the monsoon season. Results showed that *Anneslea fragrans*, *Gordonia axillaries*, and *Cyclobalanopsis championii*, all windward species, had significantly higher diurnal mean photosynthetic rates in monsoon season than in non-monsoon season. While *Ficus fistulosa*, a leeward species, showed the opposite response. These findings revealed that photosynthetic productivity of the windward species was higher in the monsoon season and leeward species in the non-monsoon season. Furthermore, the mean of optimum temperature for photosynthesis was 23.5 °C for the windward species and 28.2 °C for the leeward species. These results indicated that the windward trees physiologically had the characteristics of temperate species, while the leeward trees showed the characteristics of tropical species.

**Effect of red and far-red light on shoot elongation cessation and internode length.** Kushida, T. (*Japan Science and Technology Agency, Japan; kushidat@hgc.jp*), Honma, T. (*Tokyo University of Agriculture, Japan; t\_honmac@calbee.co.jp*), Nakashima, A., Yamamoto, M. (*Wakayama University, Japan; nakat@sys.wakayama-u.ac.jp; s044060@sys.wakayama-u.ac.jp*), Nagata, H. (*Phytoculture Control Co., Ltd., Japan; nagatafamily@zvtv.co.jp*).

The mechanism of the photoperiodic reaction was studied in *Populus euramericana* cv. I-214, a short day plant with a 14-h critical photoperiod, for shoot elongation cessation and terminal bud formation. Further, the effect of the time of exposure to red light (R; FR/R = 0.7) and far-red light (FR; FR/R = 1.5) on shoot elongation cessation, terminal bud formation, and internode length was also studied. Initially, this effect was investigated under a 15-min exposure. Observations were recorded for FR immediately before, in the middle of, and after the dark period of 14-h and 14.25-h photoperiods. Consequently, the highest values were recorded for percentages of shoot elongation cessation and terminal bud formation; maximum internode length was observed under the condition of 15-min exposure to FR before the dark period. Additionally these effects by FR before the dark period were nullified by the exposure to R immediately after FR. These results indicate that the wavelength of light before the dark period plays an important role in regulating the photoperiodic effects, such as shoot elongation cessation, terminal bud formation, and internode growth, and thereby affect growth and development.

**Effects of *Acacia* plantation on tree species composition and microclimate in grassland of Mt. Makiling, Philippines.** Lee, D.K., Lee, Y.K. (*Seoul National University, Republic of Korea; silviculture@empal.com*) Woo, S.-Y. (*The University of Seoul, Seoul, Republic of Korea*), Abraham, E.R.G. (*University of the Philippines at Los Baños, Philippines*).

Restoration activities improve degraded ecosystems functionally, by changing, positively, species composition and microclimate. A study area in Mt. Makiling was rehabilitated and protected from fire for over 12 years, after which species composition and microclimate were examined. After the area was burned extensively in 1991, reforestation was done by planting *Acacia mangium* and *Acacia auriculiformis*. Three study areas were selected in 2003: two areas were planted with *A. mangium* and *A. auriculiformis*, and one was still dominated by *Imperata cylindrica* and *Saccharum spontaneum*. Species composition was measured. Air temperature and relative humidity were monitored every hour for 12 months and soil temperature every two hours for 11 months using HOBO data loggers. *A. auriculiformis* showed higher growth of height and DBH than those of *A. mangium* in 10 year-old plantation. However, more species appeared in *A. mangium* plantation than in *A. auriculiformis* plantation. Grassland showed not only higher air temperature, relative humidity and soil temperature than *Acacia* plantation but larger variations per hour. Highest peak of air temperature, relative humidity and soil temperature were shown in April. These results show that rehabilitation activities in grassland stabilized the microclimate.

**Physiological and growth responses of *Abies alba* trees to defoliation.** Li, M., Schaub, M., Cherubini, P., Kräuchi, N. (*Swiss Federal Research Institute WSL, Switzerland; maihe.li@wsl.ch; marcus.schaub@wsl.ch; paolo.cherubini@wsl.ch; norbert.kraeuchi@wsl.ch*).

Climate change including air pollution has an impact on forest ecosystems – directly (e.g., on defoliation and growth response) and indirectly (e.g. on tree physiology). To understand the effects of environmental changes on forests, crown transparency is applied as the most common indicator for forest health. However, this index does not include any information on the physiological response of trees. For example, severe defoliation will lead to decreased

physiological activity and growth rate. To our knowledge, there is still very little information available on the relationships between the crown transparency percentage and its effects on tree physiology (e.g. altered photosynthetic rate, reallocation of carbohydrates) and growth. In an *in situ* manipulation experiment in Switzerland, we simulated defoliation by removing different-aged needles from *Abies alba* Mill. trees grown on a light gradient. Following the defoliation (2002), we measured gas exchange rates with a newly developed conifer chamber combined with a LI6400 photosynthesis system allowing measurement of photosynthesis at low light conditions, non-structural-carbohydrates, and tree-ring width during three growing seasons (2002–2004). We aim to gain a better understanding of the physiological and growth responses to defoliation, and to estimate a threshold of transparency which may lead to adverse effects in *Abies alba* trees.

**Effects of warming to the spring growth of *Populus X euramericana*, *Pinus densiflora* and *Quercus serrata*.**

Nakashima, A., Yamamoto, M. (Wakayama University, Japan; nakat@sys.wakayama-u.ac.jp; s044060@sys.wakayama-u.ac.jp), Honma, T. (Tokyo University of Agriculture, Japan; t\_honmac@calbee.co.jp), Kushida, T. (Japan Science and Technology Agency, Japan; kushidat@hgc.jp).

We investigated the spring sprouting in *Populus euramericana*, *Pinus densiflora* and *Quercus serrata* for the plants grown under several controlled temperature conditions of the outdoor temperature altered by +4.5 °C, +3.0 °C, +1.5 °C, ±0.0 °C and -1.5 °C. The results showed that the spring sprouting period of *Q. serrata* began earlier under warmer conditions. But the spring sprouting of *P. euramericana* and *P. densiflora* was not influenced by the warm conditions. Sprouting of winter buds of those species required high heat summation under the warm conditions. It is considered that dormancy of winter buds of those species did not release enough under the warm conditions because of shortage of cooling stimulation. End of annual growth period of those species were later under the warm conditions. And, the dry weight of all under warmer conditions was larger than that of being under non-warm conditions, because growth periods were longer as warmer.

**Responses of forest trees in plantations and natural settings to atmosphere enriched with CO<sub>2</sub>.** Oren, R. (Duke University, USA; ramoren@duke.edu).

The free-air CO<sub>2</sub> enrichment (FACE) methodology has been employed in experiments on forest trees for about 10 years, yet results from these experiments reshaped the way we envision forests will respond to atmosphere enriched with CO<sub>2</sub>. Not all results from these few experiments are in agreement. In general, net primary productivity increases, but carbon storage in trees and soil increases less or not at all, indicating that heterotrophic respiration is higher under elevated atmospheric CO<sub>2</sub>. The inconsistency in results is not surprising considering that each experiment represents a unique setting in site characteristics, stand origin and composition, and stage of development. In fact, even a single species of a single origin at a prescribed stage of stand development was shown to respond to enriched CO<sub>2</sub> differently among plots within a site, based mostly on nitrogen availability. To account for the observed differences in response, and utilize more fully the information generated by these few expensive experiments, results are best employed in modeling experiments on forests responses to elevated CO<sub>2</sub>. These models should consider the effects of carbon and nutrient cycling, direct and indirect interactions between elevated CO<sub>2</sub> and water availability, and pollutants such as ozone.

**Combined effects of elevated CO<sub>2</sub> and fertilization on carbon allocation and forest floor CO<sub>2</sub> efflux in a loblolly pine plantation.** Palmroth, S. (Duke University, USA; sari.palmroth@duke.edu), Butnor, J.R. (USDA Forest Service, USA; jbutnor@fs.fed.us), McCarthy, H.R., Ward, E.J. (Duke University, Durham USA; hrm@duke.edu; eric.ward@duke.edu), Johnsen, K. (USDA Forest Service, USA; kjohnsen@fs.fed.us), Katul, G.G., Oren, R. (Duke University, USA; gaby@duke.edu; ramoren@duke.edu).

We studied the combined effects of elevated CO<sub>2</sub> (550 ppm) and nutrient amendments on forest floor CO<sub>2</sub> efflux (F<sub>ff</sub>) and below ground carbon (C) allocation in a maturing *Pinus taeda* L. plantation at the Free Air CO<sub>2</sub> Enrichment experiment (FACE) in Duke Forest. CO<sub>2</sub> fumigation commenced in 1994 and fertilizer has been applied once a year since 1998. F<sub>ff</sub> was measured continuously with eight chambers (491 cm<sup>2</sup> each) connected to an IRGA during 2000–2004. The results suggested that elevated CO<sub>2</sub> increased annual F<sub>ff</sub> by ~ 10% while both fertilization only and elevated CO<sub>2</sub> + fertilization suppressed it by ~ 15%. These differences were traceable to dissimilar F<sub>ff</sub>-soil temperature and -moisture responses that reflected differences in the amount and allocation of recent photosynthates. When compared to ambient conditions, elevated CO<sub>2</sub> alone enhanced photosynthetic production and the extra C was allocated to both aboveground production and F<sub>ff</sub>. Adding nutrients under elevated CO<sub>2</sub> increased the aboveground growth much more due to a shift in C allocation. Although inter-annual differences in photosynthetic production and growth were large due to variation in weather, soil fertility controlled the partitioning of the available carbohydrates between aboveground growth and belowground respiration in all years.



**Differential responses to shade among canopy and understory tree seedlings of lowland tropical rain forest in Sri Lanka.** Panditharathna, K.A.K. (*University of Sri Jayewardenepura, Sri Lanka; kumudini\_p@hotmail.com*), Singhakumara, B.M.P. (*University of Sri Jayewardenepura, Sri Lanka; singha@eureka.lk*), Gamage, H.K. (*Victoria University of Wellington, New Zealand; gamagehars@student.vuw.ac.nz*), Ashton, M.S. (*Yale University, USA; mark.ashton@yale.edu*).

Seedling responses to shade are important for the restoration practices used in tropical rain forests. Plants forming the understory of tropical forests are exposed to very low irradiance, compared to canopy species. We predicted that seedlings of understory species would possess foliar responses (morphology, anatomy, and physiology) similar to shade-adapted plants relative to seedlings of canopy species. We grew 43 tree seedlings of canopy and understory species in 18 different families that exist in rain forests of southwest Sri Lanka. Seedlings were grown for 2 years in controlled environmental shelters that received 2%, 20%, 50%, and 100% of full sunlight. We found that relative to understory species, mean leaf size, and specific leaf area were greater for canopy species while anatomical attributes were higher for understory species. Understory species had higher net photosynthetic rates and stomatal conductance relative to canopy species. Findings suggest that the understory species are more likely to tolerate shade due to their higher carbon gain through the production of smaller but thicker leaves in low light. We conclude that leaf level responses can be used in determination of differences in shade-tolerance of the studied species, which could be applied to restoration practices in tropical rain forests.

**Climate, topography, growth and carbon isotope composition of *Nothofagus cunninghamii* at Mt Donna Buang, Victoria, Australia.** Pfautsch, S. (*Albert-Ludwigs-University, Germany, and University of Melbourne, Australia; pfautsch@unimelb.edu.au*), Adams, M.A. (*University of Western Australia, Australia; adamsma@cyllene.uwa.edu.au*), Gessler, A. (*Albert-Ludwigs-University, Germany*).

On the basis of tree growth ring analysis, mean annual growth of *Nothofagus cunninghamii* at Mt Donna Buang did not vary between trees growing as an understorey to eucalypts or growing as co-dominants in deeply incised valleys. Growth varied with altitude and was best closer to the summit (>1000m asl) and at the lower limits of the observed range (<500m asl) and was least on the steeply sloping and south-facing slopes of intermediate altitudes. Growth and carbon isotope discrimination ( $\delta^{13}\text{C}$ ) in late wood were moderately well related. As a co-dominant, *Nothofagus cunninghamii* was significantly more depleted in the heavy isotope  $^{13}\text{C}$  than as an understorey and a highly significant altitudinal variation owed much to the same steeply sloping sites that affected growth. Using the wettest and driest years in the record we found strong and consistent altitudinal gradients in  $\delta^{13}\text{C}$  that increased by 4–5 ‰ per km increase in altitude. When coupled with a lack of any relationship between  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  in foliage, the spatial and temporal patterns in carbon isotope and growth data strongly suggest that water availability plays little role in governing growth and is instead more likely related to light availability.

**Validation of a multiple homogeneity index with climatologic data from Venezuela.** Pineda C., N.M., Jaimes C., E.J., Mendoza M., J.G. (*Los Andes University, Venezuela; pineida@cantv.net; edgarja@cantv.net; josegmm@hotmail.com*).

The Multiple Homogeneity Index (Índice de Homogeneidad Múltiple – IHM) measures the spatial and temporal homogeneity in correspondence with the exchange of matter, energy and information within and between the systems and the surrounding atmosphere. This homogeneity refers to the degree of structural and functional simplicity of a given system. For the definition of the IHM, a matrix of eigenvalues obtained from Principal Components Analysis was used. This presentation aims at proving the predictive potential of the IHM, previously defined and validated by edaphic, pedogeomorphological, socioeconomic, cultural, public health, and environmental health data. The climatic information collected was measured and recorded between the years 1961 and 2000 by the Meteorological Service of the Venezuelan Air Force. The monthly average, maximum and minimum values of the following climatologic parameters were used: overall radiation, insolation, temperature, precipitation, evaporation, relative humidity, wind speed, atmospheric pressure, and cloudiness. Automated data processing was done with the Lands Homogeneity Automated System (Sistema de Información Automatizado de Homogeneidad de Tierras – SIAHT). This validation will serve as a basis for studies of the multiple homogeneity of forest and agroforestry systems in any ecological zone in intertropical regions.

**Temporal and spatial variation of  $V_{c_{max}}$  within a Swiss beech canopy.** Schaub, M., Zimmermann, N., Kräuchi, N. (*Swiss Federal Research Institute WSL, Switzerland; marcus.schaub@wsl.ch; nez@wsl.ch; norbert.kraeuchi@wsl.ch*).

There is considerable concern over the extent to which increasing concentrations of long-lived greenhouse gases and aerosols, and associated changes in climates could affect forest ecosystems. To better assess the likely range of ecosystem responses, models have been developed which enable us to predict species and ecosystem processes, i.e. above ground net primary production. In order to calibrate such models for the environmental conditions as they occur

in Switzerland, and to gain a better understanding about the variance of photosynthetic capacity according to the spatial position and leaf age, we measured A-Ci curves on four levels from randomly selected leaves inside the crown of five mature beech (*Fagus sylvatica*) trees, every month from May to October in 2002 and 2004 using the LI6400 photosynthesis system. Additional measurements of the leaf-nitrogen content enabled us to calculate two key parameters describing the photosynthetic capacity:  $V_{c_{max}}$ , being the maximum rate of carboxylation under conditions of saturating substrate RuBP, and  $J_{max}$ , which expresses the maximum rate of electron transport under conditions of saturating irradiance. Considerable variation in photosynthetic capacity within the crown was detected according to leaf position and leaf age.

#### **Leaf $\delta^{13}C$ , photosynthetic characteristics and nitrogen content of *Buddleja davidii* from low and high altitudes.**

Shi, Z., Cheng, R., Liu, S. (*Chinese Academy of Forestry, P.R. China; shizm@forestry.ac.cn; chengrm@forestry.ac.cn; liusr@forestry.ac.cn*).

Leaf  $\delta^{13}C$  and main eco-physiological characteristics of the plant *Buddleja davidii* were compared between two populations. One was from 1300 m above sea level (a.s.l.), another from 3400 m a.s.l. Leaf  $\delta^{13}C$  value of high altitude population was almost 3‰ higher than that of low altitude population. The photosynthetic parameters  $V_{c_{max}}$  (maximum rate of carboxylation),  $J_{max}$  (maximum rate of electron transport), and  $A_{max}$  (the net  $CO_2$  assimilation rate under conditions of photosynthetic photon flux density (PPFD) and  $CO_2$  saturation) of the high altitude population were higher than that of low altitude population, their ratios were 1.28, 1.67 and 1.56 respectively. The ratios of  $R_d$  (mitochondrial respiration) and nitrogen content per leaf area of high altitude population to low altitude population were 1.86 and 1.46. There were good linear relationships between the photosynthetic parameters and leaf nitrogen contents in both populations. *In situ* fluorescence-gas exchange studies shown that stomatal conductance ( $g_s$ ) and the ratio of intercellular  $CO_2$  concentration to ambient  $CO_2$  concentration ( $C_i/C_a$ ) of high altitude population were lower, but its mesophyll conductance ( $g_m$ ) was higher. These results suggested that higher leaf  $\delta^{13}C$  value of high altitude population mainly caused by its higher photosynthetic capacity and long-term lower  $C_i/C_a$ .

#### **Spring phenology of Norway spruce (*Picea abies* (L.) Karst.) at ambient and elevated [ $CO_2$ ] and temperature.**

Slaney, M. (*Swedish University of Agricultural Sciences, Sweden; Michelle.Slaney@ess.slu.se*), Medhurst, J. (*CRC/CSIRO Forestry, Australia*), Linder, S. (*Swedish University of Agricultural Sciences, Sweden*), Wallin, G. (*Göteborg University, Sweden*).

During 2001, twelve whole-tree chambers (WTC) were constructed around individual trees and used to examine the long-term physiological responses of field-grown Norway spruce to the predicted climate scenario for the year 2100 (i.e. 700 ppm  $CO_2$  and 3 °C warmer in summer/5 °C warmer in winter). The spring phenology of the WTC and non-chambered reference trees was followed for three consecutive years. In addition to climatic variables, beginning in April, bud development was followed and once bud burst occurred, shoot length, stem diameter, soil moisture and soil temperature were measured from 2002 to 2004. Compared to ambient air temperature, bud swelling began earlier, new shoots emerged two to three weeks sooner and ceased to grow earlier in response to elevated air temperature. Although total shoot length increased during the first 2 years of treatment, there was a significant decrease after the third year and trees growing in elevated  $CO_2$  had the shortest shoots every year. Stem diameter increased when shoot elongation terminated in elevated temperature chambers and increased before shoot elongation (i.e. bud burst) began in ambient temperature chambers. This reflects the timing of resource allocation. The greatest increase in stem diameter occurred in trees grown in elevated  $CO_2$  and ambient temperature.

#### **How will global warming affect tree growth and forest productivity?** Teskey, R. (*University of Georgia, USA; rteskey@uga.edu*), Turnbull, M. (*University of Canterbury, New Zealand; matthew.turnbull@canterbury.ac.nz*).

Throughout the world, there have been studies devoted to the direct effects of elevated  $CO_2$  concentrations on trees. Relatively few experiments have focused on understanding how elevated temperatures will affect tree physiological processes and forest productivity. We know that an increase in air temperature can be expected to slightly enhance rates of net photosynthesis in elevated atmospheric  $CO_2$  concentrations. Elevated temperatures are expected to have a much greater effect on dark respiration. The often-observed close coupling of temperature and respiration rates has been used in many predictive models, with the predictions of decreasing productivity in forests in a warmer future climate. However, this conclusion may be too simplistic. Even though carbon losses from respiration increase with increasing temperature, in many instances, tree growth and forest productivity may be enhanced by an increase in temperature of 1–3 °C. This conclusion results from a combination of factors. Acclimation of physiological processes to changing temperatures may substantially reduce the carbon cost of dark respiration in warm conditions. In addition, longer growing seasons extend the period of photosynthetic activity. However, temperature related stresses, such as frosts after budbreak and damage from super-optimal temperatures, must also be considered.

**The effects of microenvironment on photosynthesis, chlorophyll contents and growth of four tropical species in the La Mesa watershed, Philippines.** Woo, S.-Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Lee, D.K., Lee, Y.K. (*Seoul National University, Republic of Korea*).

This study compares four species of trees whose seedlings were planted in flat and sloping grassland in plantation sites established in May 2002 in the La Mesa watershed, Philippines. Tree growth, chlorophyll content and eco-physiological characteristics were monitored. The height, diameter at the root collar, photosynthetic rates, transpiration, stomatal conductance and water-use efficiency of the four species grown in the sloping grass area were higher than those of seedlings grown in the flat grass area. Meanwhile, the chlorophyll content of the four species grown in the flat area was higher than in the sloping area. A lower air temperature and higher soil moisture in the sloping area is hypothesized as the main reasons for these results.

**Effects of year-round warmer condition to the growth and phenology of *Cryptomeria japonica*.** Yamamoto, M., Nakashima, A. (*Wakayama University, Japan; s044060@sys.wakayama-u.ac.jp; nakat@sys.wakayama-u.ac.jp*), Honma, T. (*Tokyo University of Agriculture, Japan; t\_honmac@calbee.co.jp*), Kushida, T. (*Japan Science and Technology Agency, Japan; kushidat@hgc.jp*).

This study aimed to examine the effects of year-round warmer conditions on the growth and phenology of two-year-old *Cryptomeria japonica* seedlings. The growth and the phenology of *C. japonica* were investigated under several controlled temperature conditions. The results indicated that, the growth period was longer under warmer conditions, because growth halt was later and the initiation of the shoot elongation was earlier under warmer conditions. Though the initiation of shoot elongation was earlier under warmer conditions, cumulative temperatures from growth halt to the spring flush increased under warmer conditions. Main shoot elongation, the speed of main shoot elongation, and length of between branches were greater under +2.0 °C and +3.0 °C treatments. Number of branches was increased under warmer conditions. Male flowers were not formed under ±0.0 °C treatment, but were formed under warmer conditions. The blooming period began late under warmer conditions. It seemed that the growth and phenology of *Cryptomeria japonica* seedlings should change under warmer condition.

## Impacts of drought and heat on forests

Organizer: Heinrich Spiecker *University of Freiburg, Germany; instww@uni-freiburg.de*

**Tree rings predict which trees will survive the next drought and which will die: a case study from South Tirol (Italy).** Cherubini, P. (*WSL Swiss Federal Research Institute, Switzerland; paolo.cherubini@wsl.ch*), Nötzli, M., Stary, N. (*WSL Swiss Federal Research Institute, Switzerland, and University of Zurich, Switzerland*), Saurer, M., Siegwolf, R. (*Paul Scherrer Institute PSI, Switzerland*), Kräuchi, N. (*WSL Swiss Federal Research Institute, Switzerland*), Minerbi, S. (*Autonome Provinz Bozen-Südtirol, Italy*).

A severe drought occurred throughout Europe in the summer of 2003. *Pinus sylvestris* L. mortality waves in South Tyrol (north-eastern Alps, Italy) were observed. We analyzed tree-ring width and carbon stable isotopes of trees which died after the drought ('dead trees'), and trees that survived ('survivors'), at three different sites. We found that 'dead trees' had faster growth rates than 'survivors', until a first major drought in 1976. After 1976, 'dead trees' were already weakened and had very slow growth rates, in comparison with those of the 'survivors'. At the beginning of the 1990s, the 'dead trees' had further abrupt growth reductions in comparison with the 'survivors'. Tree-ring carbon stable isotopes show clearly that 'dead trees' had a significantly reduced stomatal activity during the ten years prior to their death, which occurred in 2003, in comparison with the 'survivors'. Thus, the drought in 2003 can be considered as a lethal factor that finally lead to the death of trees which were already suffering for a long time period. Tree-ring stable carbon isotopes may therefore enable us to identify trees that will not survive future major drought events.

**Climate, site conditions, and declining oaks in southern Sweden.** Drobyshev, I., Sonesson, K. (*Swedish University of Agricultural Sciences, Sweden; Kerstin.Sonesson@ess.slu.se*).

There is a general agreement about the complex nature of oak decline in Europe. A number of factors have been noted to negatively affect the condition and growth of oak, including unfavourable climatic situations such as summer droughts and winter/spring frosts, adverse site conditions, fungal infection of oak roots, insect outbreaks, and indirect effects of nutrient imbalances. In the current study we identify possible risk factors negatively affecting growth and condition of oaks (*Quercus robur* L.) in the Swedish province of Scania. The study, which was originally initiated to explain a sudden dieback of a 45-year-old oak stand, is expanded to include eight stands varying in tree ages and soil

properties. Negative pointer years for oak are identified in a master oak chronology for southern Sweden (>600 trees) and their impact is analyzed in the stands studied. By applying dendrochronological methods we evaluate annually resolved histories of tree growth at each site, and contrast these with historical climatic data and site soil properties.

**Monitoring crown damage in alpine forests: effect of water stress and heat on different tree species.** Eccel, E., Salvadori, C., La Porta, N. (*IASMA, Italy; emanuele.eccel@ismaa.it; cristina.salvadori@iasma.it; nicola.laporta@iasma.it*).

A water balance has been calculated for a thermophilous oak forest grove in the Italian Alps to investigate relationships between water stress and plant damage. In the experimental site, a meteorological station has been in operation since 1993, providing a data series for modeling. The calculation approach has been adapted from a protocol developed for a European pilot study—the Penman-Monteith ‘one step’ method—has been used for calculating evapotranspiration, resistance coefficients have been evaluated according to maximum values found in literature and adapted to a daily step for the water balance model. Ad hoc equipment installed at the site, and measures performed—under-canopy precipitation, soil moisture, and leaf area index—allowed an experimental verification of the results of single parameterizations. The water balance model, and particularly relative transpiration, allowed a good description of previous years’ dry periods, where some summers turned out to have a major impact on the phytosanitary state of plants. Water stress data of the previous decade were analyzed and correlated with data of defoliation and discoloration of permanently monitored tree species growing in the area. Links between stress indexes and health tree status of the studied species have been investigated and will be discussed.

**Natural or human threats such as drought and heat 2003: Socio-economic impacts on the forest sector.** Ibanez, L., Couture, S. (*ENGREF/INRA-ENGREF, France; ibanez@nancy-engref.inra.fr*), Peyron, J.-L. (*GIP ECOFOR, France; peyron@gip-ecofor.org*), Thoroe, C. (*Federal Research Establishment for Forestry, Germany; oekonomie@holz.uni-hamburg.de*).

All sorts of damage follow phenomena due to climate events or human activities such as heat, drought, frost, storms, diseases, pollution, or global changes. They are influenced by the context in which they take place and by both prevention (ex-ante) and mitigation (ex-post) policy measures. In the frame of the French-German program on drought and heat 2003, all of these issues have been analyzed from an economic point of view in order to assess the actual consequences of such phenomena. They comprise direct consequences on forests, direct and indirect consequences on forest activities and uses, feedback effects on forests, prevention measures, background influence, and mitigation measures. This assessment helps to define the right strategies and policies for damage mitigation, risk management, and monitoring, and then to evaluate decisions. However, it can only be rigorously drawn with delay. Consequently, past experiences are very valuable to prepare this work, foresee some impacts, adapt efficient methods, estimate parameters, and finally, point out remaining questions that could necessitate additional research.

**Impacts of drought and heat on tree and forest growth: A synthesis of studies on short-, medium- and long-term effects observed under temperate climatic conditions.** Kahle, H.-P., Unseld, R., Spiecker, H. (*University of Freiburg, Germany; instww@uni-freiburg.de*).

Shortage in water supply is the most widespread limiting factor for tree growth. Trees have developed various strategies to mitigate or avoid drought stress. Stress responses range from short-term physiologic accommodation, to medium-term modifications and long-term genetic adaptation. Depending on strain intensity, small effects might be recognized only as weakened vitality, being completely reversible. Whereas severe disturbances might lead to plastic shifts, associated with irreversible organ and tissue damage and increased mortality. Based on retrospective observational data on forest growth taken from selected case studies, as well as from systematic surveys, the role of drought and heat in the past are analyzed. Special emphasis is laid on medium- to long-term effects on growth. Historic drought events are compared with the 2003 drought, and the validity of the historical analogue concept is critically discussed. Only very few data are available that cover the growth in the year 2003. High resolution data from dendrometer measurements on spruce and beech sample trees on selected sites in different elevations give insight into the specific magnitude and also intra-annual development of radial growth in 2003 as compared to preceding years.

**Drought-resistance characteristics of trees in the Loess Plateau of China estimated by  $\delta^{13}\text{C}$  of annual rings.** Koretsune, S., Fukuda, K., Sasaki, H., Iiyama, K. (*University of Tokyo, Japan; satomi@nenv.k.u-tokyo.ac.jp*), Chang, Z. (*Northwest Scientific-Technical University of Agriculture and Forestry, China*).

The Loess Plateau in China has been threatened by erosion and desertification, and there are many afforestation trials. However, physiological research on tree species has not adequate, and there are many areas where planted trees decline

or die. Therefore, it is very important to select tree species that are drought-resistant and appropriate to each area. The objective of this study was to clarify ecophysiological characteristics of trees on the Loess Plateau of China. Stomatal sensitivity and water-use-efficiency were studied by measuring the stable carbon isotope ratio ( $\delta^{13}\text{C}$ ) in the tree rings to assess drought-resistance, and growth rates were investigated by measuring ring widths. The effects of temperature and precipitation on water-status and growth rate were also examined. Water-use-efficiency and stomatal sensitivity of pine (*Pinus tabulaeformis*) to temperature/precipitation were high, however, its growth rate was low. On the other hand, water-use-efficiency and stomatal sensitivity of locust (*Robinia pseudoacacia*) were low, but the growth rate in the younger age was high. These results showed that pine is more drought-resistant than locust. Thus, pine is a more appropriate tree for planting than locust because drought-resistance with high water use efficiency are more necessary than high growth rates for planting trees in arid areas.

**Drought has stronger effect on pine stands than ammonia pollution.** Kupänskiènò, E., Deltuvas, R. (*University of Agriculture of Lithuania, Lithuania; likup@takas.lt*), Huttunen, S. (*University of Oulu, Finland*).

Mechanisms of ammonia effects on vegetation remains incompletely described due to scarce longer-term data concerning this phenomenon in varying climatic conditions. An eight-year study (1994–2002) was undertaken to evaluate the effects of a nitrogen fertilizer factory on Scots pine stands along a transect located within a distance of 0.5–22 km from the factory. Sites were compared according to the concentrations of  $\text{NO}_2$  and  $\text{NH}_3$ , and also tree and needle morphological characteristics, needle surface quality, nutritional state, content of free amino acids, and cell wall components. In the period of investigation, ammonia concentrations along the transect ranged from 4.2–42.5  $\mu\text{g}/\text{m}^3$ . The summer drought of 2002 caused changes in dispersion of  $\text{NH}_3$ . Estimated morphological, physiological, and biochemical parameters of the needles sampled along the transect demonstrate that ammonia pollution caused changes in the nitrogen and carbon metabolisms. Severe drought effects are contradicting: in some aspects mitigating and in other aspects impacting the condition of the pine stands. Generally, the study indicates that drought has a stronger effect than present ammonia pollution levels.

**Effects of growing soil moisture conditions on leaf photosynthetic properties in *Pinus densiflora* Sieb. et Zucc.** Naoko, M. (*Okayama University, Japan; miki@cc.okayama-u.ac.jp*), Otsuki, K. (*Konko Municipal Office, Japan; kosei\_otsuki@town.konko.okayama.jp*), Nishimoto, T. (*Okayama Prefectural Nature Conservation Center, Japan*), Sakamoto, K., Yoshikawa, K. (*Okayama University, Japan; skmtelm@cc.okayama-u.ac.jp; kenchan@cc.okayama-u.ac.jp*).

To clarify the differences in the leaf photosynthetic properties of *Pinus densiflora* Sieb. et Zucc. growing in different soil moisture conditions, the diurnal changes in stomatal conductance, transpiration rate, and net photosynthetic rate were examined using potted 5-year-old saplings growing at pF 4.2 and pF 1.8 soil moisture levels for 2 years. The pF 4.2 treatment saplings, growing under water stress, tended to reduce their stomatal conductance to avoid losing water in comparison with the pF 1.8 treatment saplings, growing under moist conditions. However no distinct differences in net photosynthetic rates were observed between the soil moisture conditions. The internal conductance of pF 4.2 treatment saplings was higher than that of pF 1.8 treatment saplings. It is suggested that *P. densiflora* growing under the moist conditions maintained the high net photosynthetic rate because of the high stomatal conductance, although the water loss was large, while, *P. densiflora* growing under the water stress prevented the loss of water and presented the high  $\text{CO}_2$  assimilation rate, which was caused by the higher internal conductance.

**Drought effect: The key factor for successful artificial regeneration.** Sarvaš, M., Tučeková, A. (*Forest Research Institute Zvolen, Slovakia; sarvas@fris.sk*).

Artificial regeneration consists of different stages (forest nursery, handling and transporting of planting stock, short-term storage, and planting) and the amount of available water in soil is crucial for efficiency of plant growth. Water is needful for successful reforestation to harmonize these stages and prevent the effect of stress factors on planting stock. The measurement of electrolyte leakage from taproots was examined for determination of drought on physiological quality of plants. The control beech plants reached 21% of electrolyte leakage and the plants exposed for 24 h to 25 °C and 15% air humidity reached 49% electrolyte leakage. The oak control plants had 19% of electrolyte leakage. On the other hand the oak plants exposed for 24 h to 25 °C and 15% air humidity reached 52% electrolyte leakage. In addition, the application of hydrogel STOCKOSORB in nursery practice and in reforestation was tested. Using 100g/m<sup>2</sup> of STOCKOSORB application on nursery bed before sowing resulted in an 11% increase in seedling height compared to the control. The survival of beech seedlings was almost 20% higher after the first growing season than the control. The application of STOCKOSORB (in reforestation) increased survival of beech plants by 33% over the control plants after the first growing season.

**Drought and heat wave 2003 and its impacts on European forests.** Spiecker, H. (University of Freiburg, Germany; [instww@uni-freiburg.de](mailto:instww@uni-freiburg.de)).

The persistent drought and heat of the summer 2003 caused severe damage throughout European forests. Challenged by this extreme weather phenomenon, French and German forest scientists jointly initiated a program—Drought 2003— involving scientists of different disciplines beyond national borders. Besides visible, immediate, or short-term impacts of the drought and heat on forests, the scientists expected further effects in the long-term. These effects are related to tree physiology, soil properties, and nutrient availability in soils and trees, as well as the root system, reducing tree growth and vitality, having an impact on environmental, social, and economic goods and services provided by forests. While numerous investigations have been undertaken on each of these topics, a synthesis about drought effects on forests taking different climatic scenarios into consideration is purposed by this French-German program. An overview of the results of the program consisting of nine working groups will be presented: climatology, forest monitoring, pests and diseases, water balance and tree physiology, forest growth, soil processes, biodiversity, socio-economic impacts, and forest management.

**Drought tolerance of indigenous woody species in the loess plateau of China.** Yamamoto, F., Yamanaka, N., Du, S. (Tottori University, Tottori, Japan; [fukuju@muses.tottori-u.ac.jp](mailto:fukuju@muses.tottori-u.ac.jp); [shengdu@alrc.tottori-u.ac.jp](mailto:shengdu@alrc.tottori-u.ac.jp); [yamanaka@alrc.tottori-u.ac.jp](mailto:yamanaka@alrc.tottori-u.ac.jp)), Otsuki, K. (Kyushu University; Japan; [otsuki@forest.kyushu-u.ac.jp](mailto:otsuki@forest.kyushu-u.ac.jp)), Xue, Z., Wang, S., Hou, Q.C. (Chinese Academy of Sciences, China; [shengqi\\_wang@yahoo.com.cn](mailto:shengqi_wang@yahoo.com.cn); [houghch@ms.iswc.ac.cn](mailto:houghch@ms.iswc.ac.cn)).

Drought tolerances of woody species on the loess plateau near Yan'an city, Shaanxi Province, were studied on the bases of pressure-volume analysis using pressure chambers. Differences in drought tolerance among eight different woody angiosperms including indigenous species such as *Syringa oblata*, *Armeniaca sibirica*, *Rosa hugonis*, *Acer stenolobum*, *Caragana microphylla*, *Pyrus betulaefolia*, *Quercus liaotungensis*, and introduced *Robinia pseudoacacia* were evaluated using pressure-volume (p-v) analysis in August, 2003. The effect of re-saturation method on the result of p-v analysis also was investigated. The drought tolerance of *R. pseudoacacia*, determined on the bases of the results of p-v analysis such as xylem pressure potentials at turgor loss point ( $\psi_w^{tlp}$ ) and osmotic potentials at saturated condition ( $\psi_s^{sat}$ ), was less than that of indigenous species such as *S. oblata*, *A. sibirica*, and *R. hugonis*. The drought tolerance of indigenous *Q. liaotungensis* was comparatively greater than that of introduced *R. pseudoacacia*. In most species, shoot segments excised directly from the non-watered branch samples had lower  $\psi_w^{tlp}$  and  $\psi_s^{sat}$  than those of segments excised from the re-saturated branch samples.

**Stand structure of natural *Quercus liaotungensis* forests under drought stress in the loess plateau of China.**

Yamanaka, N., Du, S., Yamamoto, F. (Tottori University, Japan; [yamanaka@alrc.tottori-u.ac.jp](mailto:yamanaka@alrc.tottori-u.ac.jp); [shengdu@alrc.tottori-u.ac.jp](mailto:shengdu@alrc.tottori-u.ac.jp); [fukuju@muses.tottori-u.ac.jp](mailto:fukuju@muses.tottori-u.ac.jp)), Otsuki, K. (Kyushu University; Japan; [otsuki@forest.kyushu-u.ac.jp](mailto:otsuki@forest.kyushu-u.ac.jp)), Xue, Z., Wang, S., Hou, Q. (Chinese Academy of Sciences, China; [shengqi\\_wang@yahoo.com.cn](mailto:shengqi_wang@yahoo.com.cn); [houghch@ms.iswc.ac.cn](mailto:houghch@ms.iswc.ac.cn)).

Stand structure of natural *Quercus liaotungensis* forests under drought stress was investigated on the loess plateau near Yan'an, China. Annual precipitation of Yan'an is 517 mm and the area is located in the forest-grassland transition zone. In October 2003, we selected four natural forest stands (Q1–Q4) near Yan'an. We demarcated study plots of 20 x 40 m in each stand and marked all trees (DBH > 1.0 cm) with plastic tags. DBH and tree height values of all *Q. liaotungensis* trees were measured. Core samples at 30 cm height were collected using a core sampler for canopy trees of *Q. liaotungensis* in each plot. All forests investigated were 30–50-year-old secondary forests, located on ridges or on the upper portion of north-facing slopes. The dominant tree species was *Q. liaotungensis* and its dominance (basal area percent) in Q1, Q2, Q3, and Q4 plots was 93.6, 95.7, 92, and 86.2%, respectively. Tall tree species of *Acer stenolobum*, *Armeniaca sibirica*, *Pyrus betulaefolia*, *Acer ginnala*, and *Platyclusus orientalis* were occasionally found mixed with *Q. liaotungensis*. Maximum size of *Q. liaotungensis* among the four study plots was 38.5 cm DBH. Shrub species of *Cotoneaster multiflorus*, *Spiraea pubescens*, and *Caragana microphylla* were dominant in understory.

**Impacts of recent dry weather on a tropical rain forest in Sumatra.** Yoneda, T., Mizunaga, H. (Kagoshima University, Japan; [yoneda@agri.kagoshima-u.ac.jp](mailto:yoneda@agri.kagoshima-u.ac.jp)), Nishimura, S. (Forest Research Institute Malaysia, Malaysia), Fujii, S. (University of Human Environment, Japan), Muktar, E., Chairul, (Andalas University, Indonesia), Hotta, M. (Kagoshima Prefecture College, Japan), Ogino, K. (University of Shiga Prefecture, Japan).

This study aimed to identify the impacts of recent dry weather on stand dynamics of a tropical rain forest in Sumatra, based on data collected on a one hectare plot over a 22-year period (1981–2004) with observations made at 1.5 year intervals. The west coastal area in Sumatra suffered severe dry weather during the last 10 years due to the Indian Ocean Dipole Mode events. Basal area of the plot increased linearly for the former 10 years and tended to keep constant for the latter 10 years. Growth rates, mortality, and recruitment rates clearly changed among the three intervals suffering different intensity of dry weather. The major 24 genera largely changed their dominance in basal area during the 22 years. Light hardwood genera with higher growth rates increased and heavy hardwood genera with lower growth rates decreased. These changes were caused by the increase of competition among trees owing to death and defoliation of many canopy trees under the severe

water stress conditions. It is suggested that these impacts of dry weather could extend to the montane forest in the cloud belt of this region. We will consider the impacts from view points of the CO<sub>2</sub> issue and forest conservation.

## **Forestry in climate change mitigation**

Organizer: Lauri Valsta *University of Helsinki, Finland; lauri.valsta@helsinki.fi*

### **Carbon sequestration and changes in land use.** Alig, R.J. (*USDA Forest Service, USA; ralig@fs.fed.us*).

Land use changes involving forestry, such as afforestation, can contribute to mitigating effects of climate change by increasing carbon storage in forests and wood products. Most U.S. afforestation opportunities are in the South, but that region also has substantial projected population growth and deforestation. Afforestation and deforestation are driven by different factors, with both affected by activities in other sectors. The United States would need to offset more than 25 million ha of projected deforestation over the next 25 years to reduce aggregate impacts on carbon storage in forests. That amount of afforestation would be larger than has taken place in recent decades. If policy makers wish to alter such trends, private landowner behaviour and incentives are a major consideration. Coordinating multiple policies would promote designing more effective incentives for inducing land use changes to help mitigate climate change and fostering co-benefits of afforestation. Uncertainties in the socio-economic and climate systems affect such assessments, and a range of scenarios should be examined regarding future developments in such systems. Policy makers also need to be aware that unintended consequences of policies can lead to significantly different outcomes than envisioned, including leakage possibilities.

### **Critical evaluation of budget approaches for carbon release to the atmosphere, related to the forestry sector in Sweden.** Berg, S., Lindholm, E.-L. (*Forest Research Institute of Sweden; staffan.berg@skogforsk.se*), Englund, F. (*SP Swedish National Testing and Research Institute; Finn.Englund@sp.se*), Jarnehammar, A., Johansson, R. (*Swedish Institute for Wood Technology, Sweden; finn.englund@tratek.se*).

Four IPCC approaches for calculation of carbon storage and release from products are evaluated. The results indicate that the choice of method has considerable consequences for the balance from a country perspective, here presented as Sweden. An analysis, based upon value-based criteria, demonstrates that Stock Change is the most satisfactory approach, as it gives credit to carbon stored as a result of trade in forest products. The results reveal that the product pool in Sweden/year constitutes a small part of the carbon that is sequestered in forest biomass. The issue is in fact whether products at present are a sink or source for carbon emission. This is due to stagnation and reduced use of wood in long-term wood products. At present, with a default life time of 50 yrs, the amount of carbon sequestered in wood is calculated to a low level in relation to what is calculated for all forest tree biomass in Sweden. However, a 50 year longer anticipated life brings up the storage to about 6% of the forest biomass. Products therefore represent both a potential sink for carbon releases but also a possibility for increased storage of carbon through extended use of forest products.

### **Impacts of forestry policy on carbon sequestration in Japanese plantation forests.** Hiroshima, T. (*University of Tokyo, Japan; hiroshim@fr.a.u-tokyo.ac.jp*).

In 2001, the Forestry Agency in Japan revised the National Forest and Forestry Basic Law and draw up the new forestry policy. The policy aims to balance carbon sequestration with timber production satisfying both the carbon uptake capped by the Marrakesh Accords and larger timber production than the current level of stagnation. In this research we estimate the amount of carbon to be sequestered in Japanese plantation forests according to the forestry policies that refer to yield regulation, preparation of a multistoried forest and so on. The simulation model on a nationwide scale is developed to predict the domestic timber supply and the carbon sequestration based on the several policy scenarios. The results imply that; (1) there is room for increasing domestic timber supply to achieve the carbon sequestration goal and (2) it is especially effective in carbon uptake to convert even-aged forests to multistoried forests.

### **Economic interactions in forestry carbon sequestration.** Valsta, L. (*University of Helsinki, Finland; lauri.valsta@helsinki.fi*), Sedjo, R.A. (*Resources for the Future, USA*), Pingoud, K., Pohjola, J. (*Finnish Forest Research Institute, Finland*).

It has been demonstrated that the forests can have a significant role in controlling the greenhouse gas concentrations in the atmosphere. We review the economic considerations related to forests and forest products. The human activities involved include forest protection for the joint benefit of biodiversity and carbon sequestration; modifying practices for forests under private, industrial or public management; establishing new forest plantations; and use of wood-based

products to substitute for more fossil fuel intensive products. Two forestry's special features are the time dimension and the spatial dimension. As forestry decisions have influences for several decades and even centuries, the time path of carbon flows resulting from different measures has to be carefully analyzed. Also, sequestration into forests and wood has various time scales, depending on biological and usage factors. The spatial dimension is important as roundwood and forest industry products have global markets. The phenomenon known as leakage can overrun measures intended for carbon sequestration. We review the methodological questions and recent studies addressing these topics. Additionally, we consider the largely unresolved question of relation between carbon in forests versus carbon in wood products: are they competing or can they both be increased and in which ways.

## **Managing and conserving genetic resources in a changing climate**

Organizer: Sally Aitken *University of British Columbia, Canada; Sally.Aitken@ubc.ca*

**Potential impact of climate change on ecosystems, species distributions, and genetic resource management in British Columbia.** Hamann, A., Wang, T., Aitken, S.N. (*University of British Columbia, Canada; Andreas.Hamann@ubc.ca; Tong-li.Wang@ubc.ca; Sally.Aitken@ubc.ca*), Yanchuk, A.D. (*BC Ministry of Forests, Canada; Alvin.Yanchuk@gems4.gov.bc.ca*).

One way to investigate whether expected global warming is likely to threaten forest ecosystems, tree species, or their genetic resources is through bioclimate envelope studies. We use canonical discriminant analysis to determine current climatic envelopes, and subsequently a Mahalanobis-distance based multivariate matching procedure to predict future distributions of various spatial units (ecological zones, species ranges, seed zones). Large potential impacts of global warming on ecological zones in B.C. are the initial expansion of the climatic envelope for Interior Coastal Hemlock as well as the rapid reduction of most montane ecosystem climates by 2025. Subsequently, Interior Douglas-fir and Ponderosa Pine climate regions expand throughout the interior plateau replacing current climate envelopes of sub-boreal and boreal ecosystems between 2055–2085. Species ranges generally shift upward and north, but follow complex patterns for some species. British Columbia's coastal seed zones are predicted to shift upward in elevation by approximately 50 m per decade. Interior seed zones are also predicted to shift northward at a rate of approximately 50–100 km per decade. Seed zones currently covering the southeast (particularly the Nelson zones) may provide suitable planting material for an extended portion of British Columbia in the future.

## **Global warming affecting sexual reproduction of forest trees: implications for forest genetic conservation?**

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The latter half of the 20th century has experienced an unprecedented climate change affecting a wide variety of plants and animals in their sexual reproduction. However, scientific evidence in forest trees is rare. Since 1989, pollen production of different anemophilous wooden species has been recorded weekly at 20 monitoring sites in Austria. Data collected by the European Allergy Network, beginning in the early 1980s, were also analyzed. Total pollen production varies erratically annually, even under undisturbed environmental conditions. While total pollen production in elder, hazelnut, and elm is slightly decreased, it has increased slightly in fir, spruce, and larch. However, for all species a strong and statistically significant trend shifting the pollination period towards earlier dates was detected, causing meagre seed set or complete failure. Shifted pollination has no negative effect on early flowering species—elder and hazelnut—or late flowering species—fir and spruce. However, sexual reproduction in larch and elm is negatively affected. This phenomenon is due to rapidly changing temperature gradients which have been historically typical for April in central Europe. In the last decade, this typical weather period increasingly moved towards March, interfering with a successful pollination. Altered pollination is further discussed in the context of seed production with special emphasis on the management and conservation of forest genetic resources.

**Stability of zonal forest cover in a changing climate.** Mátyás, C. (*University of West Hungary, Hungary; cm@emk.nyme.hu*).

The distribution area of dominant species of zonal forests can be circumscribed relatively precisely by macroclimatic factors. Numerous prediction models describe area shifts based on climatic change scenarios without investigating the migration potential of the species and the genetic background of acclimation and tolerance. Although the extension of distribution limits towards cooler environments also poses questions, the shift of the lower limits contain the more serious ecological risks, especially at the semiarid forest/steppe limit. Along with changing climatic conditions, forest trees



exhibit a rather robust persistence, due to their genetically determined plasticity. Mass mortality and/or increased virulence of diseases and pests are usually triggered by an array of negative extremes, not seldomly interpreted as a forest protection problem. In most cases these phenomena appear suddenly, as a complete surprise. The difficulties to foresee extant and future responses originate from the sparse information on genetic limits of tolerance, due to limited interest to investigate conditions way outside the optimum of species. Results from a large-scale cooperative project in Central Europe serve as an illustration of stability problems at the lower forest limit from a genetic and ecological perspective.

**Climate warming and pitch pine: Genetic status, reproductive fitness, and northward movement of a rare southern component of Canada's forests.** Mosseler, A. (*Natural Resources Canada, Canada; amossele@nrcan.gc.ca*), Rajora, O.P. (*Dalhousie University, Canada*), Major, J.E. (*Natural Resources Canada, Canada*).

Pitch pine, *Pinus rigida* Mill., exists in small scattered stands at only three locations in eastern Canada. Reproductive and genetic characteristics were investigated to develop a foundation for management and restoration in the event of a northward range expansion under climate warming. Seed yields and seed quality appeared to be comparable to pitch pine at the center of its geographic range. For seed and seedling growth traits, most of the variation was attributable to differences among trees within stands and, to a lesser extent, among stands within a population. The population effect was non-significant. For reproductive traits, reproductive efficiency and inbreeding estimates, high levels of variation were found among stands. Estimates of genetic diversity at 32 allozyme gene loci indicate these stands have maintained high levels of genetic diversity compared to populations at the center of the geographic range. Such comparatively high levels of genetic diversity suggest that these stands may represent a remnant of a wider distribution during warmer climates, rather than a population expanding its range northward. The high seed viability and genetic diversity indicate suitability for species restoration and expansion in Canada. Representative samples have been successfully established in other locations, demonstrating the potential of this species for industrial wood supply and ecological restoration in eastern Canada.

## **Sub-theme: Promoting Development Through Improvements to the Forest – Wood and Products Chain**

### **Promoting development through improvements to the forest – wood and products chain**

Organizer: Howard Rosen *USDA Forest Service, USA; hrosen@fs.fed.us*

#### **Wood and non-wood product chains of planted forests and the regional development in the Tropics.** Bhat, K.M. (*Kerala Forest Research Institute, India; kmbhat@kfri.org*).

The proportion of people living in extreme poverty, on less than \$1 a day, in developing countries dropped by almost half between 1981 and 2001 and a faster rate of poverty reduction is projected to the year 2015 (World Development Indicators 2004). The predicted roundwood supply from plantation forests for over the same period will increase significantly from the current level of 35 per cent of global supply, with a major share of 61% from the Asia Pacific Region. Citing teak and bamboo/rattan as case examples from major tropical countries of planted forests, the paper explores opportunities for improvement of wood and non-wood product chains, including those outside forests, in contributing to poverty reduction and trading of eco-labeled products with an ultimate goal of sustainable development. Further, critical needs of inputs in terms of knowledge exchange and technological interventions were addressed in prioritizing research in the chain of custody with management plans, codes of harvesting/processing practices and certification. Greater challenges are ahead in improvement of non-wood product chains that provide traditional livelihood to the poor in Asia, Africa and Latin America.

#### **Understanding and managing wood quality for improving product value in New Zealand.** Cown, D. (*Ensis, New Zealand; Dave.Cown@ensisjv.com*).

Since the 1970s, forest managers in New Zealand have been aware of the impacts of several practices such as genetic improvement and the adoption of more aggressive silvicultural techniques related to spacing, thinning and pruning. Collectively these trends have resulted in a significant reduction in rotation lengths from more than 40 years to around 25 years. In common with several other softwoods, the major species – radiata pine – has a crown structure which is sensitive to growing space and very pronounced patterns of wood property development with tree age and geographic location. Together, the combined effects of knots and characteristic wood properties lead to a large juvenile wood zone. While growth rates can be impressive, some of the resulting wood characteristics are somewhat limiting for demanding end-uses. Large utilization studies over the past 20 years or so have increasingly defined the important wood properties affecting product appearance, stiffness and stability. Tree breeders are actively selecting material to improve future generations and there is a strong emphasis on tools for predicting forest quality and log and lumber segregation, while including wood quality in forest inventory. The next challenge is to develop similar cost-effective techniques for predicting product stability.

#### **Marketing of forest products in a changing world.** Hansen, E. (*Oregon State University, USA; eric.hansen2@oregonstate.edu*), Juslin, H. (*University of Helsinki, Finland; Heikki.Juslin@helsinki.fi*).

Marketing in the forest sector has evolved, responding to new challenges in the business environment. Marketing philosophies have changed from production oriented to marketing oriented. A new era is beginning: responsible forest industry and responsible marketing. Since the 1950s, the customer has been the driving force behind marketing. Recently research and theory development have focused on the resources and capabilities needed to satisfy customers and to manage in a highly competitive environment. New paradigms (e.g. key account management) have emerged to manage customer relationships and to build value propositions. The challenge of forest products marketing science is to combine the resource and capability based view with the customer relationship and value proposition view. Research work targeted to new business models aims at this combination. Future success demands that companies be capable of ‘doing the right thing’, ‘doing things right’ and ‘identifying and using the best available tools’. By doing the right thing we refer to social and environmental responsibility. Doing things right means choosing the appropriate approach to a problem. Using the best tools available means, for example, embracing new technologies for better marketing information and planning systems. By doing these things, companies can make the future of marketing.

**Local economic development in the face of global structural changes.** Rametsteiner, E. (*BOKU University of Natural Resources and Applied Life Sciences, Austria; ewald.rametsteiner@boku.ac.at*).

The paper will review recent developments in economics, innovation and entrepreneurship research to answer key questions related to local economic development, especially in rural areas. Case studies will be used to illustrate the effects of major structural and other changes on local economic development. There are shifts in production patterns and production centres including industry relocation, climate change mitigation measures, changing lifestyles and related consumption patterns, societal demand and changing core competencies for competitiveness. What are major obstacles that need to be addressed to utilize development potentials arising from these and other major developments? What implications does this have for forest and forest-related development policies that are geared to the improvement of economic viability and sustainable development of local communities? Cases will be used from different global regions to illustrate findings. These include, for example, bio-energy, tourism, vertical co-operation along the forestry-wood chain, horizontal co-operation to overcome structural power disparities/weaknesses along the forestry-wood chain. Main conclusions of the paper will focus on implications for local and regional development policy.

**Simulation modelling of the economic value of forest stands under alternative management options.** Tomé, M. (*Centro de Estudos Florestais, Portugal; magatome@isa.utl.pt*).

Models of forest growth and dynamics increasingly play a key role in the development of sustainable forest management. The output that foresters expect from growth models has developed in parallel with silviculture, from the initial stage of resources exploitation – no growth model was needed at that time – to the yield table's era, when wood was the only product expected from the forests, to the present situation where foresters expect growth models to guide them in acting in a sustainable way. Another important characteristic of present forest management is the dynamic context in which today's forests live, either environmental (global changing), economic (requirement of high quality products) or social (increasing use of forests for the general welfare of urban society and for the production of non-wood products such as fruits and mushrooms). Present growth models should be able to fulfill all these requirements. The evolution of growth models from yield tables to the present state is analyzed in this presentation and the improvement needed for the future is discussed. Particular emphasis is put on the relationship between the researchers that develop the models and the several potential users that have a word to say in what concerns the improvements that they would like to see implemented in growth models in order to solve their day to day problems. Model based evaluation of alternative forest management options need to be tailored for different user groups and stakeholders: at the operational level models can be incorporated into forest management planning for evaluation of sustainability at local and regional levels; at the national level, or even at the continental scale, models of forest growth and dynamics provide an essential component for large-scale scenario modeling. Some case studies of the use of models for the evaluation of the economic value of forest stands under alternative management options, covering different spatial scales, will be presented and discussed.

## **Wood production in agroforestry and in short-rotation forestry systems – synergies for rural development (A)**

Organizers: Lars Christersson *Swedish University of Agriculture Sciences, Sweden; Lars.Christersson@lto.slu.se*, and Swoyambhu Man Amatya *Ministry of Science and Technology, Nepal; fsdamatya@wlink.com.np*

**Physiological background of woody biomass production.** Christersson, L. (*SLU, Sweden; lars.christersson@lto.slu.se*), Amatya, S.M. (*Ministry of Science and Technology, Nepal; fsdamatya@wlink.com.np*).

Most tree breeding programmes and modern genetic engineering activities are aimed to make plants more effective in transforming the radiation energy of sunlight into chemical energy in the form of desired wood while at the same time making the trees resistant and hardy. The crucial point for high biomass production is the amount of intercepted light and avoidance of water and nutrients as the limiting factors together with good resistance to insects, fungus, virus and browsing animals and hardiness to frost and drought. In this context it is of importance to use trees that have the potential for rapid and thick canopy development. The design of the plantation is therefore of great importance. Limiting factors for high biomass production that foresters can influence include the choice of tree species, provenances and clones and the nutrient and water supply. On the other hand high demand for water and nutrient of some tree species can also be utilized in modern society by utilizing tree plantations as vegetation filters. Waste products from society can then be used for irrigation and fertilization of woody biomass plantations.

**Long-term productivity of New Zealand's plantation forests.** Clinton, P.W., Beets, P.N., Coker, G., Davis, M.R. (*Forest Research, New Zealand; Peter.Clinton@forestresearch.co.nz*), Parfitt, R.L. (*Landcare Research, New Zealand*), Payn, T.W. (*Forest Research, New Zealand*), Smaill, S. (*University of Canterbury, New Zealand*), Simcock, R.C. (*Landcare Research, New Zealand*), Watt, M.S., Xue, J.M. (*Forest Research, New Zealand*).

It is widely held that successive rotations and repeated disturbance by management activities will result in a decline in soil quality due to lack of forest ecosystem resistance and resilience, and therefore loss of soil function. Changes in the state of the forest environment in the course of producing or extracting forest products will inevitably affect the value of future products in terms of both volume and quality. It is paramount that these environmental impacts do not reduce the opportunities for wealth and social benefits derived from forests. Long-Term Site Productivity (LTSP) experiments that cover the range of edaphic and environmental conditions found throughout New Zealand plantations are providing new knowledge of indicators of the state of soil quality and function that are vital for the early prediction or detection of loss of productive capacity. Our goal is to define biophysical indicators of site quality and productive capacity. As well, we are testing the utility of plant genotypes with different physiological characteristics as indicators of site quality in terms of water and nutrient supply. The outcomes of this research will provide best management practices for maintaining and improving soil quality for future generations.

**Pruning trials in high-quality wood arboriculture plantations.** Marchi, E., Rossi, S. (*University of Florence, Italy; enrico.marchi@unifi.it*).

Many arboriculture plantations have been developed in the last decade, thanks to the financial support of the European Union. The main aim is to produce high-quality wood. In order to investigate the type and extent of mechanical injury that pruning caused to tree bark, 10 types of shears, lopping shears and Stik tree pruners were selected to represent the range of implement designs currently used in Italy. The main design features (thickness, height and length of the blade; cutting edge angle) were measured. These pruning tools were used on *Quercus robur*, *Juglans regia* and *Prunus avium* branches of increasing diameter. The amount of detached and crushed bark was determined by means of an image analysis method. Such injuries may significantly affect the healing process and pathogen attacks and, ultimately, alter the wood quality. The results showed significant differences in the action of the different pruning tools, depending on tree species, cutting edge angle and branch diameter.

**Comparison of root biomass between forest and grassland in the Mt. Gwanak, Korea.** Park, P.S., Song, J.I. (*Seoul National University, Republic of Korea; pspark@snu.ac.kr*).

Forests and forest edges have different stand structures and species composition, resulting in different root distributions. Different aboveground vegetation structures accompany the different belowground biomass. While aboveground stand structure and biomass production have been extensively studied, much less is known about belowground biomass production. Root biomass 0–30 cm belowground was compared to examine the difference of root biomass distributions between forests and grassland near forest edges. Root biomass and moisture content was measured to a depth of 0–15 cm and 15–30 cm at six sites each in forest and grassland near the forest edge in the Mt. Gwanak in Korea. Mt. Gwanak is one of the mountains surrounding Seoul with early to mid successional stand structure, mostly revegetated after 1960s. While the amount of root biomass within 0–30 cm depth was not significantly different, the biomass distribution (the ratio of root biomass between soil depth 0–15 cm and 15–30 cm) showed significant differences between forest and grassland ( $p < 0.001$ ). The root biomass within 0–30 cm was 722 g/m<sup>2</sup> in the forest, and 943 g/m<sup>2</sup> in the grassland. In the grassland, 83% of root was distributed in the soil at a depth of 0–15 cm. Most roots were at 0–30 cm depth in the grassland, while roots extended much deeper in the forest. Forest and grassland showed similar moisture content in the aboveground herbaceous plants and roots. Herbaceous plants had 59% moisture content in the forest, and 61% in the grassland. Roots in the forest had higher moisture content than grassland, with 50% (0–15 cm soil depth), and 50% (15–30 cm soil depth) in the forest, and 44% (0–15 cm soil depth), and 48% (15–30 cm soil depth) in the grassland. In both forest and grassland, root biomass decreased with soil depth. However, grassland had a greater concentration of root biomass near the surface.

**Timberbelt plantings of *Pinus pinaster* in south-western Australia: Productivity, environmental benefits and challenges.** Ritson, P. (*Forest Products Commission, Australia; peterr@fpc.wa.gov.au*).

Recent broad scale plantings of *P. pinaster* on farms have been in block layouts, but, agroforestry designs with the trees planted in timberbelts (strips) 2–10 rows wide, offer benefits as well as challenges for management. A major potential benefit is the increased productivity of trees planted in timberbelts. Measurements in 22 stands showed the edge effect (faster growth of outside-row trees) increased with age. Re-measurement and stem analysis data were used to develop a growth model for timberbelt and block plantings. This indicated that, over a 30-year rotation, the ratio of stem volume growth in timberbelts compared to block plantations was, for example, 1.5 (10-row belt), 2.0 (5-row belt) or 2.7 (2-row belt). Particular environmental benefits from timberbelts of *P. pinaster* on farms in south-western Australia are salinity

control and shelterbelt values for pastures, crops and livestock. Some challenges discussed are ways of dealing with potential problems: (1) farm livestock must be excluded until the trees have sufficient height to withstand browsing, and (2) wood quality issues of low-density wood in fast-grown trees and heavy branching in outside-row trees.

**Technical and economic analyses of eucalypt wood harvesting subsystems at the third rotation.** Souza, A.P., Minette, L.J., Machado, C.C. (*Federal University of Viçosa, Brazil; amaurysoouza@ufv.br; minetti@ufv.br; machado@ufv.br*), Moreira, F.M.T. (*IBAMA, Brazil*).

The four subsystems (A, B, C and D) studied were: A (Feller-Buncher + Skidder + Slingshot); B (Feller-Buncher + Slingshot + Forwarder); C (Slingshot + Forwarder), and D (Chainsaw + Forwarder). Time study, productivity, mechanical availability, efficiency, energetic yield, operating and production costs were evaluated for each machine in all harvesting subsystems. The statistical design was of blocks with 3 repetitions and 4 treatments, totaling twelve experimental plots, where the 4 treatments related to the harvest subsystems were evaluated. The subsystems A and C presented the lowest and the highest production costs, respectively. The subsystems B and D presented very close production costs, and the difference was not considered significant. The subsystem D presented the worst energetic yield. In all phases of each subsystem the rate of productivity of the machines studied increased as the value of the mean volume per tree increased. All the harvest subsystems studied presented a potential improvement in some of their phases.

**Energy forestry development in Europe and the USA.** Verwijst, T., Weih, M. (*Department of Short Rotation Forestry, Sweden; Theo.Verwijst@LTO.SLU.SE*).

This paper provides an overview of the development of short rotation forestry for bio-energy purposes in Europe and the USA. One of the major observations is that short rotation forestry (SRF) as a stand-alone crop for bio-energy hardly has an economic viability under current international market conditions. Environmental applications, apart from bio-energy purposes, are becoming increasingly important drivers for extended implementation of SRF systems. Further development and implementation of such applications requires multidisciplinary research and extension work, as well as establishment of successful demonstration projects.

**Fertilization impacts on tree nutrition and growth of a slash pine plantation and on soil fertility at the end of 33-year plantation rotation in subtropical Australia.** Xu, Z.H. (*Griffith University, Australia; zhihong.xu@griffith.edu.au*), Simpson, J. (*Department of Primary Industries and Fisheries, Queensland, Australia; john.simpson@dpi.qld.gov.au*), Prasolova, N. (*Griffith University, Australia; n.prasolova@griffith.edu.au*).

A rotation-long field experiment was established to quantify the impacts of fertilization at establishment and age 14 years on tree nutrition, water use efficiency (WUE) and growth of a slash pine (*Pinus elliottii* var. *elliottii*) plantation for a full rotation of 33 years, and on soil fertility at the end of 33-year rotation in southeast Queensland, Australia. The experiment initially consisted of 4 phosphorus (P) treatments (0, 24, 47 and 94 kg P/ha) applied as superphosphate at establishment with 4 replications. The stands were thinned and re-fertilized at age 14 years with total P rates to 0, 48, 94 and 188 kg P/ha. In the full rotation, tree growth in height, basal area and volume significantly improved with the P rate. Foliar P concentration significantly increased with the P rate but decreased with the plantation age. The P deficiency was a major growth-limiting factor. Foliar carbon isotope composition indicated that P application appeared to improve tree WUE. At harvesting, P fertilization had significantly increased total P and available P concentration in the top 30 cm soils. Organic C, total N and potential N mineralization rate in the top 20 cm soils did not differ between the treatments.

## Finishing and surfacing

Organizer: Bernie Dawson *Forest Research New Zealand; Bernard.dawson@forestresearch.co.nz*

**Improved finishing and surfacing techniques in the furniture industry.** Anim, A. (*Radebs Wood Enterprise Products Limited, Ghana; alexanim2002@yahoo.com*).

The demand for wood is increasing in recent times due to population explosion in both the rural and urban areas. The furniture industry is likely to face the prospect of wood famine due to the scarcity of wood on the market. It is expected that if the furniture industry can improve the quality of their products it is likely to increase the life span of its products and consequently halt the increasing demand for furniture and other wood products. This paper addresses an improved finishing and surfacing techniques for furniture production. It builds up on previous work done on the selection of quality glue and

other chemicals for effective furniture production. In this paper, a new cutter head has been designed to reduce the incidence of poor surface finish of wood products characterized by knife marks due to excessive vibration of the cutter head. Preliminary results indicate that the surface finish of the wood products is improved if the numbers of cutter heads are increased. To address the problem of polishing facing the furniture industry, several studies have been undertaken on the chemical composition of different compounds and their suitability for the furniture industry discussed in this paper.

**Improved photostability of radiata pine timber surfaces.** Dawson, B.S.W., Gallagher, S., Kroese, H., Singh, A.P., Torr, K., Schwitzer, M. (*ensis: A Joint Venture between CSIRO and Forest Research, New Zealand*; [Bernard.dawson@forestresearch.co.nz](mailto:Bernard.dawson@forestresearch.co.nz)).

In order to overcome the failure of varnished wooden systems in exterior situations, various stabilisations of both the wood and the coating material can be entertained. This paper reports a chemical treatment of the wood to stabilize its surface prior to varnishing. Radiata pine wood surfaces have been reacted with delignifying chemicals in a very controlled process in order to remove a significant portion of the surface lignin without pulping the wood surface. Microscopic and chemical techniques have been used to characterize the effects of the chemical treatment and to demonstrate an affected envelope of two to three millimetres in depth. Once the photostabilisation treatment had been completed, a polymeric phase was then built up both in- and on the wooden surface zone. Reactive monomers were introduced first to assist in stabilising the less dense surface envelope before aliphatic polyurethane was applied to achieve a good film. The finished surface constituted a wood polymer coating with the properties of photostabilisation, hydrophobicity, flexibility and external durability. Testing has involved exterior exposure in Rotorua, New Zealand and 3000 hours rain/sunlight simulation in a weatherometer.

**Surface roughness evaluation of medium density fiberboard manufactured in Thailand.** Hiziroglu, S., Kosonkarn, P. (*Oklahoma State University, USA*; [hizirog@okstate.edu](mailto:hizirog@okstate.edu)).

Wood composites contain irregularities due to the sanding process which play an important role when they are used as substrate for thin overlays. The objective of this study is to evaluate surface characteristics of commercially manufactured medium density fiberboard (MDF) panels in Thailand. A skid type profilometer with diamond stylus of 5 µm tip radius and 90° tip angle was employed for the experiments. Average roughness ( $R_a$ ), mean peak-to-valley height ( $R_z$ ) and maximum roughness ( $R_{max}$ ) were used to evaluate quantitatively surface characteristics of the specimens. Roughness measurements were taken from both sides of the sanded and unsanded specimens along and across the sandmarks over 15.2 mm tracing span. Panel type-C had the smoothest surface with values of 2.39 µm, 21.03 µm and 26.93 µm for  $R_a$ ,  $R_z$  and  $R_{max}$ , respectively. It was found that no statistically ( $p < 0.1$ ) significant difference existed between the values of all three parameters taken in both sandmarks directions of all types of panels. Also none of the panels considered in this study had superior surface quality over the other. Further studies showed that roughness behaviour of MDF samples varied with relative humidity levels.

**Weathering performance of wood-fibre plastic composites.** Kiguchi, M. (*Forestry and Forest Products Research Institute, Japan*; [mkiiguchi@ffpri.affrc.go.jp](mailto:mkiiguchi@ffpri.affrc.go.jp)).

The market for wood-fibre plastic composites (WPC) is expanding in the world and the exterior wood market is a main target for WPC in Japan. Colour change, chalking and dimensional change of WPC during outdoor conditions are serious problems for their exterior use. Weatherability of WPC was assessed by natural and accelerated weathering trials. Discolouration (whitening) of WPC by weathering was caused by degradation of wood and plastic. Dark colour pigments as additives improved colour stability of WPC, but chalking on the surfaces still occurred. Grafting of light stabilizers to wood-flours decreased discoloration of WPC. Samples of WPC that were finished with regular exterior coating exhibited wear after a short period of weathering whereas with improved coatings, the surface withstood the effects of weathering for longer periods.

**Impregnation of timber with stains.** Kwiatkowski, A., Hann, J., Ozarska, B., Vinden, P., Kougiolis, C., Nobel, A. (*University of Melbourne, Australia*; [a.kwialkowski@pgrad.unimelb.edu.au](mailto:a.kwialkowski@pgrad.unimelb.edu.au), [jhann@unimelb.edu.au](mailto:jhann@unimelb.edu.au), [bo@unimelb.edu.au](mailto:bo@unimelb.edu.au), [p.vinden@unimelb.edu.au](mailto:p.vinden@unimelb.edu.au), [con.kougiolis@akzonobel.com.au](mailto:con.kougiolis@akzonobel.com.au)).

Staining is usually confined to the timber surface as, historically, the pigments have been too large to penetrate the voids effectively, and the dyes were not durable. This project aims to use impregnation methods to introduce stains evenly into the whole volume of the timber, thus providing durable coloured timber products. The study involves investigation of the formulation of various carrier solutions with dyes, conventional stains and micronized metal oxides of iron and zinc. Colouring of timber is undertaken to enhance the appeal of plantation timber and provide a novel appearance which can increase usage and marketability. In this project, there are three major aspects: (i) aesthetic – the appealing appearance of the coloured timber, (ii) colour stability particularly when exposed to UV light (iii) timber dimensional stability and resistance to weathering. This poster presents preliminary results of timber staining trials with newly formulated biocidal stains using hardwoods (Mountain Ash – *Eucalyptus regnans*, Blue Gum – *E. globulus*)

and softwoods (Radiata Pine – *Pinus radiata*). Further studies will involve trials with various formulations of emulsions using nontoxic pigments based on metal oxides.

**Electromagnetic shielding effect of carbonized laminated bamboo board.** Lin, S.H., Wang, H.H. (*National Pingtung University of Science and Technology, Chinese Taipei; lsh@mail.npust.edu.tw; hhwang@mail.npust.edu.tw*).

Laminated bamboo board (LBB), 15–35 mm thick, and derived from 3–7 layers of phenol-formaldehyde resin-impregnated moso bamboo veneers were carbonized at 600 to 1,000 °C, and retained for 1–3 hours. The objective of this study was to examine the effects of carbonization on the electromagnetic shielding of the various products. The carbide yield of the LBB decreased with increasing carbonization temperature. The higher the temperature, the lower the yield. Carbonized laminated bamboo board (CLBB) displayed better electrical conductivity, should it be produced at higher carbonization temperature. Thickness and retention time showed significantly negative correlation with the resistivity of the carbonized laminated bamboo board. CLBB manufactured at the designed conditions could be categorized as semiconductor-like products. Specimen thickness, retention time and carbonization temperature were significantly correlated with the electromagnetic shielding effect of the CLBB. The resistivity was, on the contrary, significantly negatively correlated with its electromagnetic shielding power. Most of the tested CLBB fulfilled the minimum electromagnetic shielding demand and was classified as regular grade. The interlayer space in the crystalline structure of CLBB decreased, while the diffraction angle of the material showed a reverse effect with increasing carbonization.

**Surface characterisation toward wood finishing: 3D roughness, wettability and other measurements.** Negri, M., Sandak, J., Gaeti, N., Tessadri, B. (*VALSA/CNR Trees and Timber Institute, Italy; negri@ivalsa.cnr.it*).

The finishing process of wood depends upon many factors, such as the finishing products (chemical and physical properties of products), the finishing process (machines, type of process) and the wood itself. Our approach is focused on evaluation of physical and physical-chemical properties, determined using assessed and non-assessed methods, and by standard and non-standard processes. Some physical properties of the wood surface are strictly related to the finishing process. The contact stylus roughness profiles are discussed in relationship with the anatomical features of wood species. A set of additional parameters are obtained with 3D non contact laser technology under development, and the peculiarity of this approach is presented. The wettability measurements provide physical and chemical information about surface properties towards finishing products. Two methods are compared and discussed; the Wilhelmy balance based approach and the improved sessile drop measurement method. The colour of the wood surface also influences the choice of finishing products. Some results of measurements carried out on processed wood surfaces by using a portable spectrophotometer (400–700 nm) are presented.

**Microwave modified wood impregnation with metal.** Shaginov, A., Torgovnikov, G., Vinden, P. (*University of Melbourne, Australia; shaginov@unimelb.edu.au; grigori@unimelb.edu.au; pvinden@unimelb.edu.au*).

The application of very intensive microwaves to wood gives rise to a novel wood product, ‘Torgvin’, which has very high permeability, increased flexibility and altered physical and mechanical properties compared to the natural wood. Torgvin can be impregnated with low melting point metal for manufacturing new material, ‘Vintorg’, which can have the following advantages: high strength properties, dimensional stability, electric conductivity, radiation protection properties and an attractive appearance. These properties can open up a number of new fields of industrial applications for this material.

**Unwelcome migrants on surface of adhesively bonded wood.** Widsten, P., Gutowski, W.S., Li, S., Cerra, T., Molenaar, S., Spicer, M. (*CSIRO Manufacturing & Infrastructure Technology (CMIT), Australia; petri.widsten@csiro.au*).

Specimens of various Australian timber species were characterized in terms of extractive content and density. The bond strength of cross-lap joints prepared from the specimens using structural polyurethane showed a high correlation with their surface oxygen/carbon (O/C) ratio, bulk phenolic extractive content and density. The species that produced the lowest bond strengths had high surface nonpolar extractive coverage, high bulk phenolic extractive contents and high densities while the opposite was true for the species with good gluability.

**Predicting the service life of materials used for residential construction.** Williams, R.S. (*USDA Forest Service, USA; rswilliams@fs.fed.us*).

In recent years, computers, sensors, microelectronics and communication technologies have made it possible to automate the way materials are tested in the field. The instrumentation vastly improves the quantity and quality of the data that can be obtained. These technologies can yield detailed data that are critical for developing reliability-based service life prediction (SLP) models. Reliability-based SLP offers a means for assessing the suitability for many new materials that are being used in the construction industry. Among many new materials being used for residential

construction, sealants have become an integral part of modern construction to help control moisture. Sealant test specimens were installed in specially designed apparatus that subjected the specimens to weather-induced deformation that caused specimen degradation. The information and weather were correlated to yield information on critical factors affecting the sealant degradation. The results showed a clear link between the sealant response during weathering and the weather conditions causing this response. Instrumentation of the outdoor test facility and the data collection system are briefly described and methods for analyzing data are evaluated.

## **Cross-sectoral policy linkages in forestry sector**

Organizers: Yves C. Dubé *UN Food and Agriculture Organization, Italy*; [yves.dube@fao.org](mailto:yves.dube@fao.org), and Franz Schmithüsen *Swiss Federal Institute of Technology, Switzerland*; [franz.schmithuesen@env.ethz.ch](mailto:franz.schmithuesen@env.ethz.ch)

**Cross-sectoral linkages between Romanian forestry and other sectors.** Abrudan, I.V. (*Brasov Transilvania University, Romania*; [abrudan@unitbv.ro](mailto:abrudan@unitbv.ro)).

The paper presents an analysis of the current linkages between the Romanian forest sector and other economic sectors. The complex network of public policies and legislation affecting forest sector development is structured in three categories: 1) policies establishing the institutional framework—economic growth, privatization, public finance, employment, rural development and landscape planning, 2) policies related to specific economic sectors, and 3) policies promoting the development—environmental protection, water management, nature conservation, education and research. The most important public policies, and the direction and scale of their impacts, are discussed for each of these categories. The international commitments of Romania and the European Union accession process are also presented as significant factors impacting forest sector development. Recommendations to maximize the positive impacts and minimize the negative impacts on forest sector development include: 1) strengthening of the authority responsible for forests in order to increase its coordination, monitoring and lobbying capacity, 2) establishment of inter-ministerial committees or working groups as mechanisms to address cross-sectoral issues, 3) adapting the role of the National Forest Administration to its new position in the Romanian forestry sector, and 4) strengthening of private forest owners associations.

**China's application of the FAO manual for environmental and economic accounts for forestry.** Dai, G., Huang, D. (*China National Forestry Economics and Development Research Center, P.R. China*; [daigc@forestry.gov.cn](mailto:daigc@forestry.gov.cn); [bfhd@sohu.com](mailto:bfhd@sohu.com)).

The paper describes the China's pilot application of the FAO Manual for Environmental and Economic Accounts for Forestry. Jilin province, one of the main state-owned forest regions, was selected for the pilot. It is also a key natural forest region by both area and volume. This paper reviews the current situation, forest resource trends and the roles that the forestry sector plays in local socio-economic development and environment. Forest balance accounts for forestland and standing timber including physical and monetary accounts as well as forest health accounting. The results show that forest sector contributes to economic and environmental improvement, and social welfare. It also contributes locally and nationally with timber and non-timber products, and environmental services such as carbon storage, biodiversity, habitat preservation and water resource protection. Cross-sectoral policies that affect forest sustainable development are analyzed, including property rights, taxation, Natural Forest Protection Program (or the logging ban), and the Land Conversion Program (conversion of cropland to forest). Specific policy instruments and institutional arrangements to improve sustainable forest management are recommended.

**Relationships between people and forests: contribution of forest resources to the local and national economy. (A case of the Terai-belt of Nepal).** Dhakal, M., Masuda, M. (*The University of Tsukuba, Japan*; [maheshwar\\_dhakal@hotmail.com](mailto:maheshwar_dhakal@hotmail.com); [masuda@sakura.cc.tsukuba.ac.jp](mailto:masuda@sakura.cc.tsukuba.ac.jp)).

The government of Nepal implemented a community forestry program two decades ago. The program uses a form of participatory forest management to address a number of issues, including poverty alleviation. In the mid-hills, community forestry has had a significant, positive effect on people's livelihoods. But, in the Terai area of southern Nepal, the program is still in its infancy. To date, the government has begun to establish community forests, where disputes are not problematic and consensus is easily achieved (primarily plantations and natural areas). Although, some people consider that collaborative forest management is an option for Terai, others question whether other options would be preferable. This paper focuses on the fundamental relationships between the people and forest resources of Terai. Specifically, it explores the gaps between policy principle and program practices, with reference to social and natural attributes of forest management in Nepal. Without recognition of local participation in the forest management regime it is quite difficult to find the management option that is acceptable to all concerned with the forests of Terai.



**Cross-sectoral linkages in forestry: policy and environmental accounting frameworks.** Dubé, Y.C. (*UN-FAO, Italy; yves.dube@fao.org*), Lange, G.-M. (*Columbia University, USA*), Schmithüsen, F. (*Swiss Federal Institute of Technology, Switzerland*).

To broaden and better integrate forestry policy planning into national development planning, a new policy and legal framework, including the system of integrated environmental and economic accounting (SEEA) for forestry, is proposed. The paper will review current policy and legal frameworks as well as some policy applications of forestry accounting, and constraints to its implementation. Argument is made for the need to focus on public capabilities to manage complex political networks, and the development of sub-national accounts to strengthen local institutions in cross-sectoral policy data collection and analysis, linking local and national efforts.

**The Brazilian forest sector: challenges and strategies for its development.** Hoeflich, V.A. (*Embrapa Forest, Federal University of Paraná, Brazil; hoeflich@cnpf.embrapa.br; hoeflich@ufpr.br*), Sales Medrado, M.J. (*Embrapa Forest, Brazil; medrado@cnpf.embrapa.br*), Alves, M.V.G. (*Federal University of Paraná, Brazil; marcos@floresta.ufpr.br*), Soares Koehler, H. (*Federal University of Paraná, Brazil; koehler@ufpr.br*).

The paper points highlights some important issues related to the Brazilian primary forest products industry. As the most important market in Latin America, it has been participating in diverse product areas, including solid wood products, lumber, paper, pulp and furniture. The paper also documents the importance of the Brazilian forestry sector and its related linkages in economic, social and environmental terms. The paper draws attention to several challenges related to development of the Brazilian forest sector, including: 1) the present economic, technological, social and environmental concerns; 2) the challenges to be faced and issues raised in order to promote growth; and 3) the strategies to enhance development of the sector.

**Cross-sector impacts in the forest sector of the United States.** Ingram, C.D., Alig, R.J., Lee Abt, K. (*USDA Forest Service, USA; cdingram@fs.fed.us; ralig@fs.fed.us; kabt@fs.fed.us*).

Over the last 15 years, global dialogues on sustainable development mandate the recognition of the human and natural dimensions of changing resource conditions. These dynamics are indelibly linked across economic, social and environmental decision-making. In the United States, forest resources, and the land on which they occur, are in themselves multiple-sector production units. They can provide, *inter alia*: millions of days of recreation and leisure, billions of dollars of potable water for rural and urban populations, millions of cubic meters and tons of wood and fiber for construction, education, health and hygiene, hundreds of thousands of kilometers of transportation routes, many places to live and work, and infinitely valuable cultural and religious significance to the nation's citizens. The significance of the long-run historical shifts between forest and agriculture land in the United States is captured in a number of land use allocation models. A look at these and complementary forest resource assessments and natural resource asset and environmental accounting approaches, reveal the challenges of understanding the level and extent of cross-sectoral impacts in the forest sector. This discussion also highlights some caveats for developing cross-sectoral analysis for future strategies of forest resources conservation and management.

**Cross-sectoral linkages in mountain development: the case of northern Thailand.** Kaosa-ard, M. (*Chang Mai University, Thailand; mingsarn@chiangmai.ac.th*).

This paper focuses on the impact on local livelihoods and the natural environment of changes in state policies, market access and population growth, and the associated responses of local actors, in the mountainous area of northern Thailand. Substantial increases in these three factors have led to a profound change: increase in land area enclosed for protection purposes, in-migration from the lowlands and abroad, and road construction and highland development programs. Fundamental environmental concern has shifted as a result from resource depletion to resource conflict. Responses of upland peoples and their advocates include: 1) cash-crop conversion, 2) social mobilization, and 3) demands for participation. The paper argues that three broad areas must be addressed in order to meet the environmental and social challenges of the mountainous North. First, the problem of tenure insecurity should be addressed. Second, the human security of local communities should be incorporated into national security policies. Finally, multi-actor cooperation—with an emphasis on participation by grassroots actors—must be promoted in the empirical assessment of the environmental and social sustainability of mountain livelihoods and development plans.

**Contradictions between two human rights in the forest sector: Ownership rights and rights to environment.** MenĀele, L. (*University of Latvia, Latvia; liga.mengele@vmd.gov.lv*).

The role of the cross-sectoral policies has arisen recently regarding sustainable development. I shall focus on the connection between human rights concerning forests and the concept of sustainable forest management. Sustainable development requires balance between environmental, economic and social interests. Property rights, as fundamental

human rights, can be seen as a basis for economic development. The understanding of rights to the environment can be treated as rights to claim for the protection of nature. Thus the connection between both human rights and the concept of sustainable development can be established. The right to the environment has not been mentioned directly in human rights legislation. The protection of the right to the environment has been realized indirectly through the other human rights: rights to life, rights to health, rights to well being, etc. The realization of human rights can be seen as another avenue towards sustainable development. The protection of human rights to the environment can lead to the protection of forests from overexploitation, which is connected with the economic development process.

**Effects of road construction and agricultural population on forest conversion in rubber villages of Sumatra, Indonesia.** Miyamoto, M. (*Forestry and Forest Products Research Institute, Japan; motoe@affrc.go.jp*).

Agricultural expansion is the main factor contributing to forest clearance in Indonesia. In particular, the expansion of cash tree crop cultivation, primarily rubber and oil palm, has had a greater impact than the expansion of shifting cultivation. This study examines why forest conversion to rubber has accelerated, based on household surveys (160 households) in four rubber villages in Sumatra. In the study villages, road construction accelerated forest clearing for rubber, since roads reduced the transportation cost and raised the profitability of rubber in rural areas. However, not only road construction contributed to increasing forest conversion, but also agricultural population pressure. Most people in the villages depended on agricultural income because their off-farm income is very low. And also many workers from Java, which has a huge agricultural population, were working in the large land-holding rubber fields. This study shows that road construction and agricultural population play important roles in hastening forest conversion to rubber in Sumatran villages.

**Determining the importance of the forestry sector in the Turkish national economy using input-output analysis.** Türker, M.F. (*Karadeniz Technical University, Turkey; mft@ktu.edu.tr*).

Input-output models are used for analyzing inter-industry structure. They show analytically the economic structure of a country and the relation of sectors to each other. Input-output models also play an important role in solving such economic problems of sectors as production, income and employment. In this study, production, value added, import, export and forward and backward linkages of the Turkish forestry sector in national economy, consisting of 97 sectors, are calculated. Income and employment multipliers were also examined. The main objective of this study was to undertake an economic analysis of the forestry sector and determine its importance. Data used in this study were obtained from the input-output tables, input coefficients matrix and inverse coefficients matrix prepared by the State Institute of Statistics in 1996. This study showed that the forestry sector has a small share in national production (0.3%), that export (0.01%) and import (0.3%) in the forestry sector is minimal compared with national averages, and that the total outputs of the forestry sector are used as intermediate consumption by other sectors. Because the value added of this sector is greater, it was concluded that the forestry sector could be used to decrease unemployment and balance differences in incomes.

**Negotiation on sector boundaries in European forest governance and the implications for understanding the nature and mechanisms of inter-sectoral coordination.** Verbij, E. (*Wageningen University, The Netherlands; evelien.verbij@wur.nl*).

This paper discusses the nature and mechanisms of inter-sectoral coordination in forestry, using Austria and the Netherlands as comparative case studies. Sector boundaries form the starting point of this investigation, as inter-sectoral coordination can only be understood relative to these boundaries. However, these boundaries are challenged by societal developments of globalization and governance processes, as well as in forestry by the acknowledgement of forests being multi-functional, and the presence of an increasing demand for sustainable forest management. Empirical focus of this study is therefore on processes of boundary negotiation and setting, in relation to coordination activities across these blurred boundaries in Austria and the Netherlands. Preliminary results show substantial differences. In the case of Austria, forest sector boundaries are still distinguishable, although heavily challenged, resulting in most decisions have remained 'sectoral'. This is in great contrast to the Netherlands where sector boundaries seem to have faded, and self-determination-in-action has become the dominant orientation for boundary negotiation and setting. Implications are formulated by comparing both cases for understanding the nature and mechanisms of inter-sectoral coordination in this increasingly boundless world.

**Cross-sectoral forest impacts in the tropics: How much do they matter?** Wunder, S. (*CIFOR, Brazil; s.wunder@cgiar.org*).

Rapid tropical forest loss is continuing, and an increasing number of observers point to 'cross-sectoral' or 'extra-sectoral' factors for an explanation. But the same observers usually do not agree on which set of potential cross-sectoral factors one should look at, which effects tend to be the most important, nor is there consensus on the expected sign of different factors' first-derivative effect on forest cover. This presentation draws mainly on a multi-year eight-

country study of trade, macroeconomics, sectoral land-use structure and forest impacts to identify the main cross-sectoral factors in a comparative setting. It also draws selectively on results from a decade of CIFOR research on the underlying causes of deforestation. The results confirm the dominating and, sometimes dramatic, cross-sectoral effects on forest cover, but also caution that some partial effects can change signs according to the scenario context in which they occur, producing counter-intuitive results.

**The role of forest management in the socio-economic development of Poland's agricultural region.** Zajac, S., Golos, P. (*Forest Research Institute in Warsaw, Poland; stan.zajac@ibles.waw.pl; p.golos@ibles.waw.pl*).

This study was undertaken in 1999 in the Bialowieza, Browsk and Hajnowka Forest District Administrations (FDAs), which has a total area of 52,000 ha and is situated in the agricultural region of north-eastern Poland. The study used input-output analysis to explore: 1) the type and strength of relationships between forest management and its socio-economic environment, and 2) the role and significance of forestry in the development of the region. FDAs employed 452 people, with salaries totaling \$1.8 million/yr. FDAs supplied the environment with the generated cash flows (taxes and fees) amounting to \$5.5 million/yr, enabling creation of 322 jobs outside forestry. FDAs supplied goods and services for the amount of \$5.8 million/yr, mainly revenues from the sale of 120,000 m<sup>3</sup> of harvested wood. The wood-processing industry employed 1,111 people, and was also a source of taxes and fees amounting to \$1.9 million/yr. Fifteen jobs were created per 1,000 m<sup>3</sup> of harvested, sold and processed wood: two in FDAs, four in the firms providing goods and services and nine in the recipients of goods and services. Simultaneously, this was a source of taxes amounting to \$29,700/yr, of which \$12,900/yr was paid by FDAs, US\$1600/yr by the environment of suppliers, and \$15,200/yr by the environment of recipients.

## **Agroforestry for economic, social and environmental prosperity in rural areas: Current highlights from Australia's Joint Venture Agroforestry Program**

Organizer: Rosemary Lott, *Australia; Rosemary.Lott@rirdc.gov.au*

**Florasearch: selection and development of multipurpose species for large-scale revegetation of southern Australia.** Bennell, M. (*SA Department of Water, Land and Biodiversity Conservation, Australia; bennell.mike@saugov.sa.gov.au*), Bartle, J. (*Department of Conservation and Land Management, Western Australia*), Hobbs, T. (*SA Department of Water, Land and Biodiversity Conservation, Australia*).

FloraSearch aims to develop broad scale woody crops in short-cycle agroforestry systems for the wheat-sheep zone of southern Australia. This work has been undertaken in recognition of the immense scale of revegetation necessary in regions affected by salinity and other natural resource management issues. The FloraSearch project has three components: 1) investigation of potential products, 2) species sampling and evaluation, and 3) regional analysis of industry potential. The investigation of potential products referred to two criteria: market size and potential for utilizing large volumes of feedstocks, and the feasibility of making products of adequate quality, scale and price. The most prospective industries include: pulp and paper, wood composites, bioenergy, extractives and livestock fodder. Species evaluation in southeastern Australia required sifting species from a pool of approximately 10,000 taxa. From 392 prioritized species, about 140 were subsequently sampled to indicate suitability for pulp and paper, fibreboard, bioenergy and fodder. The Regional Industry Potential Analysis is a methodology that spatially integrates species, environmental, industry and economic information to assist in evaluating appropriate industries. Developments will be focused on locations where the maximum economic, environmental and community benefits can be gained. Future research will focus on continued species evaluation: field trials of priority species to provide data on the productivity, genetic improvement and crop development.

**Agroforestry and farming systems in Australian landscapes.** Campbell, A. (*Land & Water Australia, Australia; Andrew.Campbell@lwa.gov.au*).

Conventional wisdom in natural resource management in Australia holds that for most of southern Australia, existing farming systems are leaky (i.e., too little water is used by crops resulting in excess water transferring to groundwater and resulting in salinity problems). It follows that a much greater degree of perennality is required to increase water use by crops and pastures if agriculture is to become more sustainable. The integration of woody perennials managed for commercial purposes within farming systems (i.e., agroforestry) is seen to offer win-win possibilities across the so-called triple bottom line of environmental, economic and social benefits. This is undoubtedly the case—at least in potential. In practice, considerable challenges must be overcome before agroforestry systems are likely to be implemented on a large scale. This paper overviews the potential and challenges for agroforestry in Australia, drawing in large part on a decade of research funded

through the Joint Venture Agroforestry Program (JVAP). It highlights some of the design issues inherent in agroforestry at farm, catchment and industry scales. It discusses the adoption context in which farmers consider agroforestry, and the consequent challenges for public policy makers wanting to see wider implementation of less leaky farming systems. Finally, the author speculates on future possibilities drawing on JVAP-funded research currently underway.

**Towards a surface water management design framework for banded agricultural systems.** Ellis, T., Potter, N., Hairsine, P.B., Brophy, J. (*CSIRO Land and Water, Australia; Tim.Ellis@csiro.au*).

In many Australian catchments, removal of natural vegetative has altered local hydrology, mobilized pollutants and resulted in degradation of land and water resources over a range of spatial scales. For many years, the reintroduction of deep rooted perennial vegetation (principally trees) onto rural land has been proposed for amelioration of this degradation, particularly secondary dryland salinity. Here we investigate a preliminary design framework for farming systems from the perspective of surface water management. The framework allows the arrangement of bands of crops/pasture and trees across hillslopes to meet local water yield targets. A cascade of simple water balance models was used for rapid assessment of the feasibility of certain designs for meeting the targets given local climate, soil and vegetation properties. An outcome of the project has been stimulation of discussion regarding local water management targets, within the context of requirements at local, sub catchment and regional scales. In parallel with this project, work undertaken by the CRC for Catchment Hydrology and the CSIRO may lead to expansion of this approach to allow design of these systems to meet pollutant export targets. These and other models (e.g., productivity) may provide the components for a multi-criteria design framework for rural hillslopes.

**The Australian Master TreeGrower Program 1996–2004: Development, delivery and impact of a national agroforestry education program.** Reid, R. (*University of Melbourne, Australia; rowan.reid@unimelb.edu.au*).

With broad financial support, the School of Resource Management has developed the Australian Master Tree Grower Program (MTG). By 2004, 63 regional MTG programs had been conducted involving over 1250 participants and over 30 partner organizations. MTG is a comprehensive package aimed at ensuring agroforestry development is driven by farmers and supported by industry, governments and community groups. Australia is currently experiencing a dramatic rise in the number of small-scale forest owners and the extent of their forests. International experience suggests that increasing farmer participation in forestry can have quite different social, economic and environmental impacts to that of industrial or government forestry. The expectation of MTG is for greater integration of forestry into the rural landscape and complement industrial and government forestry. The program is an example of facilitating participatory learning. The results of continuous internal monitoring and two external reviews confirm that MTG is positively impacting perceptions, enthusiasm and activity. Farmers believe they are making better farm forestry management decisions and are making a greater commitment to agroforestry. They are also making a greater contribution to agroforestry research, development and extension by participating in regional MTG farm forestry networks. There is great interest in expanding the program into Africa and southeast Asia.

### **Small-scale private forestry and its role in producing multiple benefits for society: Enhancing management for multiple objectives and challenges of forest fragmentation and parcelisation**

Organizers: John Herbohn *University of Queensland, Australia; j.herbohn@uq.edu.au*, Steve Harrison, and John Bliss

**Family forests and community wellbeing.** Bliss, J.C. (*Oregon State University, USA; john.bliss@oregonstate.edu*).

Despite their domination of many rural landscapes, family forests have received relatively less examination in the forest-based rural development literature than community or industrial forests. The ability of family forests to contribute to the well-being of rural areas around the world is challenged by industrial consolidation in global wood markets, transfer of family ownership to corporate ownership, parceling of forestland at the urban fringe, shifting social values accompanying demographic change and other global trends. This paper addresses three questions. 1) What are the relationships between family forests and rural community wellbeing? 2) What factors challenge the sustainability of family forests and their ability to contribute to community wellbeing? 3) How can these challenges be overcome? The paper draws upon the literatures on land tenure, natural resources dependency and natural resource – based sustainable rural development. It reflects upon the experience of family forests in North America, Northern and Western Europe, New Zealand and Australia, and considers those regions of the world in which family forests are of

growing significance, such as the rapidly evolving market-based economies of Eastern Europe. Relationships between family forestry and community forestry are also considered.

**The nature and importance of non-financial motivations of farm foresters in Australia and how these can be enhanced to produce environmental benefits for the public good.** Harrison, S. (*Australia*); Herbohn, J. (*University of Queensland, Australia; j.herbohn@uq.edu.au*).

A series of surveys into farm forestry have been conducted in north-eastern Australia, particularly in areas of moderate to high rainfall, which were originally rainforest or eucalypt forest land. A consistent finding from these surveys is the high interest in multiple-use forestry including environmental objectives. On the other hand, the state forest service in the region has a focus on industrial forestry with plantations of exotic *Pinus* species. It would appear that introducing measures to support farm forestry is likely to have relatively high environmental payoff. This paper reviews the evidence of environmental objectives of farm forestry in north-eastern Australia, and examines measures which may be implemented to encourage tree planting, with particular emphasis on enhancing environmental benefits. While any farm forestry support measures could be expected to have positive environmental benefits, areas which appear to offer particular promise include improving the regulatory environment (e.g., provide extension support such as in relation to species-site matching, silviculture, reducing sovereign risk and providing marketing support), targeting forestry systems with high biodiversity values (including nature refuges) and high landscape amenity values, and improving wildfire prevention measures.

**Social responsibility of small-scale forestry and large-scale forest industries in rural regions.** Hyttinen, P. (*Regional Council of North Karelia, Finland; pentti.hyttinen@pohjois-karjala.fi*).

Small-scale forestry contributes to the livelihood of rural regions in many parts of the world. Forestry also represents an influential sphere of activities in industrial production of those areas. From the viewpoint of regional income generation, the existence of large-scale forest industries in the region is an essential factor. They guarantee the constant flow of income from timber sales to the small-scale forest owners. They also help in maintaining the infrastructure in remote rural areas. Moreover, large-scale plants through their needs for constant timber supplies have traditionally played an important role in keeping forest owners interested in management activities and they have also played an important role in promoting co-operation among small-scale owners. Social responsibility has become an increasingly important image factor for companies, and a challenge is the fact that as large companies act more globally, they become less dependent on the regional timber supply. At the same time, the ongoing trend towards outsourcing of specific activities or production segments, has opened new opportunities for co-operation among large- and small-scale actors, with the latter playing an important role as suppliers of intermediate level products. Consequently, the roles of these actors can be seen in a new framework.

**A model for understanding development processes in family forestry.** Lidestav, G. (*Swedish University of Agricultural Science, Sweden; Gun.Lidestav@ssko.slu.se*).

An analytical model is presented for understanding different aspects or phenomena in family forestry, e.g. the persistence of self-employment or a patrilineal inheritance practice. The model contains variables that influence the development processes. In the model, all land is considered a basic resource around which work and family life is organized. The land is associated with certain property rights given to the children, through the right of inheritance, as a result of marriage. Besides these reproductive prerequisites, work has to be invested in order to get revenue from the capital invested or to increase the value of the property. This increment in value is subject to taxation. Gender has an impact on marriage, inheritance position and division of work. Connecting these institutions or concepts as threads to the hub we get a 'wheel model'. However, these threads are certainly not fixed, and they connected to each other not only by the hub but also directly. The connections can be named practices or tradition and we end up with a 'web model'.

**Activities and equipment for Swedish self-employed non-industrial private forest owners.** Lindroos, O. (*Swedish University of Agricultural Sciences, Sweden; Ola.Lindroos@ssko.slu.se*).

When mechanization began to accelerate 20 years ago, self-employment among non-industrial private forest owners (NIPF) was predicted to disappear; it was expected that forestry activities would be conducted by entrepreneurs and their machines. Time has however proven self-employment to be more persistent than predicted. Techniques for self-employment have developed simultaneously with the larger machines, as a response to the forest owners' desire to work in their own forest. Development has resulted in a great diversification of equipment adapted for the different demands. This paper presents results from two studies on Swedish self-employed NIPF-owners; one on changes in equipment use and one on performed activities. Full sales statistics on equipment for silviculture, harvesting, extraction

and processing of firewood for the year 2002 were gathered through interviews with manufacturers and general agents. Forest owners were addressed by questionnaires, focusing on values and activities. Both equipment sales and performed activities have remained at a high level over the last twenty years. Pre-commercial thinning is the most frequently performed activity among self-employed NIPF-owners, followed by planting, cutting and extraction. Equipment sales for extraction purposes have changed, while equipment sales for cutting and pre-commercial thinning have remained the same.

**Aspects affecting the role of private forests in the Czech Republic.** Skoupy, A., Pecl, J. (*Mendelu University of Agriculture and Forestry, Czech Republic; skoupy@mendelu.cz; pecl@mendelu.cz*).

The paper deals with important changes in forestry in the Czech Republic. After 1989, the area of forests was redistributed in a process of restitutions between new owners at the expense of the state. In the course of the last thirteen years, the state returned about 38% of the forest area to private subjects, villages and municipalities. Owner changes brought a necessity to deal with the problem of effective and professional management, mainly on small areas. The state forest policy is aimed at supporting of sustainability, and enhancing the importance and functions of the forest by means of legislative and financial tools of management. The state supports unifying the private owners of small forests and properties into co-operative forms of management. It supports, financially, professional and advisory activities in private forests. In the private sector, changes occur in the use of traditional means of mechanization towards the use of 'small mechanization'. Promotional, professional and advisory activities are also pursued by the Association of Owners of Communal and Private Forests. Small Czech and imported tractors have been introduced to the operation and the paper also deals with the evaluation of these machines.

**The effect of extension activities on safe work behaviour of self-employed forest owners.** Staal Wästerlund, D. (*Swedish University of Agricultural Sciences, Sweden; Dianne.Wasterlund@sso.slu.se*).

The accident rates among self-employed private forest owners in Sweden are estimated to be several times higher than among professional forest workers. To raise the awareness of forest owners about the risks involved in forest work, the Swedish Forest Owners Association organized, in 2003–2004, several forest days with information and demonstrations of safe work practices. A study was made to determine who were participating in such forest days, what expectations the forest owners had on the information provided during the day and their attitudes towards safety. A few weeks later, the forest owners were asked how they have used the safety information and if their attitudes to safety had changed. Also, the organizers of the forest days were studied on their attitudes to safety and their image of work behaviour among forest owners. The study showed that the forest days attracted forest owners that had a high self-employment rate and who were regular visitors to such information events. The organizers as well as the participants attributed the high accident rates mainly to lack of safety knowledge, but also estimated their own knowledge as good. The effects of the information on work behaviour depended on the information activity organized.

**Small-scale CDM afforestation and reforestation projects: The ENCOFOR case study in Uganda.** Tennigkeit, T., Kallweit, K. (*UNIQUE forestry consultants & FIS, Uganda; timm.tennigkeit@unique-forst.de; kay.kallweit@unique-forst.de*), Emmer, I. (*Face Foundation, Netherlands; igino.emmer@facefoundation.nl*), Kaegi, W. (*B.S.S. Switzerland; wolfram.kaegi@bss-basel.ch*), Mugumya, X. (*National Forest Authority, Uganda; xavierm@nfa.org.ug*), Muys, B., Quijano, J.G. (*K.U. Leuven, Belgium; bart.muys@agr.kuleuven.ac.be; juan.garcia@agr.kuleuven.ac.be*), Schlamadinger, B., Schwaiger, H. (*Joanneum Research, Austria; bernhard.schlamadinger@joanneum.at; hannes.schwaiger@joanneum.at*), van Straaten, O. (*ICRAF, Kenya; o.vstraaten@cgiar.org*), Zomer, R. (*IWMI, Sri Lanka; r.zomer@cgiar.org*).

ENCOFOR is a EuropeAid-funded project designing and promoting afforestation and reforestation projects in the Clean Development Mechanism. In Uganda, the ENCOFOR project supports the development of a small-scale CDM afforestation and reforestation project together with the National Forest Authority. The aim is to promote a two-tier approach: growing trees to sequester CO<sub>2</sub> from the atmosphere and producing timber and fuelwood for the domestic market. Other aspects include rural income generation for poverty alleviation and conservation of biodiversity in natural forests. In co-operation with the national partners, a learning-by-doing approach has been chosen to develop a CDM decision support system. The system offers support to project developers including robust environmental and socio-economic impact assessment tools. A feasibility study showed that CDM afforestation and reforestation projects are only viable in Uganda if carbon credits are produced in addition to other forest products. Moreover, short-term benefits and long-term gains for the development of local communities are a pre-condition to establish successful projects. Considering existing land-use systems, a cluster of small-scale projects (each sequestering less than 8,000 t CO<sub>2</sub> per year) are the most feasible approach. The presentation will indicate the lessons learned from implementation of a demonstration project.

**Public health effects of accidents in self-employed forestry work.** Wilhelmson, E. (*Swedish University of Agricultural Sciences, Sweden; emma.wilhelmson@ssko.slu.se*), Burström, L. (*National Institute of Working Life – North, Sweden; lage.burstrom@arbetslivsinstitutet.se*), Staal Wästerlund, D. (*Swedish University of Agricultural Sciences (SLU), Sweden; dianne.wasterlund@ssko.slu.se*).

Little is known about the extent of work-related accidents among private forestry workers. The absence of an effective accident registration system largely excludes this group from accurate representation in official statistics. In this study, data from 1996 to 2001 was collected from hospital injury records managed by the Accident Research Group at the Norrland University Hospital in Umeå, Sweden. During that period, it was found that 485 persons in the Umeå region were given medical attention due to injuries possibly acquired during forestry work. Questionnaires about the accidents were sent to each of the 485 injured persons and 80% were returned. The responses showed that 225 of the respondents were injured during forestry related work between 1996 and 2001. Out of these, 29% had been on sick leave for some period of time and 42% had lingering symptoms related to the injury. On average, each injury led to 13 days of sick leave and 24 hours of institutional care. The results of the study also indicate that accident/injury rates among small-scale forestry workers are higher than reported in official statistics. Wood handling was shown to be a key factor behind the large number of accidents for self-employed workers. This is an activity that has previously been discounted in accident studies within the industry. An effective, centralized injury registration system would provide researchers with the vital information necessary for future studies on accident prevention among forest workers.

## **The role of the International Energy Agency in creating a carbohydrate-based economy: bioenergy, biofuels and bioproducts**

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**Characterization of degradation products of *Populus alba glandulosa* and *Pinus rigida* woods by sub- and supercritical water treatment.** Choi, J.W. (*Korea Forest Research Institute, Republic of Korea; francis04@foa.go.kr*), Lim, H.J., Han, K.S. (*Chungbuk National University, Republic of Korea*), Choi, D.-H. (*Korea Forest Research Institute, Republic of Korea*).

To understand decomposition behaviours of lignocellulosics, two woody biomasses, poplar (*Populus alba glandulosa*) and rigida pine (*Pinus rigida*), were treated with supercritical water (375 and 415 °C at 23 MPa), as well as subcritical water (275 and 325 °C at 23 MPa) for 6, 10, 30 and 60 seconds using flow type system. After separation of solid residues from products, liquid parts were extracted with ethyl acetate. Organic soluble fractions were analyzed by GC-MS to identify degradation products and aqueous fractions were subjected to sugar analysis by GC and HPLC. Solid residues were characterized by chemical analyses, such as lignin contents and nitrobenzene oxidation. Both woody biomasses were degraded up to 90% under supercritical water condition. Assuming that lignin contents in solid residues amount to over 85%, most cellulose are easily decomposed rather than lignin. Although some portion of reducing sugars were measured by DNS method, no hydrolyzed products of cellulose, such as glucose, were observed even in 6 second-treatment by GC and HPLC, indicating that hydrolysis of cellulose could be concomitant with pyrolytic reaction of carbohydrates under experimental condition. GC-MS analysis revealed that several carbohydrate-pyrolyzed products such as 2-furaldehyde and 5-hydroxymethyl furfural, were found in the organic fractions. Phenolic derivatives—phenol, vanillin, syringol and syringaldehyde—which are converted from lignin, were also produced under supercritical water condition.

**Technical progress in bioconversion: steps towards commercialization.** Mabee, W.E., Gregg, D.J., Gilkes, N., Saddler, J.N. (*University of British Columbia, Canada; warren.mabee@ubc.ca; jack.saddler@ubc.ca*).

The world production levels of bio-based ethanol are rising rapidly in response to increased prices for oil, and a growing understanding of the need to improve the security of fuel supplies. Examples of policy decisions designed to support increased ethanol production and use are discussed in this paper, including the Brazilian experience of the 1980s and 1990s, as well as current Canadian initiatives for supporting commercial ethanol production. Lignocellulosics represent a new platform for the production of bio-based ethanol that may be adopted in many countries. Technology to support the lignocellulose-to-ethanol platform is beginning to be commercialized by industry. At least five major pilot facilities for lignocellulosic bioconversion currently exist or are under construction, including industry-led initiatives by Iogen and Abengoa. One of the remaining barriers to commercializing this process is the range of high costs associated with the enzymatic hydrolysis step. Research initiatives designed to address this problem are discussed. The move towards lignocellulosics will expand the range of areas suitable for the application of bioconversion technology. It will promote a higher level of transport fuel security by diversifying acceptable biomass sources.

**Sustainable biomass production for energy from forestry: technology transfer for science-based decision-making.** Richardson, J. (*IEA Bioenergy Task 31, Canada; jrichardson@on.aibn.com*), Björheden, R., Smith, C.T., Domac, J., Richards, K.

Forest ecosystems are the world's largest accessible source of biomass. Under varying levels of management intensity, much of this is used for conventional forest products such as lumber, pulp and panels. Throughout most of the developing world, forest biomass is also harvested for energy for cooking, heating and other daily needs. Increasingly in the western industrialized world also, interest is focused on the forest as a feedstock for bioenergy—a sustainable, carbon-neutral alternative to fossil energy. Forest biomass for energy may come from harvesting residues, from silvicultural treatments, or from utilization of otherwise un-merchantable species or assortments. To be truly sustainable, forest systems harvesting biomass for energy must consider nutrient cycling, wood ash recycling, carbon sequestration, stand productivity and soil and water conservation, as well as cost-efficient forest operations. Social and cultural issues must also be taken into account. In many jurisdictions, policy and tax measures can help to make this form of renewable energy a viable alternative.

**Bioenergy for reducing greenhouse-gas emissions.** Schlamadinger, B. (*Joanneum Research, Austria; Bernhard.schlamadinger@joanneum.at*), Cowie, A.L. (*State Forests of NSW, Australia; annettec@sf.nsw.gov.au*).

Bioenergy, based on renewable biomass, can play a significant role in mitigation of greenhouse gas (GHG) emissions. The International Energy Agency Bioenergy Task 38 'Greenhouse Gas Balances of Biomass and Bioenergy Systems' is an international collaborative network that develops methodologies for assessing GHG balances of bioenergy systems. Countries participating in Task 38 are: Austria, Australia, Canada, Denmark, Finland, Ireland, The Netherlands, New Zealand, Norway, Sweden and the USA. The Task has developed computer models and case studies for the assessment of GHG balances of bioenergy systems compared with fossil energy systems. A major objective is to aid decision-makers in selecting the most effective options to limit emissions or enhance removals of greenhouse gases. Exchange of models, ideas and experience is facilitated through regular workshops. Position papers and joint publications on the role of bioenergy and carbon sinks in greenhouse gas mitigation have been prepared. For example, Task 38 has produced a 'Frequently Asked Questions' paper on bioenergy, carbon sinks and global climate change. The Task also contributes to the work of the Intergovernmental Panel on Climate Change, to clarify the biomass (sinks) provisions of the Kyoto Protocol.

**Bioenergy development in Australia.** Schuck, S. (*Stephen Schuck and Associates Pty Ltd, Australia; sschuck@bigpond.net.au*).

This paper provides an overview of the framework for, and status of bioenergy development in Australia. It sets out the drivers and key issues for bioenergy, focusing on the Australia's recently released Energy White Paper, its mandatory renewable energy target, and other Federal and State Government policies and programs supporting renewable energy and bioenergy. This also includes support for biofuels, the New South Wales Greenhouse Gas Benchmark Scheme, as well as the nationwide GreenPower scheme. The paper examines some key Regulations related to the legality and eligibility of various biomass fuels, including plantation and forestry wastes. Aspects of bioenergy have been contentious in Australia, and the attitudes of some environmental organizations and electricity retailers are outlined. The paper notes how bioenergy development is being fostered in Australia through Bioenergy Australia, a group of 40+ government and industry organizations. Also covered are various supporting studies and reports from a spectrum of environmental and government organizations, setting the stage for further development. The paper concludes by providing several examples of bioenergy projects that have recently been developed, or are under development in Australia, and gives an indication of likely future opportunities and directions for the bioenergy industry and for the forestry industry.

**Energy-wood demand/supply trends in Europe and rural development: outlook for 2010.** Tahvanainen, L. (*University of Joensuu, Finland; liisa.tahvanainen@joensuu.fi*), Toivonen, R., Rämö, A.-K. (*Pellervo Economic Research Institute PTT, Finland; ritva.toivonen@ptt.fi*).

Globally, energy production is the most important direct end-use sector of wood. In Europe, the share is relatively small, but the overall use of wood in energy production is growing. The target of the EU is to double the share of renewables (triple the use of bio-fuels) between 1995 and 2010, which indicates strongly growing demand for energy-wood. This would strongly accelerate international trade of wood-based bio-fuels, and the development would no doubt also have impacts on industrial round-wood markets. Overall impacts would concern the whole forestry-wood chain and finally national economies, particularly rural regions. New business opportunities will appear in energy and fuel production and trade, but the traditional forest industry sector may face losses due to competition for wood fibre. Final impacts may lead even to changing demand/supply balance of forest industry products. The impacts on rural economies are not only positive, and thus the overall impacts should be thoroughly analyzed. This paper provides an overview of future development trends of wood-based bio-energy markets in Europe. The empirical section of this paper analyzes energy-wood and industrial round-wood market linkages and development in the case of Finland, using forest owner survey data from 2001 and 2003, and relevant statistics.



**Short rotation crops and bioenergy with emphasis on the Scandinavian situation.** Verwijst, T. (*Department of Short Rotation Forestry, Sweden; Theo.Verwijst@LTO.SLU.SE*).

This paper gives an overview of the developments in short rotation crops (SRC) for bioenergy in Scandinavia. It describes the past and present drivers for SRC development, and identifies current trends that provide opportunities for Scandinavian forestry, agriculture and the bioenergy industry. A major question addressed in the paper is how the Scandinavian systems could be modified to function in different parts of Europe and elsewhere. Barriers to large-scale implementation in Scandinavia and their solutions are illustrated and compared to the situation outside Scandinavia.

**Oil palm waste utilization in Malaysia.** Why Kong, H. (*Forest Research Institute Malaysia (FRIM), Malaysia; hoiwk@frim.gov.my*), Sean, H.S.

There are enough oil palm residues in 2000 to support an additional 2,550 MW of energy generation capacity in Peninsular Malaysia. It was found that if all of the shells and fruits fibres of oil palm in Peninsular Malaysia are fully utilized at a conversion efficiency level of 21%, there is about 802 MW of net electricity generation capacity. This is realistically achievable since the mills are already using the higher caloric value residues of shells and fruit fibre. If the empty fruit bunches are also considered, then the net capacity available will increase by almost 315 MW to 1117 MW. Oil palm fronds and trunks have a total generating capacity of 1433 MW, bringing the total potential generating capacity of oil palm residues to 2550 MW. This potential energy is not currently utilized.

## **The role of wood chains in the social and economic development of tropical countries**

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**The energy co-generation production chain: From forest biomass residues.** Muller, A.C. (*Catholic University of Paraná, Brazil; muller@sulbbs.com*); da Silva, C.F. (*Copel, Brazil*); Franzoni, J.A. (*Artefama, Brazil; jafranzoni@brturbo.com*); Hoeflich, V.A. (*Embrapa Forest, and Federal University of Paraná, Brazil; hoeflich@cnpf.embrapa.br; hoeflich@ufpr.br*).

The purpose of this paper is to report an analysis of the application of the concept of productive chains in the co-generation of energy using biomass residues from wood production. The methodology examines the factors involved in the productive systems as well as the institutional mechanisms in order to promote an efficient administration. The paper presents the National Energy Balance, in dimensions such as geographical aspects, and energy potential, sources and types. The study also examines the structure of biomass and energy consumption. The potential capacity of the Brazilian forest sector for energy production is also presented, according to the following components: volume of wood residues produced from planted forests as well as from industrial processing. The institutional arrangement and organizational framework are evaluated through the examination of associated legislation and regulatory acts related to the process of biomass co-generation. A comparison between thermo-electrical co-generation and the generation of hydro-electric power is also presented. The analysis points out the advantages and disadvantages of these alternative measures of energy generation. For conclusion, the study points out the relevance of these components of energy to co-generation in Brazil.

**Raising the added value of tropical/subtropical plantation species.** Okuyama, T., Yamamoto, H., Yoshida, M. (*Nagoya University, Japan; tok@agr.nagoya-u.ac.jp*), Matsune, K., Nakamura, K., Inoue, Y. (*Sumitomo Forestry Company Ltd, Japan*).

In order to encourage the plantation in the tropical/subtropical regions, enhancing the investment through raising the added value of plantation species is essential. It is effective to raise the timber usability of tropical plantation species through silvicultural control as well as genetic improvement. Growth stress and density were measured to evaluate the wood suitability for timber in the following plantation species: *Acacia mangium*, *Acacia auriculiformis* and their hybrids, *Paraserianthes falcataria*, *Eucalyptus grandis*, *Eucalyptus globulus* and their hybrids, and *Tectona grandis*. Tentative results are: 1) The selection of the tree stand according to the released strain measured prior to harvesting raises the value of the plantation forest as a whole. 2) Longitudinal growth stress estimated from the released strain and the density do not change with the diameter, that is, hastening the growth does not debase the wood for timber use. 3) It is important to take into account the growth stress at the selective breeding stage. 4) Some species begin to form mature wood at a diameter of around 15–20 cm, regardless of different growth speeds. This predicts that the faster the growth, the better the quality of timber that is formed.

**Use of natural feature grade timber in structural components of furniture.** Othenin-Girard, A. (*University of Applied Sciences, Switzerland (alain.oftenin-girard@bluewin.ch)*), Ozarska, B. (*University of Melbourne, Australia; bo@unimelb.edu.au*).

In Australia, until today, furniture manufacturers have been using feature grade eucalypt timber mainly for decorative purpose in non-structural applications, for example table tops, bench tops, bed heads and bedside tables. They were reluctant to use feature timber in structural furniture components such as chair legs and bed frames due to lack of data on the strength and stiffness of feature grade timber. The aim of this research project is to develop a technical guideline for manufactures, using Natural Feature Grade Timber (NFGT) in furniture production. The project consists of five parts and aims to investigate: mechanical properties of NFGT of selected eucalypts, determine optimal cross sections of furniture components using SPACE GASS, a stress analysis computer program, strength properties of chairs manufactured with NFGT, development of a final product, and international survey concerning chair joinery methods, member cross sections and wood species. The benefits of this research for the industry are significant because the use of featured eucalypt timber in structural furniture components would increase the total amount of timber available for furniture manufacturers. Consequently there will be further value adding of timber in furniture products and the possibility to use fast growing plantation eucalypts for furniture manufacture.

**Risk analysis of risk in the economic evaluation of forest stands of *Pinus* spp.** Simioni, F.J. (*University of Planalto Catarinense, Brazil; simioni@uniplac.net*), Hoeflich, V.A. (*Embrapa Forest, and Federal University of Paraná, Brazil; hoeflich@cnf.embrapa.br; hoeflich@ufpr.br*).

The objective of the paper is to analyze the economic results of forest stands of *Pinus* spp, using the Monte Carlo Method in the simulation of the Internal Rate of Return (ITR). The project simulated variables previously selected in the cash flow, in order to obtain new financial indicators. The methodology was shown to be efficient in risk analysis, because it made possible the accomplishment of simulations considering more than a single variable at a time. The main conclusions were: a) the expected average ITR was 16.3%; b) the average standard deviation that represented the risk was of 0.01%, and c) the width of variation of ITR was from 13.6% up to 20.4%. In these conditions, the planted forest present great perspectives of economical return, when compared with other agricultural activities.

## Utilization of plantation teak

Organizer: K.M. Bhat *Kerala Forest Research Institute, India; kmbhat@kfri.org*

**Teak wood characteristics from clonal and multi-provenance trials under moist tropical climate.** Baillères, H., Monteuis, O. (*CIRAD, France; henri.bailleres@cirad.fr*), Goh, D. (*Innoprise Corporation Sdn Bhd, Malaysia; dornogh@pc.jaring.my*).

Teak (*Tectona grandis* L. f.) has great potential as a species for production of valuable quality timber from fast growing plantations of the tropics under sustainable forest management. Some studies have suggested that wood quality is affected by the interaction between genetic origin and meteorological conditions. A more realistic prediction of quality and value of young plantation-grown teak is important in the current context of extensive teak plantation programs in tropical countries. Innoprise Corporation Sdn Bhd (ICSB) in Malaysia has embarked on an intensive R&D program for teak. Materials from mature selected plus trees (ortets) from a broad genetic base, and seeds of presumed high genetic value, were multiplied then planted by using a well-developed tissue culture technique at the Plant Biotechnology Laboratory of ICSB. Fifty-three clonal representatives were felled for board-sample collection. Additionally, seed sets from natural forest stands, plantations and a multi-provenance clonal seed orchard were planted in two different locations. Within these former trials (around 7 year old) 61 superior teak trees from 19 provenances were core-sampled. On the boards and the cores, the most important wood characteristics for commercial use were analysed: figure, basic density, MOE, colour, shrinkage, heartwood proportion, extract content and natural durability.

**Timber quality of teak grown outside forests.** Bhat, K.M., Thulasidas, P.K., Florence, E.J.M. (*Kerala Forest Research Institute, India; kmbhat@kfri.org*).

Home garden forestry with teak is a common practice of growing trees outside forests (ToF) in Kerala, India which accounts for more than 50% of the industrial roundwood supply. Comparative timber property investigations showed that home gardens on wet sites produced larger diameter logs with an average dbh of 39.6 cm (age 35 years), as prescribed for Site Quality I of All Indian Yield Table. In contrast, the dry sites produced smaller diameter logs (average dbh 24 cm) than the forest plantation, qualifying only for Site Quality II/III with more frequent pole sizes.

However trees in drier homesteads produced the timber of more attractive wood figure with black streaks and a darker golden brown colour. Although yield was higher, the paler wood colour and lower decay resistance (to brown rot fungi) lowered the timber value of trees grown in home gardens on wet sites. However, no significant differences were noticed in wood basic density, dimensional stability and strength properties. Due to a lack of standard spacement, thinning and pruning regimes, the market value of home garden teak was lower because of greater imperfections such as bends and knots.

**Embryogenesis of teak (*Tectona grandis* Linn. F.).** Jörgensen, J. (*Mönkeberg, Germany*), Dedi, Yulianti, E., Sugito, Sadhardjo, Sm. (*Perum Perhutani, Indonesia*).

Teak is the most important commercial tree species in Indonesia, and every year, about 10 million trees are planted. Owing to wide clonal differences, plant breeding plays an important role in the production of high quality planting stock. At the Forest Research Center in Cepu, a project was started to establish the methods of propagation by tissue culture, which is useful to accelerate plant breeding. Anthers with pollen in different developmental stages were placed on different media and cultivated under different conditions to induce embryogenesis. On some of the tested media under special conditions, globular embryos were developed; they grew into later stages of embryogenesis and then into plants which could be grown in soil. In our further research, we plan to use the embryos as a protoplast source for the fusion of protoplasts, so that crossing could be made *in vitro* and with predictable results. In the future, it is possible to use these tissues for genetic engineering.

**Evaluation of natural durability of teak wood (*Tectona grandis* L.f) in plantation in Togo, West Africa.** Kokutse, A.D. (*Université Bordeaux I/ INRA/CNRS, France, and Université de Lomé, Togo; mimidam@hotmail.com*), Stokes, A. (*Université Bordeaux I/ INRA/CNRS, France; stokes@lrbb3.pierroton.inra.fr*), Baillères, H. (*CIRAD-Forêt, France; bailleres@cirad.fr*), Kokou, K. (*Université de Lomé, Togo*).

Teak (*Tectona grandis* L.f) has been introduced in Togo at the beginning of the 20th century and has become the most important timber for exportation. Plantations cover approximately 12000 ha at present. Natural durability and colour, characteristics that are requested on the international timber market, have been studied in the trees of these plantations. Twelve hundred samples of 26 trees have been tested against four fungi. The results show considerable difference in the intensity of attack. *Antrodia* sp. and *Coriolus versicolor* are the fungi that have caused the major damage with losses of up to 20% of dry matter whereas 100% of the samples are classified durable to very durable against *Pycnoporus sanguineus* and *Gloeophyllum trabeum*. The analysis of the colour parameters show that the clarity L\* is a negative factor for the natural durability of the samples. From the four fungi tested, the clarity allows one to distinguish the durability class of the sample. The relationship between the red colour a\* and yellow b\* parameters and durability exists but they are not sufficiently close to allow for an accurate classification.

**Colour improvement on planted *Tectona grandis* sapwood by oil-curing treatment.** Mohamed, A., Wahab, R., Moktar, J. (*Universiti Malaysia Sabah (UMS), Malaysia; drrazakw@ums.edu.my*).

Naturally grown teak (*Tectona grandis*) is highly durable, easily worked, attractive, strong and relatively light. It has been used for making furniture as well as structural and decorative timber, where its durability has been proved. Bio-deterioration organisms such as termites and fungi tend to shun it. Teakwood has over the years fetched high prices in the global markets. This has led to the establishment of teak plantations in the tropical regions. The rotation lengths of these plantations vary from 20 to about 80 years, but the trend of harvesting is towards the shorter end of the time scale and short-rotation plantation teakwood is entering the market in increasing volumes. The short-rotation teakwood cannot hope to match mature-aged teak in beauty or durability, although it does possess some valuable properties. Harvested short-rotation teakwood is uneven in colour, resulting in a lower selling price. This paper investigated the improvement of wood colour by heat treating with coconut oil and palm oil. Variation in oil and oil temperature affected the colour of sapwood and heartwood.

**Status of teak (*Tectona grandis* Linn.f.) plantations in Bangladesh.** Mridha, M.A.U., Bhuiyan, M.K., Haque, M.N., Akhter, M.F. (*University of Chittagong, Bangladesh; mridha@abnetbd.com*).

Teak (*Tectona grandis* Linn. f.) is predominantly tropical or sub-tropical in distribution. It is an important and highly valuable timber species of Bangladesh. It was first planted in Bangladesh at Sitapahar in 1871, and is now a major plantation species in the tropical wet evergreen and semi-evergreen forests. The total forest area of Bangladesh is over 22,000,000 ha and most of the teak plantations are located in Chittagong, Chittagong Hill Tracts, Cox's Bazar and Sylhet, which cover more than 2,000,000 ha. The country has very good sites for growing teak; besides hill locations, some plantations are in blocks, along roadsides, on homesteads and in office compounds. The rate of return from teak

plantations would increase if the rotation length were less than 60 years. Several insects, bacteria and fungi are observed to attack teak in nursery as well as in the field. Arbuscular mycorrhizal technology is urgently needed to find out the status of biodiversity of fungal colonization in the roots and spore population in the soils of nurseries and plantations in different parts of the country to introduce the technology.

**The effect of teak forest management on land erosion (a case study).** Nurdin, W., Sadhardjo, Sm. (*Watershed Research Agency (BTPDAS Solo), Indonesia*).

One of the important forest functions was to adjust the condition of watershed hydrology. The objective was to determine the effect of teak forest management on hydrology condition, especially erosion and water management. This study was conducted in a teak forest at Cepu Forest District, Perum Perhutani, on paired watershed section (inside & outside of teak forest area) and on 12 micro-catchment areas, based on stand age. The results showed that watershed characteristics beyond the teak forest could be used for evaluating the effect of management on watershed hydrology. The water was still of good quality. The average values of erosion and sedimentation in the forest area were lower than in the non-forest area. There were 80 species and 34 families of understory. Dominant species were sigromabur (*Eupatorium odorata*), kremah (*Hemigraphis caniformis*), *Acacia villosa* and Opo-opo kebo (*Flemingia strobilifera*) with coverage around 27.2–95.8% (wet season) and 10.2–60.2% (dry season). Soil characteristics were medium C-total content (2.1%), low N-total (0.1%), high C/N ratio (20.95), very low P content (4.68 ppm), medium K (0.39 me/100 g) and pH around 7.29. The results can be used to model erosion run-off under teak forest management.

**Community-based teak forest management in Cepu Forest district, Indonesia.** Sadhardjo, Sm. (*Teak Center Cepu, Indonesia; sadharjo@hotmail.com*).

Perhutani is an Indonesian Government forest enterprise that is fully responsible for managing almost all forests on Java island, where teak (*Tectona grandis*) is the main species. The change of forest management methods from timber management to community-based forest management has been initiated as a creative model for the future. Forest community-based management is management where village institutions and all forest stake holders are involved in the process. They must agree on the way the forest is managed and contribute according to their own abilities. Participative management occurs by accommodating the interests of villagers and forest managers in managing the forest. The forest area is divided and mapped, based on each village territory. A bilateral agreement was made by both parties and witnessed by an advocate. The rights and obligations of each party is explained so that it will be possible to conduct an annual evaluation and, if necessary, make adjustments. An early finding, following the implementation of the new management system, is that illegal logging has been reduced, dramatically.

**Early performance of clones tests of teak in Perum Perhutani, Java.** Sadhardjo, Sm., Aris, W., Sugi, P. (*Teak Center Perhutani, Indonesia; sadhardjo@hotmail.com*).

Height and diameter parameter are used for assessing Teak clones test (*Tectona grandis* LF) in Perum Perhutani (a state owned forestry enterprise) at 5 years of age. The specific objectives of this research were 1) to ascertain clone variation on height, diameter and stem form to straight 2) to identify the best clone. The plots were established in four geographically different sites (Cepu, Bojonegoro, Ngawi and Ciamis) in January 1999. The estimates of heritability on height were moderate in two sites ( $h^2 = 0.12$  at Bojonegoro and  $h^2 = 0.27$  in Ngawi), higher ( $h^2 = 0.57$ ) in Ciamis and non-significant in Cepu. While the estimated heritability on diameter was high ( $h^2 = 0.51$ ) in Ngawi, it was moderate ( $h^2 = 0.2-0.41$ ) at the other three sites. With respect to the heritability on stem form, the relationship was similar ( $h^2 = 0.61$ ) on all four sites. Clones-site interactions were significant for those three parameters.

**Gene flow in a teak clonal seed orchard.** Siregar, I.Z., Siregar, U.J. (*Bogor Agricultural University, Indonesia; siregar@ipb.ac.id*).

Seed orchards are established in order to produce large amounts of genetically improved seeds. Seed production in an orchard is closely associated with gene flow. In particular the transport of pollen is related to mating events that, in certain cases, can cause reduced seed yields in the orchard. A unique marker allele at an isozyme gene locus was studied in a Clonal Seed Orchard (CSO) of teak in Java, Indonesia. The frequency of pollination by the marker tree was estimated, based on the observation of progenies of surrounding trees. Results show that most pollen is transported to neighbouring trees following a negative exponential curve. The proportion of seeds fertilized by the marker tree is low, ranging from 0%–7.5% for all trees separated by a distance of more than 14 m, while directly neighbouring trees were more fertilized by the marker tree ranging from 7.5%–12.5%. The efficiency of bridging the spatial distance between ramets in the orchard is important information for forest geneticists and seed orchard managers. In this case, the behaviour of pollinating insects has strong implications on the gene flow and it is therefore useful to improve the design and management of seed orchards.

## **Application of newly-developed technologies in mechanical wood processing towards sustainable utilization of forest products in the 21st century**

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**A new method for processing wood from the oil palm tree.** Anim, A. (*Radebs Wood Enterprise Products Limited, Ghana; alexanim2002@yahoo.com*).

The demand for wood is increasing due to population increases in both the rural and urban areas of Ghana. Unfortunately, the timber industry cannot meet the demand due to low timber production and the non-availability of raw material. The oil palm tree, *Elais guineensis*, which has a small diameter log, has recently gained increasing popularity in Ghana due to a Presidential initiative on the use of extracted oil from the oil palm tree. The oil palm tree is regarded as a promising species to meet the timber demand of the industry. In the past, it was felled purposely for the extraction of its juice for the manufacturing of alcohol. Several studies in Indonesia and Malaysia have reported on the difficulties encountered in processing oil palm. In this study, cutting tool wear and mechanical strength properties of the oil palm tree were examined to determine its potential as raw material for the downstream processing sector. It was observed that cutting tool wear was reduced and productivity increased when the oil palm tree was heated before processing. There was, however, a slight reduction in the modulus of rupture and modulus of elasticity when the oil palm tree was heated before processing.

**Extending tool life by cryogenic treatment and by cooling tools with refrigerated air.** Gisip, J. (*Purdue University, USA; jgisip@purdue.edu*), Stewart, H.A. (*Murphysboro, USA*), Gazo, R. (*Purdue University, USA; gazo@purdue.edu*).

Cooling cutting tools and cryogenic treatment resulted in the reduction of tool wear. This study used six two-flute, tungsten carbide tools to machine MDF on a CNC router with a total of over 166,000 m length of cut per flute. Three of the six tools were cryogenically treated. A combination of cryogenic and non-cryogenic tools was used to cut at three different temperatures, i.e. at -6.7 °C, 4.4 °C and 21 °C. A vortex tube produced air of -6.7 °C and 4.4 °C which was used to cool the tool during cutting. A current draw of the router spindle was measured with power analysis equipment to monitor the router bit performance. Surface quality from cutting was observed according to an ASTM Standard. Tool wear was analyzed with a light microscope and scanning electron microscope (SEM). Elemental analysis using SEM was conducted in order to characterize and quantify elements present on the tools. Both use of refrigerated air and cryogenic treatment reduced tool wear, and thus increased tool life between 15 and 220%.

**Trial ablation on printed popular paper with pulsed Nd:YAG lasers.** Hattori, N. (*Tokyo University of Agriculture and Technology, Japan; hattori@cc.tuat.ac.jp*), Kawabe, T. (*Forest Agency, Japan*), Kosaka, T., Ando, K. (*Tokyo University of Agriculture and Technology, Japan*), Yahagi, S. (*Toshiba Corporation, Japan*).

In order to reuse printed PPC paper, laser ablation was performed with pulsed Nd:YAG lasers. The normal pulsed YAG laser and the Q-switched one were irradiated to papers printed with three kinds of toners, and the surface qualities of the removal areas were investigated through microscopic observations and apparatus analysis. It became clear that the wavelength of YAG laser (1064 nm) is suitable for removing the toner selectively without damaging the paper. After irradiation of the normal pulsed YAG laser, whose pulse width is longer than 1 ms, damage to paper fibers was observed, although toner was almost removed. Irradiation of the Q-switched YAG laser of about 100 ns in pulse width could remove toner mostly without damage to the fiber. Ablation with Q-switched Nd:YAG laser of 4 ns in pulse width was also performed. The original brightness of all samples was not recovered.

**Optimal blade speeds for circular saws.** Hutton, S.G. (*University of British Columbia, Canada; hutton@mech.ubc.ca*), Taylor, J. (*Forintek Canada Corporation, Canada; taylor@van.forintek.ca*).

A primary aim in wood processing is to achieve a high volume of sawn lumber while maintaining an acceptable degree of cutting accuracy. The faster a circular saw can run, the higher the feed speed that can be used, as long as cutting accuracy can be maintained. Circular saws that are clamped at their inner radius are known to become unstable as the rotation speed of the saw approaches the lowest critical speed of the saw. This speed corresponds to the lowest speed that a bending wave will propagate around a stationary saw. Thus, in applications using clamped saws it has been the usual practice not to run the saws at speeds greater than 85% of the critical speed. However, some mills using guided spline-arbor saws (where the blade is free to move on the arbor) have been able to operate saws above their critical speed. At the same time, other mills have not been able to successfully run at these increased speeds and, in general, there is a lack of information pertaining to what speeds are optimal for different blades. This paper presents results that address these issues.

**Conversion of middle diameter sugi logs into sawn lumber: sawing yield by using sawing patterns in consideration of log strength.** Murata, K., Ikami, Y., Matsumura, Y. (*Forestry and Forest Products Research Institute, Japan; saw@ffpri.affrc.go.jp; ikami@ffpri.affrc.go.jp; myukari@ffpri.affrc.go.jp*).

In the conversion of logs into sawn lumber it is very important to sort logs appropriately for the end use. Since most sawn lumber is used for construction members in Japan, we can easily decide its end use, namely for structural member or not, and consequently we can convert the logs efficiently, if we can estimate the strength of the sawn lumber before the conversion of the logs. In this study, middle diameter sugi (*Cryptomeria japonica* D. Don) logs were sorted by strength and converted into sawn lumber by using the sawing patterns in consideration of the log strength. Sugi logs were sorted by the quality of the log face and the dynamic modulus of elasticity—determined by fundamental frequency (Efr) of vibration induced by hitting in longitudinal direction. Efr of the logs ranged from 6.39–10.75 GPa, with an average of 8.34 GPa. The average lumber value yield was higher in round sawing than in cant sawing. Efr of sawn lumber for structural members ranged from 3.51–12.59 GPa and averaged 8.87 GPa.

**Comparison of cutting performance of high speed steel and stellite-tipped blades.** Okai, R. (*University of Education, Winneba, Kumasi Campus, Ghana;reynoldsokai@yahoo.co.uk*), Tanaka, C. (*Kagoshima University, Japan;tanakach@agri.kagoshima-u.ac.jp*), Iwasaki, Y. (*Iwasaki Saw Filing Cooperation, Japan; metate-a@tx.miracle.ne.jp*).

This paper reports on a component of ongoing research investigating the use of tip-inserts in band saw blades. This paper reports on cutting tool wear as a result of different mechanical and chemical properties of three tree species: oil palm (*Elais guineensis*), afina (*Strombosia glaucescens*) and sugi (*Cryptomeria japonica*). The cutting tools were made from stellite and high speed steel of designations SUS420J2 and SKH 51 according to the Japan Industrial Standards. Among the tested wood samples, the greatest cutting tool edge recession were recorded in SUS420J2 and TiN coated SKH 51 tools when machining *E. guineensis*—in spite of *S. glaucescens* possessing the highest modulus of rupture and modulus of elasticity. On the contrary, stellite in spite of having the lowest hardness (HV580) among all the tested cutting tools, recorded the least cutting tool edge recession when machining wood samples of *E. guineensis*. However, it was observed that among all the tested cutting tools, stellite recorded the highest cutting tool edge recession when machining *S. glaucescens*. The high proportion of silica in *E. guineensis* contributed to the high wear recorded in the high speed steels cutting tools.

**The use of microwave technology in manufacturing of bent wood components.** Ozarska, B., Worsley, M., Juniper, L., Rozsa, A. (*University of Melbourne, Australia; bo@unimelb.edu.au; mworsley@unimelb.edu.au; ljuniper@pgrad.unimelb.edu.au; a.rozsa@pgrad.unimelb.edu.au*), Hyams, M. (*Swinburne University of Technology, Australia; mhyams@groupwise.swin.edu.au*).

Bent wood components have been extensively used internationally in a broad range of high-value wood products. Various wood softening methods for bending have been used, such as steam heating, chemical treatment and radio-frequency heating. In Australia, a research team at CRC Wood Innovations is developing an innovative technology for the manufacture of furniture components that involves microwave softening of wood to enable bending it to a wide range of shapes. Research focuses on: investigating wood structural changes and the mechanical behaviour of microwave heated wood during the bending process, determining the optimal radii of curvature and bending parameters for a wide range of plantation timber species, developing an on-line automated 'mass production' bending process, and developing innovative design and products utilizing the new bending technology. The use of microwave wood softening dramatically reduces the time of heating in comparison with the steam heating of wood components. Time required to heat 25 mm thick *Eucalyptus regnans* using steam is approximately 45 min, while it takes only 1.5 min to heat this timber in the microwave unit. Microwave wood bending technology also reduces the production cost, minimizes waste, shortens the lead time, and improves product quality.

**Characterizing surface defects in rubberwood processing.** Ratnasingam, J. (*Universiti Putra Malaysia, Malaysia; jswaran@forr.upm.edu.my*), Tan, C.Y. (*Syarikat Petaling Corporation Sdn. Bhd., Malaysia*).

Despite its extensive application in the furniture manufacturing industry throughout the south east Asian region, the machining characteristics of rubberwood (*Hevea brasiliensis*) are not completely understood. For most applications, machining defects have been reported to be a major contributor to yield losses in processing. In an effort to evaluate this problem, a series of experiments were undertaken using a Weinig 22A Unimat moulder (cutterhead rpm of 6000, cutter Ø 120 mm) to produce machined rubberwood surfaces with differing pitch lengths ranging from 0.8 mm to 1.5 mm, by altering the feed speed. The results showed that surfaces with the pitch length of cutter marks 1.0 mm or more, were more prone to manifest machining defects, and inevitably reflected a rougher surface finish. The machining

defects were predominantly fuzzy grains, transformed to torn grains and grain tear outs, reflecting greater surface impairments. Yield calculations showed an 18% loss when such surface defects are allowed to develop during the machining operations. This study demonstrates that industrial processing of rubberwood must adhere to the recommended cutter marks pitch length of at maximum of 1.0 mm if machining defects are to be minimized and processing yield increased.

## Using wood composites as a tool for sustainable forestry

Organizer: Jerry Winandy *USDA Forest Service, USA; jwinandy@wisc.edu*

**In-situ micro-dielectrical evaluation of the curing process of adhesives in plywood manufacturing.** Ballerini A., A., Gacitúa E., W. (*Universidad del Bío-Bío, Chile; aballeri@ubiobio.cl; wgacitua@ubiobio.cl*).

A key stage in the plywood manufacturing process is the pressing of the board, where consolidation occurs and design of the physical and mechanical properties are established. At this stage the adhesive system plays a major role, especially in the way in which it changes from the aqueous state to a high resistant solid matrix. This project determined through micro-dielectric spectroscopy and thermal analysis, at a laboratory and industrial scale, the way in which operational variables associated with wood (moisture content and density), adhesive and hot pressing (pressure, temperature and time) affect the curing mechanism of the adhesive and the mechanical resistance of the matrix formed. Curing diagrams were made of the adhesive system during hot pressing, and a manual of the methodology required to monitoring the adhesive curing at an industrial scale was produced. Results from this study allow a 10–15% reduction in the amount of adhesive required to make plywood. In addition, it was possible to reduce the total pressing time approximately 11 and 20%, at a laboratory and plant scale, respectively.

**Characterizing the rheological properties of wood-plastic composite formulations.** Chastagner, M.W., Wolcott, M.P. (*Washington State University, USA; mchastagner@wsu.edu; wolcott@wsu.edu*).

In the last decade, the wood-plastic composites (WPC) industry has grown to the point that its production may impact local wood supplies. The primary material for WPC is wood flour derived from sawmill waste, but can also be made from whole tree chips. As such, this product category can potentially influence sustainability of the forest industry. The flow of the molten wood-plastic blending during processing is critical to the formation of the end product. This behaviour is characterized by the rheological properties of the material. As production of WPC has increased, the need to better understand the rheological behaviour of the melt has become an important concern, since changes in the rheological properties can alter the overall product shape and the mechanical properties of the composite. In this work, the rheological properties of high-density polyethylene (HDPE)/maple (*Acer* spp.) and HDPE/pine (*Pinus* spp.) composites were studied with a specially designed slit die. Melt viscosity was found to increase with filler content and decrease with shear rate. Depending on the formulation, the measured melt viscosity was between 13% and 41% lower than similar formulations examined using standard capillary techniques. In addition, the technique produced excellent reproducibility within the individual formulations.

**Physical and mechanical properties of oriented strandboard made using kraft lignin phenol formaldehyde resin.** Donmez, A., Kalaycioglu, H. (*Karadeniz Technical University, Turkey; adonmez@ktu.edu.tr; khulya@ktu.edu.tr*), Hiziroglu, S. (*Oklahoma State University, USA; hizirog@okstate.edu*).

Kraft lignin phenol formaldehyde (KLPF) resin has certain advantages over other commercially used exterior resins as a binder in oriented strandboard (OSB). Since kraft lignin is used as substitute for almost 50 percent of phenol in a typical resin, KLPF is not only more environmentally friendly but also less expensive compared to other binders. The purpose of the study was to evaluate the potential of this resin to produce experimental OSB panels. Six panels, 56 x 56 x 1.5 cm, with an average target density of 0.60 g/cm<sup>3</sup> from aspen (*Populus americana*) were manufactured under laboratory conditions. Properties determined included: modulus of elasticity (MOE), modulus of rupture (MOR), internal bond strength, screw holding strength, water absorption, thickness swelling and density profiles. MOE values of control samples made using phenol formaldehyde and KLPF resins were 2332 and 2338 N/mm<sup>2</sup>, respectively. Corresponding average values for MOR were 21.66 and 19.18 N/mm<sup>2</sup>. Based on the initial findings, both mechanical and physical properties of the samples were not adversely influenced by modified resin. Test results of the panels revealed that all properties met the minimum requirements specified in related standards and are comparable to those of commercially produced OSB panels. KLPF showed good potential for the manufacture of OSB panels.

**Study of wood plastic composites: a methodology for evaluation of interfacial adhesion.** Gacitúa E., W., Oyarzún R., P., Ballerini A., A. (*Universidad del Bío-Bío, Chile; wgacitua@ubiobio.cl; poyarzun@ubiobio.cl; aballeri@ubiobio.cl*).

Wood plastic composites (WPC) are complex compounds. Their physical and mechanical properties are significantly influenced by their composition. The objective of this study was to manufacture WPC and to develop a methodology for evaluation of the interfacial adhesion by mean of thermo-mechanical analysis. Radiata pine wood flour was blended with polyethylene and polypropylene. Maleic anhydride polypropylene was used as a coupling agent. Mixtures with three proportions of wood-to-plastic (40–60%, 50–50% and 60–40%) were made in a thermal mixer and their thermo-mechanical properties were evaluated with dynamic mechanical analysis. Results indicate that the highest proportion of wood in the mixture produced the best thermo-mechanical properties. In addition, the coupling agent is very important in the interfacial adhesion of the compounds, improving its final properties. The behaviour of the WPC during creep was determined using the Burger model.

**Strength of 25 and 35° pitch metal plate connected laminated veneer lumber (LVL) from bintangor.**

Jamaludin, M.A., Ahmad, M., Nordin, K. (*Universiti Teknologi Mara, Malaysia; mohda310@salam.uitm.edu.my; mansur628@salam.uitm.edu.my; kamar629@salam.uitm.edu.my*).

Limited research has been conducted to determine the performance of layered wood composites with metal plate connections. Consequently, this research was carried out to determine the strength and failure mode of metal plate connected laminated veneer lumber (LVL) joints. These are common joints in the heel of pitched roof truss systems. The LVL was from bintangor (*Calophyllum* spp.) which is a non-commercial wood species. Its utilization will contribute toward expanding the supply of natural wood resources, thus reducing the demand for present commercial species. In this study, two pitches (25 and 35°) and three lumber sizes (40 x 120 x 750 mm, 40 x 120 x 772 mm and 40 x 120 x 820 mm) were used. The nail plates were 100 x 150 x 1 mm. Tests conducted were based on the ASTM D1761: Part 22: 1980 and AS 1649:1998. Results showed that collectively, the mean maximum load for the 25° pitched joints (54.053 kN) were higher by 2.6% than the 35° pitched joints (52.704 kN). Teeth withdrawal was observed in the 25° pitched joint failures. In the 35° pitched joint tests, both teeth withdrawal and wood failure was observed as the joints failed.

**Strength properties of engineered I-joists made from laminated veneer lumber, solid wood, oriented strand board and plywood.** Jamaludin, M.A., Nordin, K., Ahmad, M. (*Universiti Teknologi Mara, Malaysia; mohda310@salam.uitm.edu.my; mansur628@salam.uitm.edu.my; kamar629@salam.uitm.edu.my*).

This study evaluated the strength of engineered I-joists made from compositions of different materials. The materials were made from wood of lesser-used forest and plantation species. The successful utilization of these materials would increase the commercial values of the lesser-used natural wood resource. It will also contribute toward reducing the burden imposed on the commercial wood resource from natural forests. The materials for the I-joists in this study were laminated veneer lumber (LVL), oriented strand board (OSB), plywood and solid wood (light red meranti). The LVL was from lesser-used meranti species (*Shorea* spp.), whereas the OSB was from rubberwood (*Hevea brasiliensis*). Solid wood joists from light red meranti were used as a control. The static bending test (ASTM D198-84 and D143-52) was performed to determine the modulus of elasticity (MOE), modulus of rupture (MOR) and allowable bending stress for each I-joist. Solid wood joists exhibited the highest MOE, MOR and allowable stress compared to the engineered I-joists. Among engineered I-joists, composition of LVL flange and OSB web exhibited the highest MOE, MOR and allowable stress. However, all the engineered I-joists have achieved the standard required by the Malaysian Standard (MS 544:1978) for floor joists.

**Effect of resin types on the quality of composite boards made of wood waste and corrugated cardboard.** Massijaya, M.Y., Hadi, Y.S., Kusumaningrum, W. (*IPB, Indonesia; yusram@indo.net.id; yshadi@indo.net.id*).

One of the alternatives of wood waste utilization is to combine it with corrugated cardboard waste for composite board production. The objective of the research was to investigate the effect of resin types on the quality of composite board made of wood waste and corrugated cardboard. Three resin types were used in this research: urea formaldehyde (UF), melamine formaldehyde (MF) and phenol formaldehyde (PF). The research results obtained are as follows: 1) density, moisture content and MOR parallel to the grain fulfill JIS A 5908 standard, and 2) composite board bonded by PF performed better in water absorption, MOE parallel to the grain, MOR parallel and perpendicular to the grain, and internal bond compared to those of composite boards bonded by UF and MF.



**Development of composite board made of wood waste and plastics.** Massijaya, M.Y., Hadi, Y.S., Tambunan, B., Suhaimi Bakar, E., Gunawan (*IPB, Indonesia; yusram@indo.net.id; yshadi@indo.net.id; jthh@indo.net.id*).

The purpose of this research was to determine how to produce high quality composite boards composed of wood waste and plastics. The wood waste particle types were sawdust, shaving, flake and wafer. The plastics types were polyethylene, polypropylene and polystyrene. Two resin types were used at 10% based on particle oven dry weigh, namely melamine formaldehyde and phenol formaldehyde. The research results are as follows: 1) composite board composed of wood waste and plastics had good physical and mechanical properties, 2) blending wood waste and plastics improved thickness swelling properties, 3) properties of composite boards made of wafer performed were superior, and 4) the internal bond of composite board made of flake was superior.

**Comparison of board properties made from different waste papers.** Massijaya, M.Y. (*IPB, Indonesia; yusram@indo.net.id*), Okuma, M. (*University of Tokyo, Japan*).

This research was conducted to compare the fundamental properties of boards composed of different types of waste paper: office paper, advertisement paper and newspaper. The results obtained are as follows: 1) boards made from office waste papers and all resin types had the best performance in MOE, MOR and IB properties, however, in wet bending strength and bending strength retention, boards from waste newspaper were superior, 2) considering the bonding material, the order of the best fundamental properties of waste paper boards were isocyanate, phenol formaldehyde and urea formaldehyde, and 3) compared to the JIS A 5908 standard, only urea formaldehyde and phenol formaldehyde bonded boards failed to meet the minimum requirement for 8-type particleboard, while the others type boards met 13-type or 18-type board requirements.

**An experiment on producing laminated waste newspaper boards.** Massijaya, M.Y. (*IPB, Indonesia; yusram@indo.net.id*), Okuma, M. (*University of Tokyo, Japan*).

In order to improve the appearance of waste newspaper boards, several boards bonded by urea formaldehyde, phenol formaldehyde, isocyanate and laminated with thick white paper were produced. In general, boards bonded by isocyanate had better properties those bonded with phenol formaldehyde or urea formaldehyde. Lamination with thick white paper significantly improved the modulus of elasticity and modulus of rupture of waste newspaper boards regardless of resin type. Isocyanate bonded boards and phenol formaldehyde bonded boards met JIS A 5908 for 18-type particleboards, while urea formaldehyde bonded boards met 18-type for laminated and 13-type for non laminated waste newspaper boards. There were no differences between laminated and non-laminated urea formaldehyde and phenol formaldehyde bonded boards in wet modulus of rupture. Lamination by thick white paper tends to decrease the modulus of rupture and modulus of elasticity strength retention regardless of resin type.

**Strength properties of glued laminated bamboo strips for furniture.** Nordin, K. (*Universiti Teknologi MARA, Malaysia; kamar629@salam.uitm.edu.my*), Wahab, R. (*Universiti Malaysia Sabah, Malaysia; drrazakw@ums.edu.my*), Jamaludin, M.A. (*Universiti Teknologi MARA, Malaysia; mohda310@salam.uitm.edu.my*).

Utilization of bamboo, *Gigantochloa scortechinii*, as an alternative material to timber has markedly gain interest recently, not only among researchers and timber users in Malaysia, but throughout the world. Nevertheless, bamboo-utilizing industries in Malaysia are generally small, low technology, labour intensive mills producing products such as chopsticks, poultry cages, vegetable basket and skewer. Solid round bamboo is used for furniture making, but the products generally have simple construction and a limited range of designs due to a lack of fundamental knowledge and information. To make bamboo more versatile and produce more value-added products, its utilization in a form similar to lumber needs to be promoted. For this reason, the bending and compression strength of glued laminated bamboo strips of different ages (2 and 4-year-old) were assessed and compared with those of Malaysian oak (formerly known as rubberwood)—commonly used for furniture manufacturing in Malaysia. The glue bond strength properties in terms of block shear and delamination tests were also being investigated. Utilization of bamboo strips in a laminated form is seen to have great potential to supplement timber, and hence reduce dependency on some timber species for furniture and other products.

**Using sugi plantation materials for wood-based composites in Japan.** Suzuki, S. (*Shizuoka University, Japan*).

Japan currently has 2.1 billion m<sup>3</sup> in plantation forests, and utilization is an important issue. Sugi, *Cryptomeria japonica* (L.f.) D.Don, is the primary species. Three recent examples of sugi use in major construction are: the Ohdate Dome (178 m diameter) using sugi glulam timber, the Miyazaki-Dome using sugi glulam, and a king-post truss bridge (140 m long). Laminated veneer lumber and parallel strand lumber (PSL) are examples of engineered

lumber products using sugi. Recently, new technology for a super strong timber (SST) composite was developed in Japan and is intended to encourage utilization of low quality logs. SST is similar to PSL in that it is composed of long strands, but the wood strands are made by tearing and splitting small diameter logs. The plywood industry has started to peel sugi logs to produce thicker panels for structural use. Several under-utilized plantation species were shown to effectively reinforce sugi plywood. Mat-formed panels can now be manufactured using Sugi. Oriented strandboard (OSB) made from sugi is a product that achieves higher mechanical properties than particleboard or medium-density fiberboard MDF. Strandboard has been recently manufactured in a trial for commercial production. This work has shown that sugi can provide high mechanical performance when used as the base strand-material in mat-formed structural OSB panel products.

**European experiences with wood and natural fibre composites.** Thoemen, H. (*University of Hamburg, Germany; h.thoemen@holz.uni-hamburg.de*), Barbu, M. (*Transilvania University Brasov, Romania*).

Major changes are currently evident in the European wood-based panel industry. While considerable investments in new capacities has recently occurred in eastern Europe and Russia, production of particleboard and MDF in west and central Europe has leveled off with little or no growth expected. On the other hand, changes in European construction styles have opened new opportunities for structural wood composites like glue laminated timber and OSB, doubling the production capacity of these structural composites over the last decade. New environmental regulations significantly increase restrictions on process and product emissions (VOC and formaldehyde), and on organic solvent and hazardous substances used for finishing wood products. New types of composites based on wood and other natural fibres have entered the European market in recent years, and can be expected to gain further importance. The launch of wood plastic composites production has been associated with the introduction of new technologies. Products based on agro-fibres have become important for automotive applications and insulating materials. The aim of this study was to summarize recent developments in the European wood and natural fibre based composites market, to describe them in an international context, and to identify future challenges and trends. This will also then be related to its effect on forest sustainability.

**A North American perspective on using wood-based structural composite products as forest management tool to improve forest health and sustainability and to reduce forest fuels and exotic/invasive species.** Winandy, J.E. (*USDA Forest Service, USA*), Hiziroglu, S. (*Oklahoma State University, USA; hizirog@okstate.edu*).

Land managers across North America are once again beginning to see selective harvesting as a critical tool in maintaining healthy and sustainable forests. Development is underway on adaptable and adjustable processes for manufacturing value-added products from small-diameter timber, forest residue and whole tree trimmings, traditionally left in the woods after logging operations, and from exotic and invasive species. In this way, 'whole-site' forest management can be implemented to use all available living biomass material for optimum utilization, leaving minimal materials in the forest for future insect, disease, or forest fire. In other areas of North America, a diverse number of exotic and invasive woody/shrubby bio-fiber resources are sparsely populated across large areas, these materials must be removed to promote or re-establish ecosystem health, but the cost of doing so is immense. Some land managers are now working with utilization researchers to realize the value-added potential of utilizing the bio-fiber of these exotic/invasive species in high value-added structural composite products. This paper addresses specific examples of how structural biocomposite products can add value to no-value or valueless biomaterials, and thereby assist land managers in achieving land-use goals and offsetting the costs of eco-system remediation.

**Wood composite made of *Populus* plantation material in China.** Ye, K. (*Chinese Academy of Forestry, P.R. China; yekelin@forestry.ac.cn*).

*Populus* is one of the major forest plantation species in China with more than 6 million hm<sup>2</sup> of plantation forests. Wood composites made of plantation material play a very important role in balancing supply and demand of timber in China. This paper summarizes physical and mechanical properties, and chemical composition of this material. The key characteristics of wood composites made of *Populus* are: low density, light colour, high and unevenly distributed moisture content, easy to deform and high stress wood proportion. Plantation material is widely used to manufacture plywood, block board, particleboard, MDF and reconstituted fancy veneer in China. This paper also suggests focusing on future Chinese market segmentation. Particularly that: fast growing *Populus* species with high quality be further genetically improved, more intensive management be practiced in plantations (such as wider spacing, pruning, irrigation, fertilizing, and beetle prevention, aiming at large diameter, fewer and smaller knots and low taper for veneer manufacturing), more technology improvements be made (veneer peeling and softening, drying and gluing technology to make better use of materials), new products be developed to meet construction and decoration demand (OSB, LVL and reconstituted fancy veneer), and the Chinese government develop policies that favour plantation forestry.

## **Links between supply chain management and value recovery**

Organizer: Kevin Boston *Oregon State University, USA; Kevin.Boston@oregonstate.edu*

**Demand management in the lumber industry.** D'Amours, F., Frayret, J.-M., D'Amours, S. (*Université Laval, Canada; Jean-Marc.Frayret@forac.ulaval.ca; Sophie.DAmours@forac.ulaval.ca*).

Demand management in the lumber industry is about optimizing the utilization of (1) material from the forest, and (2) manufacturing and logistic resources for harvesting, transporting, transforming and distributing in order to best meet customers' needs. It is a particular aspect of supply chain management that encompasses demand forecasting, sales and operations planning (i.e., the synchronizing of sales and production activities), and order promising (i.e., the activities of promising reliable dates to customers). Demand management is particularly difficult to carry out in the context of multiple sawmills with various local specifications related to both their capacity to transform logs into dry lumber and the nature of the source of supply (i.e., log and fiber quality). Moreover, because it is a divergent process, lumber production generates co-products, which can lead to high inventory levels of low demand products. We first present a decision support mathematical model that combines demand and revenue management in order to synchronize sawmills' production and harvesting activities. The objective of this model is to maximize the profit of the sawmill network by producing the 'right product for the right customer at the right time for the right price'. Market intelligence mechanisms and sales optimization are also introduced.

**Planning for optimal short-term order fulfillment in the timber harvesting industry.** Marshall, H. (*Oregon State University, USA; Hamish.Marshall@oregonstate.edu*).

The growing of timber is largely a commodity business, gaining a competitive advantage over your competitor is less about providing a superior product and more about providing a superior service. For a forest grower this means providing the customer with the right amount and type of logs at the right time. Obtaining optimal order fulfillment in a constrained market, with limited and valuable resources takes careful planning and control of the timber harvesting process. Production planning requires a detailed knowledge of inventory levels of raw materials, customer demand and equipment and labour availability. However, beneath the surface the short-term order fulfillment problem in forestry is more complex than many other types of manufacturing operations. A good knowledge of the quantity and quality of the logs available in the forest is rarely known and mother-nature can play havoc with scheduling of equipment and labour. This paper will give an overview of the short-term order fulfillment planning problem and a summary of some of the current methods and planning systems been used in the industry today. To solve short-term order fulfillment problems, mixed integer programming, dynamic programming and combinatorial optimization are being researched and developed at Oregon State University.

**Controlling value recovery along the forest-to-mill supply chain.** Murphy, G. (*Oregon State University, USA; Glen.Murphy@oregonstate.edu*).

Foresters spend decades creating potential value in standing trees through silvicultural management. One of the challenges faced at the time of harvesting is to fully recover that value through effective marketing and sales practices and planning and control of operations. Once harvesting begins, value can be efficiently recovered (or lost) during falling, extraction, bucking, loading and transport. Value recovery, as low as 30% and as high as 98%, has been reported in the literature. Controlling value recovery ensures that logging crews minimize losses through stem damage and breakage, produce the product mix required by the market without over- or under-running orders, manufactures log products that are to specification. New solution methods for solving the short-term order fulfillment problem, using a range of operation research techniques are being researched and developed. A description of these methods and some early results will be presented in this paper. The purpose of the paper is to stimulate discussion about this problem and to make sure that planning systems are being developed for the right customer. In this paper we describe control procedures and tools that have been used by forest companies in Australasia, and North and South America to maximize value recovery.

**Quantifying supply chain performance and strategy for Lithuanian state sawmills.** Puodžiūnas, M. (*Agricultural University of Lithuania, Lithuania; pumis@iname.com*), Fjeld, D.E., Wästerlund, I. (*Swedish University of Agricultural Sciences, Sweden; Dag.Fjeld@ssko.slu.se; Iwan.Wasterlund@ssko.slu.se*).

The aim of this study is to quantify supply chain performance for Lithuanian State sawmills. The study examines supply chain performance for 6 state forest enterprise sawmills. The following indicators were used to describe supply chain performance in the different positions of the supply chain: variability (coefficient of variation for monthly flows), inventory cover time (in terms of production days), supply chain dynamics (cross correlations between monthly flows) and supply variability quotients (ratios between coefficients of variation for monthly flows). The mills were grouped

according to economic potential. Mills classified as having high and medium economic potential were primarily focused on assortments seen as main products of wood supply (boards, planks). Mills classified as having low potential were primarily focused on by-products of wood supply (palletwood). Data analysis for main- and by-products showed three main points. First, the degree of supply chain dynamics ( $\rho_{sr}$ ) and supply variability quotient ( $\omega_{sr}$ ) were both higher for main products than by-products. Second, the degree of dynamics ( $\rho$ ) was positively correlated with the coefficient of variation for final sales ( $CV_s$ ) and inversely proportional to the size of the supply chain buffer capacity ( $ICT_{sc}$ ). Third, the supply chain responsiveness is higher for main products than by-products.

## **Promoting economic development through forest products marketing and business management**

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**US markets for tropical secondary processed wood products.** Black, T., Eid Chajtur, A.A. (*Metafore, USA; tblack@metafore.org; achajtur@metafore.org*), Duery, S., Vlosky, R.P. (*Louisiana State University, USA; sduery1@lsu.edu; vlosky@lsu.edu*).

Understanding the market for secondary processed tropical wood products is the focus of a recently launched research project undertaken by the Louisiana State University Agricultural Center and the forest sustainability non-profit organization, Metafore. The intent of the project is to provide responsible producers of finished products made of tropical wood about the opportunities, constraints and characteristics for these products in the U.S. marketplace. The project has two components: a mail survey research/quantitative analysis, and qualitative interviews. We surveyed over 3500 wood importers, distribution intermediaries, secondary manufacturers, homecenter retailers, specialty retail outlets, architects and consumers in the United States as well as interviewing 30 processed tropical wood importers. The research focuses on developing marketing strategies for four main product segments: 1) millwork and molding (architectural wood millwork), 2) wood doors and wood windows, 3) wood furniture and wood furniture parts, and 4) wood flooring and decking. The results will be used to help secondary wood products manufacturers in tropical countries make informed decisions about product lines and capitalize on opportunities presented by both domestic and export markets as well as help U.S manufacturers identify strategies to sustain quality supplies of tropical species.

**Firm-based resources and their impact on determining price structures for wood product innovations.** Bull, L. (*University of Melbourne, Australia; l.bull@pgrad.unimelb.edu.au*).

As a commodity-based cyclical industry, the wood products market has traditionally competed on price. As a result of changing market and natural resource positions, firms within this industry have increasingly had to develop new product innovations to sustain profits and conserve their competitive positions within the wood products marketplace. New wood products entering the marketplace require that the commercializing firm set a price for which buyers can purchase the product. Because these new products are often participating outside the traditional commodity framework, firms must decide how they will reach an appropriate price. Firm-based resources and innovation have previously been linked to sustained competitive advantage. It is logical then that a firm's resources, specifically its physical, human, capital and organizational resources will impact upon decisions pertaining to management of the innovation. This study analyzes the concept that firm-based resources play a determining role in the pricing of new wood product innovations. Given the price-driven nature of the wood products industry, this aspect of the marketing mix is of particular importance to the management of new innovations. The findings are based on case-study-based research that took place in Australia, New Zealand and the United States.

**The impact of investments in forest research: The importance of appropriate evaluation.** González, R., Jerez, M. (*Los Andes University, Venezuela; ronalds@ureach.com*), Stock, J. (*Smurfit Carton de Venezuela; jurgen.stock@ve.smurfitgroup.com*), Garay, V., Plonzack, M. (*Los Andes University, Venezuela; vgaray@ula.ve; plonzack@ula.ve*).

This paper presents an evaluation of the impact of financial investment made in forest research. In many organizations, especially in developing countries with little or no tradition in the development of forest plantations, it is difficult to receive resources for investment in research, and in many cases such investment is considered an unnecessary expense. By means of this presentation, and from a financial viewpoint, the profitability of such investments is demonstrated by quantifying gains in volumetric growth, new technologies that result in cheaper silvicultural practices, improve the quality of products, and help diversify production. The financial evaluation of some research activities must be

considered in an integrated form in order to get a realistic perception of the profitability of a project. For example, a company that wants to evaluate the profitability of an improved seed orchard must not restrict itself to the savings from the self-supply of seed, but the genetic gains from crossing must also be evaluated financially more adequately in order to see the advantages of investing into such types of projects. In addition, and by use of financial indicators, an optimum theoretical margin of investment in research for small enterprises is determined.

**The effectiveness of self-regulation in combating illegal logging and trade: Assessing voluntary codes of conducts of European timber traders.** Grossmann, C.M., Schanz, H. (*Albert-Ludwigs-University of Freiburg, Germany; carol.grossmann@ifp.uni-freiburg.de*).

The impact of international trade with wood products on forest loss is of great interest. Awareness is growing of the increasing dimension of illegal logging and trade, and its negative ecological and economic consequences. The European Union has developed an 'Action Plan for Forest Law Enforcement, Governance and Trade'. With shifting attention from government to governance rule setting, the importance of corporate self-regulation, and particularly voluntary codes of conduct, has been emphasized to promote respective improvement in the forest-timber-supply chain. The effectiveness of such voluntary codes of conduct to combat illegal logging and trade, however, remains open. This paper explores the effectiveness of corporate self-regulation, focusing on European timber importers and traders. Based on environmental marketing and business management theory, a comparative assessment is carried out of the design, motives, and adherence to voluntary codes of conducts of timber trading firms in Germany and the Netherlands, within the different political, social and economic contexts. The analysis encompasses psychometric information to detect subjective variables influencing environmentally benign management decisions. The paper concludes: 1) with policy recommendations regarding the importance of voluntary codes of conduct in combating illegal logging and trade, and 2) an applicable methodology to improve the effectiveness of corporate codes of conduct in the timber trade sector.

**Finnish forest sector economic outlook: Short-term forecasting in forest sector.** Hänninen, R. (*Finnish Forest Research Institute, Finland; riitta.hanninen@metla.fi*).

In the 1990s, interest in short-term forecasts and forecasting has increased due to the drastic changes in world economy. In forest sector, internationalization of the forest industry has strengthened the economic dependencies between Europe, North America and Asia. To meet future cyclical changes, we must be aware of the most probable events and the possible alternatives when making decisions. For this purpose, short-term forecasting models and forecasts are needed in the forest sector. The Finnish Forest Sector Economic Outlook (FFSEO) of the Finnish Forest Research Institute produces forecasts basing on a demand driven system. Changes in international and domestic economic growth rates are reflected in fluctuations in the demand for forest products. Demand changes are transferred to forest industry production, prices, profitability, employment and roundwood markets. Previous research is dominated by long-term scenarios, and analyses on short-term models are scarce. Private forest sector consultants, analysts and organizations publish and sell short-term forecasts (e.g. forest products markets and prices) but their basic assumptions are not often well documented. The FFSEO is an example, where academic researchers produce well documented analysis and forecasts useful for forest policy decision making. FFSEO have been helpful to Finnish organizations of nonindustrial private forest owners and small industrial firms lacking resources for forecasting. Formulation of new short-term forecasting techniques is a future research challenge.

**Transmission of demand shocks in forestry-wood chain: a case of lumber and stumpage markets in northern and central Europe.** Hänninen, R., Toppinen, A. (*Finnish Forest Research Institute, Finland; anne.toppinen@metla.fi; riitta.hanninen@metla.fi*), Toivonen, R. (*Pellervo Economic Research Institute, Finland; ritva.toivonen@ptt.fi*).

This paper focuses on the fluctuations driven by shocks in the consumer countries' economic growth and how these pass through lumber industry export prices to the exporters' national roundwood prices. In over-supplied European lumber markets, competition between producer countries is high, with the new EU countries gaining gradually more market shares and changing market structures. Fluctuations of product prices affecting market shares are known to be large, but timing and duration of price transmission is not known between competitor countries. Differences in the adjustment to demand shocks between countries indicate possibilities to differentiate products. Our empirical analysis covers four large lumber exporting countries in Europe (Finland, Austria, Estonia and the Czech Republic) and monthly time series data for 1994–2004. Thus, our econometric analyzes not only demonstrate competition between different regions in Europe, but are also informative about behavioral differences between western and transition economies. Our results confirm that roundwood price development is tied to cyclical developments in the lumber export markets, but behavioral differences can be detected between countries. Knowledge of the dynamic adjustment of market prices is essential for forest policy decision makers and industry in planning marketing and future location decisions.

**Integrating research for intensive management: economic and environmental effectiveness of alternative harvesting methods.**

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An integrative study was undertaken in western Oregon, USA, to assess the costs and benefits of intensively managing young stands of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco. Harvesting economics and resource implications were determined for three alternative silvicultural prescriptions and three different logging systems: skyline yarding, tractor skidding and a mechanized (cut-to-length) system. The harvesting economics and resource impacts were divided into four parts: planning and layout costs, logging production and costs, stand damage and soil disturbance and compaction. Logging contractor layout costs showed a relationship to type of logging system: the mechanized system had the lowest layout cost, followed by the tractor systems, with the skyline systems having the highest costs. Scarring was the most typical damage to residual crop trees, accounting for 90% of the total damage. Scarring by ground-based harvesting systems was more severe than in skyline systems. Some soil disturbance and compaction was observed on the harvest units, but varied widely within and among the units. The mechanized cut-to-length system generally produced more compacted soil area than skyline yarding, although the latter system was more costly to plan and operate. Local stand and site conditions, and harvest planning and implementation are important contributors to the observed variation in residual stand damage and soil disturbance.

**Measuring innovativeness in the forest products industry.** Knowles, C., Hansen, E. (Oregon State University, USA; [Chris.Knowles@oregonstate.edu](mailto:Chris.Knowles@oregonstate.edu); [Eric.Hansen2@oregonstate.edu](mailto:Eric.Hansen2@oregonstate.edu)).

Innovation is the introduction of new products, processes, or business systems. Previous research has consistently shown innovation to be a driver of firm growth and is critical for maintaining competitiveness. Researchers have defined innovativeness in various ways, for example, a culture of openness to new ideas. While previous research has acknowledged the importance of innovativeness, a valid and reliable scale for measuring firm innovativeness does not exist. The purpose of this study was to develop a new scale for measuring innovativeness, specific to the forest products industry through a systematic and structured scale development process. A new innovativeness scale will provide researchers with a systematic way of evaluating the connection between innovativeness and firm performance. Various measures of the construct are being investigated. Examples include: corporate culture, use of a structured new product development process, market orientation and adoption of innovative tools and systems. Financial performance is being assessed and will be related to innovativeness to determine if a relationship exists. Data collection via a mail questionnaire will begin in early 2005. The target population is North American sawmills. This study builds on previous work by the authors in the area of innovativeness in the forest products industry.

**Designing new business models for forest-products companies—the development of value propositions.**

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Increased competition in the 1990s forced forest products companies to re-evaluate their business models. Our paper explores forest product marketing by investigating capability-based value propositions that differentiate companies among selected customer accounts. We first utilize a mixed-methodology approach for: 1) identifying the product and service needs of customers, and 2) investigating the prevailing and prospective capability sets among wood-industry companies as a basis for satisfying customer requirements. We proceed by linking the customer needs with the satisfying set of capabilities to form a value proposition, which is tested through customer and industry surveys. Finally, we analyze the process of developing the suggested capability-based value proposition by conducting a comparative case study between a Scandinavian and an Anglo-Saxon company operating in the UK market. Our findings show the importance of tailor-made value propositions for each customer segment based on a careful selection of capabilities. Each capability set includes parts that are common to the whole industry, differentiation occurring through either restructuring existing capabilities or by developing novel ones. The optimal capability set is a compromise between customer requirements and industry imperatives, maximizing long-term and short-term revenues.

**Value-added wood product adoption, interfirm co-operation and information technology use: An exploratory study of large US builders' procurement strategies.**

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The consolidation of the homebuilding industry is expected to continue, and will have profound impacts on the North American forest products industry. With consolidation, large builders are gaining purchasing power, and their

procurement practices are increasingly impacting on the softwood lumber and the composite panels industries. Increasingly, large builders are looking for easy-to-install products, engineered wood products and more off-site construction. However, their strategies regarding building techniques and relationships with their suppliers and subcontractors are not yet well understood. This study explores the large home building sector with respect to changes in techniques and material selection, procurement sources and arrangements, collaborative practices and information technology use. A survey instrument was implemented within the population of the Top 100 builders in the US residential market. Findings indicate that purchasing agreements are short-term, and that 'pro-dealers' and component manufacturers are the preferred supply sources. Nevertheless, more cooperative and long-term relationships with suppliers, as well as shorter supply chains, are expected over the next five years. Moreover, the use of information technology is definitely expected to grow. The results of this study suggest a need for further research on the link between value-added products adoption, interfirm co-operation and information technologies use.

**Acceptable wood-based products.** Maplesden, F., van den Heuvel, M. (*Forest Research, Rotorua, New Zealand; frances.maplesden@forestresearch.co.nz; mike.vandenheuvel@forestresearch.co.nz*); Killerby, S. (*Tokoroa, New Zealand; skillerby@xtra.co.nz*).

The Acceptable Biomaterials Program has the overarching premise that it is in New Zealand's economic and environmental interests to develop, utilize and export novel bio-based (particularly wood-based) products and technologies in line with, and according to, international standards of sustainability encompassing life cycle thinking. The central paradigm of the program is that stakeholder acceptability can only be achieved if social perceptions, values, and the reasons underlying them are integrated with environmental considerations during the technology development cycle. The design of this program and preliminary results are described. Using decking products as a case study, the research will scope a range of social and ethical issues held by stakeholders concerning chemical use in existing and transitional technologies, and their willingness and capacity for dialogue and consensus. Environmental analysis methods that incorporate an assessment of the sum total resource and energy utilization, and pollution impacts over the entire lifecycle of a product will be utilized as the environmental underpinning of social and ethical research. The research is designed to provide mechanisms for informed dialogue and decision-making on new technologies, particularly relating to wood-based product opportunities.

**Development of a decision-support tool to predict the success of non-timber forest product commercialization.**

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While interest in non-timber forest product (NTFP) commercialization continues to grow, initial enthusiasm is tempered by the realization that many attempts fail to deliver the expected benefits. This paper describes a model that was developed to support the decisions being made by a wide range of stakeholders. The model is based on consideration of five types of capital asset required to support rural livelihoods: human, social, environmental, physical and financial. This approach enables the potential impact of NTFP commercialization on a wide variety of different measures to be predicted. We demonstrate how this model has been constructed, validated and used to develop a decision-support tool for selecting appropriate NTFPs for development. We highlight how a better understanding of the different combinations of factors determining success can result in more efficient investment of financial, technical and political support. Use of such tools to inform decision-making should assist in increasing the value of forests through sustainable development of NTFP resources, while reducing the risk of failure resulting from inappropriate interventions.

**Dimensionality of service quality: Customer perceptions about forestry services.** Toivonen, R., Rämö, A.-K. (*PTT Pellervo Economic Research Institute/Forest Economics Group, Finland; ritva.toivonen@ptt.fi; annakaisa.ramo@ptt.fi*).

Aging and urbanization of forest owners and changing forest ownership objectives increase the need for forestry related services in Europe. Land restitution strongly strengthens the need for services in the CEE-countries. Growing service markets may provide business opportunities to new entrepreneurs, and promote forest sector related economic growth, particularly in rural areas. Services may also help the forest industry to maintain long-term business relationships with landowners if occasional wood sales can be associated with long-term service contracts. Developing competitive service concepts presumes understanding forest owners' needs and perceptions about service quality. However, to date, research has concentrated on physical forest products. This pioneering study not only outlines future trends of forestry-related service markets but also analyses perceptions about service quality among Finnish private forest owners. Service and product quality research are applied as a theoretical framework. A two-phase-approach was followed: 1) 37 in-depth interviews were conducted to formulate a measurement instrument for service quality, and 2)

a structured mail survey (731 respondents) was carried out among forest owners during 2004. The results produce a tool for assessing service quality from a customer viewpoint, and highlight perception gaps between forest owners, industry, and administrative actors.

**Perspectives on the competitive ability and wood product markets for birch industries in the Baltic Sea area.**

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Finland, the Baltic countries and northeastern Russia are traditional producers of birch lumber, plywood, veneers and their further products. The recent enlargement of the European Community will alter the roundwood flows and product markets in the Baltic Sea area. Finland alone imports approximately half-a-million cubic metres of birch logs annually. Log resources represent high quality, but are concentrated on rather limited geographic areas in Finland and the Baltic countries. Resources are fully utilized in Finland, Estonia and Latvia, whereas in Russia, Lithuania and Byelorussia there is a potential for expansion of the birch-based industries. Birch lumber is predominantly used for appearance-grade products such as furniture and fixture, but also for flooring, moulding and panelling. However, new products and markets for lower-grade birch are desperately needed. Russian producers have aggressively penetrated birch plywood markets recently, lowering the export prices and setting pressure for the Finnish and Baltic producers. Estonian producers concentrate on birch lumber as partners of Swedish, Danish and German manufacturers, whereas Latvia produces veneers in collaboration with German market leaders. Lithuanian and Polish birch industries are still in initial stages, but indicate willingness to grow. For all European birch industries, the strong competition from China is apparent. The North American birch industries are predominantly concentrating on their domestic markets.

**IUFRO and UNECE/FAO take a leadership role in international forest products marketing.**

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In the realm of international forest products marketing, two entities are taking the lead in promoting information sharing, creating forums for collaboration and promotion of educational and research activities. These are: 1) The Team of Specialists on Forest Products Markets and Marketing established by the United Nations Economic Commission for Europe Timber Committee and Food and Agriculture Organization of the United Nations European Forestry Commission, and 2) The International Union of Forest Research Organizations Forest Products Marketing Research Group (5.10.00). This paper/poster will give an overview of these two organizations including structures, objectives, activities, impacts and opportunities for participation.

**The small get smaller: Fragmentation in small-scale forestry**

Organizer: John Herbohn *University of Queensland, Australia; j.herbohn@uq.edu.au*

**Urbanization and forest fragmentation in Georgia: Challenges to sound forest management.**

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Urban sprawl has been identified as a major force affecting forests in the southern United States. Georgia has the largest metropolitan area in the South, Atlanta, which has experienced a rapid growth since the 1990s. Such growth continues to expand the urban/rural interface and affect forestland area, management and timber and nontimber uses, particularly in the vicinity of Metropolitan Statistical Areas (MSAs). Data collected by the US Forest Service from the early 1980s through today are used to quantify and assess impacts of the expanding urban/rural interface on Georgia's forest resources, focusing on forestland loss, fragmentation and parcelization by owner, stand type and distance to MSAs. Privately-owned stands smaller than 20 ha already account for two thirds of Georgia's 10 million ha forestland. The relationships between trends in forest resources and variables such as population growth, tax revenue growth and increases in building permits are established. The results are used to assess forest fragmentation and parcelization due to urbanization as well as current and future decreases in the availability and management quality of the remaining forestland near large urban developments. Finally, the implications of fragmentation and parcelization for sustainable forest management and sound policy decision-making are evaluated.



**For the love of the land: The influence of generational land transfer on forest fragmentation in Washington State, USA.** Creighton, J.H., Blatner, K. (*Washington State University, USA; creighton@uamont.edu; blatner@wsu.edu*).

Generational transference of family farm property has been a topic of study in the social sciences for many years, and it is upon this issue that we base our discussion of forestland transference and lifestyle orientation of family forests in Washington State, and the possible connections to forest fragmentation. The passing of forest property from parents to children reaches beyond the continuity of families; it has implications for landscape continuity as well, especially with regards to forest fragmentation. Current research suggests that a major threat to the maintaining of family forests in Washington State is the lack of successful generational transfer of forest land. For this study, data was collected through one-on-one semi-structured interviews following the grounded theory method. The properties of generational transfer that emerged as being significant to most respondents include environmental regulations, lack of economic opportunities, high cost of maintaining forestland, differing generational values and lifestyle choices and urban influences. The average age of family forest landowners in Washington State is 65 years old, indicating that a large scale generational shift in ownership is approaching. Given the current rate of development and population growth in Washington State, the issue of generational transfer of family forests becomes critical.

**Land parcelization in subtropical and tropical Australia and the implications for the development of small-scale forestry.** Emtage, N., Harrison, S., Herbohn, J. (*University of Queensland, Australia; j.herbohn@uq.edu.au*).

Research suggests that fragmentation and parcelization of forestry land may lead to reduced timber production and a decline in quality of stand management. One way of testing this hypothesis is to examine the relationship between forestry attitudes and practices, other land-use activities, incomes and other factors in relation to the size of rural holdings. A number of surveys have been conducted on landholder attitudes and practices with respect to farm forestry in coastal Queensland and New South Wales. This paper reviews findings of these surveys, particularly in regard to property size and forestry involvement. It is concluded that forestry is less popular on the larger commercial farms than on smaller holdings of similar land type, and plantation establishment is often supported by off-farm income. However, the quality of stand management is positively correlated with area planted.

**Small-scale private forestry and challenge of forest fragmentation: New trials in Japan.** Hori, Y. (*Forestry and Forest Products Research Institute, Japan; horijas@affrc.go.jp*).

Private forests in Japan are characterized by the following; 1) most forestland is owned by many small owners, 2) the forests are fragmented, and 3) the forests have provided multiple benefits for society. Overcoming fragmentation of private forests has been one of the important issues of forestry policy. In 2002, the forest planning system was renewed to manage the forests efficiently and reliably by assembling fragmented small forests. In addition, it challenged new trials. Forest owners' cooperatives and forest contractors were able to make forest plans by proxy for owners. Forest planners receive about \$95/ha for forests that are less than 40 years old. The agreement of owners of fragmented forests is most important for assembling parcels of forestland. The forest planners (forest owners' cooperatives and forest contractors) concentrated on explaining the merits of assembling forests, the most important being cost of maintaining forests. As a result, many private forest owners became interested in the new forest planning system and have established forest plans. However, a remaining problem is that the assembled forests do not contribute to cost reduction in forest maintenance.

**Evaluating organizational designs in the forestry wood supply chain to support forest-owner cooperations.**

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In the coming decades, European wood-based industries could face a lack of wood as raw material because of low utilization of the net annual increment. On the other hand, there is a huge amount of green inventory in European forests. The main obstacle to systematic exploitation of the wood inventories is small-scale ownership. Forest Owner Cooperations (FOCs) try to overcome this by common timber sales activities. In this presentation, the concept of business-process engineering and present current business process models of FOCs are applied in Austria and Germany. Using business engineering methodology reveals high potentials for FOCs to utilize better small-scale forest resources. In addition, methods are proposed to support FOCs in developing process efficiency and adaptation to various types of forest owners.

**New forest owners as facilitators of rural development.** Schraml, U. (*University of Freiburg, Germany; ulrich.schraml@ifp.uni-freiburg.de*).

Whereas the structure of forest ownership in Germany was comparatively stable in the last decades, during the last years, several processes induced significant changes. Besides the ongoing land reform in the Eastern part, privatization of public

land, social changes in family forestry and the economic crisis of private forestry lead to an increasing number of sales. Public and private institutions sell forestlands to urban people who buy them mainly for amenity reasons. Concepts of multifunctional forestry and rural development are faced with new stakeholders in the countryside. The paper describes the main lines of the ongoing changes and provides a review of the scientific literature dealing with the new forest owners and their forest management. Results of existing surveys about the different new owner groups are compared. Establishment of new forest ownership by restitution, privatization and private sales is considered. The paper evaluates the existing regulations aiming to control the forest land markets and to foster rural development.

**Fragmenting forest ownership as a challenge for information and training service development in North Europe.**

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While private forestry dominates, a prerequisite for efficient forest policy is up-to-date information about the owner and holding structure and the objectives of forest ownership. This paper investigates these issues, and the need for information services among Estonian and Finnish private forest owners based on two large empirical surveys. The motivation for the study is the fact that forest ownership in Europe is changing: Aging and urbanization of the owners, and fragmentation of holdings being the driving forces. In the new EU-states, land restitution process results in 3–4 million new private forest holdings of 2–3 ha on average. The new owners rarely have experience in forestry, and may have low motivation for well-planned forest management. Amenity values are becoming increasingly common in the Nordic countries, while the forest ownership motivations in the new EU-countries are not yet known. The development may have dramatic impacts; such as reducing wood supply and over-utilization of forests. These impacts are multiplied in the forestry-wood chain and in rural economies. Despite this, the issue is not yet deeply studied. This paper draws conclusions about future trends in private forestry and evaluates possibilities to support sustainable forest management through information and training services.

**Forests and the livelihoods of rural people**

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**Value of the forest to upland people in northern Thailand.** Hares, M. (*University of Helsinki, Finland; minna.hares@helsinki.fi*).

Most of the remaining forest areas of Thailand are found in northern uplands. The inhabitants of these forests include ethnic minority groups. They are regarded as threats to the protected watershed forests that are supposed to be uninhabited from the government's point of view. This paper examines the significance and use of the forest among four ethnic groups dwelling in the uplands of northern Thailand and is based on fieldwork conducted in the Chiang Mai Province in 2002 and 2004. The data was collected by semi-structured and focus group interviews. The results indicated that the upland people, regardless of ethnic background, regard the forest as important or even essential for their livelihood and tended to emphasize the importance of conservation and sustainable use of the forest. Gathering non-timber forest products was viewed as a sustainable way to use forests. The most important non-timber forest products for the villagers were firewood, construction wood, herbs, mushrooms and bamboo shoots. Besides, the forests have a religious meaning for many uplanders and forests are valued for providing water and pleasant micro-climate. Local people and the government thus agree on the importance of forest protection, but mutual understanding seems to be lacking.

**Valuing the nutrient retention function of mangrove forests: perception of agricultural producers from the east coast of India.** Hussain, S.A., Badola, R. (*Wildlife Institute of India, India; hussain@wii.gov.in*).

We examined the nutrient contents in mangrove and non-mangrove soils in and around the Bhitarkanika Wildlife Sanctuary, India, and assessed whether the local agricultural producers were aware of and placed a value on the nutrient retention function of mangrove forests. Replacement cost method was used to derive the value of nutrients in mangrove soils. Sixty samples each, from mangrove and non-mangrove areas were analyzed and the quantity of organic carbon, total nitrogen and available phosphorus and potassium were derived. We estimated that each hectare of mangrove contains extra nutrients worth \$134.95 in comparison to non-mangrove areas, and the value of the nutrients was \$3.41 million for the 145 km<sup>2</sup> of the mangrove forests of the Sanctuary. The producers were aware that mangrove forests act as a source of nutrients and were willing to pay higher price for the land adjoining mangrove forests. Approximately 92% of the producers have ranked nutrient retention as the second most important function of mangrove forests, after storm protection. Despite crop depredation from wild ungulates and conflict with salt water crocodiles, the agriculturist find the benefit to cost ratio of mangrove forests high and >77% were in favour of mangrove restoration.

**Advancing communication between science, practice and capacity building at the Latvian State Forestry Research Institute “SILAVA”.** Oslejs, J. (*LSFRI “Silava”, Latvia; osleja@internet.lv*).

Forest privatization has taken place in Latvia since 1991, and now private forests make up approximately one half of the total forest area. More than 150,000 private forest owners have become new actors in the forest sector, however, they possess very limited skills and experience in forest management, which is further aggravated by the small average size of forest holdings and lack of co-operative structures in private forestry. Silvicultural sciences are at a very high level in Latvia, but the implementation at more practical levels is insufficient. Research at Latvian State Forestry Research Institute SILAVA covers a broad range of subjects from preservation of forest gene resources to general issues of forest policy. Improved dissemination of research results is a necessary condition for enhancing positive impacts of forest science on forest management practices. Unfortunately, in SILAVA there was little know-how and experience on how to communicate research to practice. With a bilateral Latvia-Denmark project, in the past three years significant work has been accomplished to develop communication between forestry research and practice and to strengthen institutional capacity: 1) needs and information use analysis, 2) strategy for communication and information, 3) extension services training, 4) guidelines for publishing, 5) mentoring, 6) web site development, 7) information to target groups, 8) guideline development, and 9) linking into extension networks.

**The use of a multi-directional trunk shaker in the mechanical harvesting of pine cones.** Pinheiro, A.C., Peça, J.O., Gonçalves, A.C., Ribeiro, N.A. (*Universidade de Évora, Portugal; pinheiro@uevora.pt*), Vacas de Carvalho, M.A. (*DRAAL Direcção Regional de Agricultura do Alentejo, Portugal*), Gomes, J.A. (*ANSUB Associação de produtores florestais do vale do Sado, Portugal*), Saraíva Dias, S., Barriguinha, A.F. (*Universidade de Évora, Portugal*), Reynolds de Souza, D. (*Reynolds & Oliveira Lda, Portugal*).

With a total area of about 600,000 ha of umbrella pine (*Pinus pinea* L.) in Europe, Portugal is the second major producing country, after Spain, with a total area of 85,500 ha. Pine cone harvesting is, however, still relying on intensive manual labour. Self-propelled trunk shakers have been recently imported. High ownership costs limit their use to contractors. This paper describes a trunk shaker that has been developed to be mounted on the front-end-loader of a farm tractor, and the results of its evaluation obtained during two years of a research project. The experimental work is being carried out in four permanent plots of umbrella pine on commercial farms in Alentejo, Southern Portugal. Field trials reveal the high performance of the machine when compared to manual labour. Nevertheless, misjudgment by the machine operator can contribute to reduce production in the future because the first and second year cones can be detached. The trials also reveal that machine developments should be oriented towards a sensor-based information system to help the operator adapt power input to optimize pine cone detachment.

**What difference can the local level trade in non-timber forest products make to rural livelihoods and poverty in South Africa? Evidence from four case studies.** Shackleton, S. (*Rhodes University, South Africa; s.shackleton@ru.ac.za*), Campbell, B. (*Centre for International Forestry Research, Indonesia, and Charles Darwin University, Australia; b\_campbell@site.ntu.edu.au; b.campbell@cgiar.org*).

What role can non-timber forest products play in the efforts to reduce poverty and vulnerability? Recent commentary suggests that the potential for forest products to play a significant role in poverty alleviation is mixed and ambiguous, with some observers being quite optimistic while others hold a counter view. This paper explores the livelihood contributions and poverty alleviation potential of four locally traded products (woodcraft, reed mats, traditional brooms and a beer made from the fruits of *Sclerocarya birrea*) from a semi-arid savanna area in South Africa. The results show that much depends on how poverty is defined and interpreted, and on whether the role of these products is assessed from a holistic livelihood perspective that includes notions of vulnerability, alternatives and choice, diversification and the needs of rural producers themselves. Overall, the products studied were key in enhancing livelihood security, but generally were unlikely, on their own, to provide a route out of poverty. However, there were notable exceptions, with marked variation evident between products and individuals. The risk-reducing role of the local trade is afforded added significance when viewed within the broader poverty context in South Africa, especially the rising levels of unemployment and HIV/AIDS, and the absence of alternative income-earning opportunities.

**Who can shoulder forestry management in Japan?** Tarumi, A. (*Forestry and Forest Products Research Institute, Japan; tarumi@ffpri.affrc.go.jp*).

By the law and the systems established in the 1990s, the terms of employment for the forestry workers have changed since the early 1990s in Japan. There has been an increase in the number of applicants for forestry work since the latter half of 1990s. However, it is very difficult for the newcomers to maintain high-quality employment because of decreases in timber prices and the associated decrease in forestry business. In this study, I categorized 105 forestry

enterprises that have been commended by the Forestry Labor Securing Support Center from 1991–2003, and compared these with enterprises and NPOs that recently started business. As a result, I suggested four elements in order to realize better management of forestry enterprises and NPOs in terms of forestry employment: 1) the relation of forest policy, 2) man-made forest rate, 3) age class composition, and 4) regional economy.

## **Wood production in agroforestry and in short-rotation forestry systems—synergies for rural development (B)**

Organizers: Lars Christersson *SLU, Sweden*; [Lars.Christersson@lto.slu.se](mailto:Lars.Christersson@lto.slu.se), and Swoyambhu Man Amatya *Ministry of Science and Technology, Nepal*; [fsdamatya@wlink.com.np](mailto:fsdamatya@wlink.com.np)

**ASEAN-Korea Environmental Cooperation Project (AKECOP) agroforestry regional research.** Lee, D.K. (*Seoul National University, Republic of Korea*; [leedk@plaza.snu.ac.kr](mailto:leedk@plaza.snu.ac.kr)), Rebugio, L.L. (*University of the Philippines Los Banos, The Philippines*; [lucreb@laguna.net](mailto:lucreb@laguna.net)).

The ASEAN-Korea Environmental Cooperation Project (AKECOP) on 'Restoration of Degraded Forest Ecosystem in Southeast Asian Tropical Region' is a five-year project launched in July, 2000. It is a fitting response to the challenge of forest restoration and biodiversity conservation in the region. It aims to contribute to the sustainable and equitable management of the tropical forests of ASEAN countries through partnership in research and capacity building, and in scientific and information sharing. One of AKECOP's regional research activities is agroforestry, and currently five of the eight ASEAN participating countries are involved. These countries believe that agroforestry is an appropriate strategy for restoring the productivity of tropical forest ecosystems, particularly in Southeast Asia. This paper highlights the activities and results of AKECOP's regional agroforestry experiments and action-research in Indonesia, Lao PDR, Philippines, Thailand and Vietnam. The research results could provide useful insights for effective agroforestry policy formulation and program development in the region.

**Development of tree plantations in Australia.** Parsons, M. (*Bureau of Rural Sciences, Australia*; [mark.parsons@brs.gov.au](mailto:mark.parsons@brs.gov.au)).

Australia's forest plantation estate is expanding, exceeding 1.7 million ha in 2004. Most plantation development until the 1980s used exotic softwood species. Most of the recent expansion has been in hardwood plantations, mainly eucalypts, which now exceed 0.7 million ha. The market and government policy factors and major sources of finance supporting plantation expansion are outlined. Most of the hardwood plantations established recently are planned to be grown on 10–15 year rotations and intended for pulpwood production. There is some interest, mainly from governments, in growing eucalypt plantations to supply sawlogs to replace supplies from natural eucalypt forests. However, only a small proportion of eucalypt plantations are thinned and pruned to enable sawlog production. There is also interest in the potential for tree plantations in low rainfall areas for wood production and environmental benefits, especially salinity control. Recent development of tree plantations has been mainly on agricultural land with species previously little used for plantation forestry in Australia. This has led to a range of technical, social and economic issues. Plantation development has therefore depended on research into genetic selection and breeding, matching species with climate and sites, silvicultural management, nutrition and pest and disease management. There is significant concern in some rural areas about the real or perceived social, economic and environmental impacts of plantations. Water use by plantations and the impact of reforestation on catchment water yield has recently become a major issue. These issues are discussed briefly with respect to the potential impact on further substantial plantation expansion.

**Hybrid poplar in North America: plantation management for multiple goods and services.** Stanton, B. (*GreenWood Resources, USA*; [bstanton@greenwoodresources.com](mailto:bstanton@greenwoodresources.com)).

In the last twenty years, North America has seen a tremendous increase in the acreage brought under *Populus* cultivation. The main poplar-growing regions are the north central, lower Mississippi River Valley and the Pacific northwest regions of the United States and the prairie provinces of western Canada. Some of the principal pedigrees upon which these plantation programs rely are *P. x generosa*, *P. x canadensis*, *P. tremuloides* x *P. tremula* and *P. deltoides*. While still a minor component of the overall forest industry of the United States and Canada, short rotation intensive culture *Populus* plantations are increasingly becoming important for a significant range of wood products including chips for papermaking, logs for the veneer, molding, cabinetry and furniture industries and biomass for energy generation. Many operations are vertically integrated into value-added manufacturing processes as an indispensable resource. Other plantation operations are stand-alone entities and, consequently, are now developing

higher-value, multiple markets to increase profitability. Also of note is the range of environmental services now provided by *Populus* that encompass the land-application of municipal and industrial effluent, phyto-remediation of contaminated soils and streamside plantings to filter fertilizer residues from agricultural runoff.

## **Current issues in forest products marketing and business management**

Organizer: Richard Vlosky *Louisiana State University, USA; RVlosky@agcenter.lsu.edu*

**Wood and the need for forest certification: a survey of perceptions in the Australian wood supply chain.** Bigsby, H.R. (*Lincoln University, New Zealand; bigsbyh@lincoln.ac.nz*), Ozanne, L.K. (*University of Canterbury, New Zealand; lucie.ozanne@canterbury.ac.nz*).

The environmental concerns of customers in the Australian wood supply chain may affect the consumption of wood products. In order to explore this hypothesis, a multi-part study of customers in the Australian wood supply chain was conducted to explore perceptions about environmental aspects of wood and other building materials. The customers included in the study are those who are in the value chain for wood products, and who have a role in creating or translating demand from final consumers, including specifiers such as architects and builders, building products retailers and furniture manufacturers. The study found that these intermediate customers generally believe that wood is more environmentally friendly than other building materials, including steel, concrete, masonry and plastic. However, about 30% of architects and 20% of builders and retailers have avoided using some building material, including wood, for environmental reasons. In addition, intermediate customers are generally aware of, and have a preference for, certified wood products. There is also a strong preference for using or stocking certified wood products, particularly for architects and building products retailers.

**A review of competitive strategies and financial performance of furniture manufacturers.** Gazo, R. (*Purdue University, USA; gazo@purdue.edu*), Quesada, H.J. (*Institute of Technology of Costa Rica, Costa Rica; henquesada@itcr.ac.cr*).

This presentation reviews competitive strategies and financial performance of furniture manufacturers, both domestic and those exporting to the USA. Customer satisfaction, price, innovation and shareholder satisfaction are the main critical success factors defined by publicly held US furniture manufacturers. A mix of cheap labour, modern technology, access to raw materials, know-how and favorable exchange rates give a competitive edge to overseas competitors, as compared to US furniture manufacturers. The most critical financial factors when measuring company performance were liquidity, operating efficiency and capital turnover. Results show that companies from North America and Europe have better performance in terms of capital turnover than companies from South Asia. When looking at trends in performance by regions it was found that while South Asia is still lagging in performance, it is catching up with North America and Europe. In terms of furniture industry sectors, the kitchen cabinet sector has more positive trends since 1997 in all three performance measures than household furniture and institutional furniture sectors.

**An analysis of international marketing strategies formulation: the development of a model.** Leodoro da Silva, J.C.G., da Costa Santos, R., Martins, G. (*Federal University of Paraná State, Brazil; garzel@ig.com.br*).

This paper is made up of two components: 1) a model for explaining the dynamics of formulation of international marketing by firms, and 2) the application of the model in the pulp and paper sector in Brazil. For making possible the development of this model, a number of previous theoretical propositions had to be analyzed in order to build a comprehensive background for this study. The data for the empirical component of this research was generated from Brazilian firms exporting paper and pulp. Data were gathered through question sheets, addressed to the top managers of these firms, on which the perception concerning the various variables used for this analysis were evaluated.

**Wood products suppliers' value creation in business relationships: a conceptual framework.** Owari, T. (*Hokkaido University, Japan; owari@for.agr.hokudai.ac.jp*), Juslin, H., Berghäll, S. (*University of Helsinki, Finland; heikki.juslin@helsinki.fi; sami.berghall@helsinki.fi*).

The concept of value has been of extensive interest among both marketing researchers and practitioners. A growing number of researchers are considering value as a constituent of relationship marketing that is becoming relevant in the global forest industry. Business relationships are of pivotal importance for value creation, which is regarded as the essential purpose for a supplier and a customer engaging in a relationship. The majority of current value research in

industrial marketing has been conducted from a customer's perspective. The authors argue that it is equally meaningful to analyze how suppliers create value for their customers and what value suppliers gain through the customer relationships. After a literature review, this study developed a conceptual framework of suppliers' value creation in business relationships. The framework aims to examine how supplier's value proposition relates to supplier-received value in business relationships. The independent variable, value proposition, is generally defined as value that suppliers intend to deliver to the customers. The dependent variable is value that suppliers receive from the customers. Further, this framework includes the intervening effects of two relationship variables, customer trust and commitment. The authors intend to apply this framework for analyzing supplier-customer relationships in the wood products industry.

**Trends in the wood construction materials market in Japan and the response of the Japanese sawmill industry: outline of market changes in the 1990s.** Shimase, T. (*Forestry and Forest Products Research Institute, Japan*; [shimase@ffpri.affrc.go.jp](mailto:shimase@ffpri.affrc.go.jp)).

This study shows that the response of the Japanese sawmill industry to changes in wood construction materials market has a diversity. The demand for wood construction materials in Japan is diverse. For instance, Japanese post-and-beam construction (a typical Japanese building method) requires numerous types and sizes of sawn timber including posts, beams, studs, rafters and boards. Moreover, the applications for Japanese post-and-beam construction are themselves diverse, ranging from 'farm houses' to 'rationalized construction'. The former still maintain their traditional style, while the latter makes use of parts, for example, wall units and floor units, pre-assembled at a factory. This diversity of demand is related closely to developments in the Japanese sawmill industry. Major changes took place in the wood construction materials market during the 1990s. One example was the spread of glued-laminated timber and structural panels, that resulted in the Japanese sawmill industry reducing production. The response of the sawmill industry varied according to operational scale. Larger sawmills tried to compete by supplying high-grade, mass-produced sawn timber, while the number of smaller sawmills reduced sharply, with some of them forming local networks in cooperation with forest owners, architects and small-scale house builders.

**Evaluating markets for environmentally certified lumber in US home centres?** Smith, R., Gomon, S. (*Virginia Tech, USA*; [rsmith4@vt.edu](mailto:rsmith4@vt.edu)).

This research examined consumer purchasing decisions for environmentally certified forest products. Consumer purchasing was examined based on two different levels of promotion and price for red oak and yellow poplar S4S boards in twelve home centers throughout the southeastern United States. Consumers were surveyed upon completion of their purchase of S4S boards. Sales volume and the percent of certified lumber sold compared to total unit sales for all S4S oak and poplar boards were used as the dependent variables. In addition, this research compared demographic factors of green consumers from previous research to those from this study. An increase in the price did not have an affect on sales purchases. This suggests that price appears to be somewhat inelastic. Point of Purchase Promotion materials did not have an effect on the purchase decision. An examination of consumers' perceptions of certification showed that consumers may misunderstand the term as the forest products industry defines it. Consumers linked certification less with environmental issues, and more as a measure of quality excellence. One of the most striking results of this research was discovering the relatively inelastic price level for S4S certified hardwood lumber. Price premium was not found to be statistically significant in any of the tests.

## **Sub-theme: Involving Indigenous Groups in Forest Science and Forestry**

### **Involving indigenous groups in forest science and forestry**

Organizer: John L. Innes, *University of British Columbia, Canada*; [john.innes@ubc.ca](mailto:john.innes@ubc.ca)

**Now that Paiute forestry is respectable.** Trosper, R. (*University of British Columbia, Canada*; [Ronald.Trosper@ubc.ca](mailto:Ronald.Trosper@ubc.ca)).

One hundred years ago, the practice of light burning of forests in the USA was dismissed as 'Paiute Forestry'. Now that fuel accumulations have reached frightening levels and fear of catastrophic fire has increased, 'Paiute Forestry' has been accepted as sensible sustainable forest management policy. Forest scientists must deal with the consequences of previous ignorance and exploitation. Having provided justification for dangerous and destructive forest practices, associated with uncompensated transfer of resources from indigenous peoples to other peoples, now scientists appear to desire to mine the knowledge as well. Indigenous peoples, however, have learned from experience. Now research protocols, publication processes and community participation in utilization of results all must be addressed. They have been addressed by many indigenous communities. The key idea is reciprocity, which at a minimum means negotiating a fair material exchange. Fairness in intellectual exchange is also required. To achieve reciprocity and consequent indigenous participation, some academic traditions must be re-examined and changed. Because of the growing recognition that context matters for knowledge, a new foundation has been established to facilitate the agreements needed to allow recognition, appreciation and enhancement of 'Paiute Forestry'.

**Indigenous people in forestry and forest science: Identifying opportunities and constraints in some groups in Ecuador.** Montenegro, F. (*Fundación Forestal Juan Manuel Durini, Ecuador*; [funfores@hoy.net](mailto:funfores@hoy.net)).

Themes related to indigenous knowledge and the people living in the forests with forestry science are treated, placing them in the perspective of the nucleation process of mankind in societies and of the knowledge construction process. I examine the similarities and differences between Traditional and Scientific Knowledge, of the relationship between Man and forest and the evolution of today's use aimed at satisfying their needs. I then contrast these with the challenges that today's increasingly populated world demands, globalized and informed, when ethnic groups with their traditional knowledge mix with other groups. The valuation of forestry traditional knowledge, the identification of the problems and the teaching of forestry sciences to ethnic groups can give different opportunities to recognize, integrate, investigate, maintain and develop their own traditional knowledge.

### **The state of scientific and indigenous knowledge and dissemination of non-timber forest product classification and utilization**

Organizer: Jim Chamberlain *USDA Forest Service, USA*; [jachambe@vt.edu](mailto:jachambe@vt.edu)

**Mushrooms, trees and money: Value estimates of commercial mushrooms and timber in the Pacific Northwest (USA).** Alexander, S.J. (*USDA Forest Service, USA*; [salexander@fs.fed.us](mailto:salexander@fs.fed.us)), Pilz, D. (*Oregon State University, USA*).

Some information exists about the value of commercially harvested wild edible fungi in the Pacific Northwest. Prices for wood products are well documented. Little information exists, however, about the joint production of, and values for, wild edible fungi and other forest resources such as trees. There is also little known about the value of recreational mushroom harvesting. Case studies illustrate the information needed to determine production and values for three commercially significant wild mushroom species in various ecoregions in the Pacific Northwest, and present net values for wild edible fungi and timber in different management regimes are outlined. These values are site specific. In addition, values for recreational harvest of wild edible fungi in south-central Washington state are also discussed. Economic comparisons of the value of timber and mushrooms are sometimes used as arguments for whether or not forests should be logged. Rarely is the answer obvious from simple comparisons of these two forest products. Production economics is concerned with choices about how much and what to produce, with what resources. Values for joint production of forest resources are sensitive to assumptions about changes in forest management, yields for mushrooms and trees, and costs.

**Alaskan nontimber forest product opportunities.** Alexander, S.J. (*USDA Forest Service, USA; salexander@fs.fed.us*), Pilz, D. (*Oregon State University, USA*), Schroeder, R. (*USDA Forest Service, USA*), Smith, J. (*Forest Resource Enterprises, USA*), Freed, J. (*Washington State University, USA*).

Nontimber forest products have been harvested from southern Alaska for millennia as resources vital to the livelihoods and culture of Native Alaskans and, more recently, as subsistence resources for the welfare of all citizens. Many of these products are now being sold, and Alaskans seek additional income opportunities through sustainable harvest and manufacture of such forest resources. We discuss the unique legal, regulatory, land tenure and environmental context that southern Alaska presents for marketing nontimber forest products; summarize the various species and types of products being harvested; and consider the marketing challenges and opportunities new entrepreneurs will encounter. The information and resources we provide are intended to enhance income opportunities for all Alaskans, while sustaining the organisms harvested, respecting traditional activities and ensuring equitable access to resources.

**Indigenous knowledge for potential drug screening and commercialized products.** Faridah-Hanum, I. (*Universiti Putra Malaysia, Malaysia; fhi81@yahoo.com*).

There is a growing trend of resorting to natural products, including traditional medicines, owing to increased awareness of the harm of synthetic materials to man and his environment. The remaining forests in Malaysia cannot cope with the tangible needs of her people in the long term, hence there is a need for producing these natural products, commercially. A study was conducted in Ayer Hitam Forest, Selangor to extract the knowledge of indigenous people from the Temuan tribe on the use of plants around them, prior to the disappearance of people and forests. A total of 98 plant species with 140 uses were recorded and they were grouped into seven methods of application, namely drink, eat, chew, poultice, rub, bath and shampoo. Most of the species were the major sources of drugs for the indigenous community in the forest and they could be potential leads for drug screening and development of pharmaceutical products. Many species form the minor ingredients of a concoction of wider curative use. Other potential uses include the development of cosmetic and nutraceutical products.

**The state of global research concerning construction materials made from bamboo.** Fu, J. (*International Network for Bamboo and Rattan, China; jfu@inbar.int*).

Bamboo is the most important construction material among non-wood forest products (NWFPs). Due to its easy availability and good mechanical properties, raw bamboo has been widely used for a long time for construction materials in tropical and subtropical regions. Bamboo has also been studied for its durability, jointing characteristics and design features. After two decades of use in industrial development and a shortage of timber, generally, bamboo is more and more applied in construction materials such as concrete forms, flooring, mouldings, ceilings, walls, doors, windows, etc. Presently, in China, bamboo concrete forms amount to one third of the total concrete form market and is exporting to neighboring countries, and possibly to Europe. Bamboo concrete forms have the advantage of high strength, high elastic modulus, good durability and low cost. Bamboo flooring has good properties like hardwood flooring and has been accepted by consumers in Asia, Europe and America. This paper will review construction materials derived from both the traditional- and modern bamboo.

**Flowering time and frost damage risk to *Vaccinium myrtillus*, the common Blueberry, in Finland 1898–2000.**

Heinonen, J., Häkkinen, R. (*Forest Research Institute, Finland; jaakko.heinonen@metla.fi; risto.hakkinen@metla.fi*).

In some years, spring frost damage of the flowers of the Blueberry, one of the most important wild berries in Finland, reduces the yield considerably. The data for this study are the phenological observations that have been gathered systematically in Finland for more than a hundred years. The time series of blueberry flowering in different parts of Finland and the temperature records of the Finnish Meteorological Institute were used to analyze changes in the flowering time and in the risk of frost injury over the years 1898–2000. A model based on the threshold value of the temperature sum adequately explains the differences in flowering time in consecutive years. The monthly mean spring temperatures increased almost linearly during the study period. The increasing rate of temperature accumulation causes the average threshold value of flowering to be reached, at the end of the period, more than one week earlier than at the start of the period. However, the threshold value of blueberry flowering increased during the study period and there was no trend in observed flowering dates. The risk of frost damage to flowers was higher if flowering took place early in spring, but there was no trend in the risk.

**The state of global research concerning edible forest products.** Lee, S.S. (*Forest Research Institute Malaysia, Malaysia; leess@frim.gov.my*), Salo, K. (*Finnish Forest Research Institute, Finland*).

Asia is the world's largest producer and consumer of non-wood forest products (NWFP) of which edible forest products make up a significant proportion. There are a wide variety of edible forest products ranging from fruits, berries, nuts, mushrooms, spices and herbs, 'forest drinks', wild vegetables such as ferns, flowers, shoots, leaves, roots, tubers and bulbs,



to oil, wild honey and bushmeat, including insects. In many countries, local forest communities collect and harvest edible forest products on a subsistence level but some countries like China and India, harvest and export large quantities of edible forest products, such as nuts and certain mushroom species. Until recently, most research on edible forest products was focused on wild edible mushroom ecology and management of wild mushroom harvests, particularly in North America, as well as of wild berries in Scandinavia and Europe. Depleting forest resources and increased awareness of the importance of edible forest products to local and rural communities has spurred recent interest in edible forest products research, particularly in Asia. Generally, information on the exploitation, management, consumption and trade of edible forest products is difficult to obtain for many countries, perhaps a reflection of the little research that has been carried out.

**Wildfood fruit processing in the Cordillera Administrative Region.** Lopez, A.V.B., Maddumba, H.A. (*Department of Environment and Natural Resources, Cordillera Administrative Region, The Philippines; erds-car@mozcom.com*).

The Philippines is known for its diverse plant species. Many of these plants which abound in the forest are considered wildfood, thriving under various ecological conditions. A proper assessment of these plants holds much promise in providing additional food requirements for the growing population, aside from promoting their conservation for future generations. During the peak season of production, it was observed that much of these fruits were being wasted. To avoid wastage, it is imperative that these fruits be properly processed and utilized. The appropriate processing techniques of some of the most abundant wildfood fruits in the Cordillera were tested. These fruits could be processed into different consumable products such as wine, vinegar, candies, jellies and pickles. Acceptability of these products was assessed through taste tests conducted by different types of clientele such as professions, non-professionals and students. Taste tests revealed the acceptability of all processed wildfood products. Possible markets for the products were noted during trade fairs and other occasions, during which the processed products were displayed.

**Failure mode and microscopic failure of *Dendrocalamus asper* (bamboo: buloh betong) loaded in tension and compression.** Mansur, A., Bahari, S.A., Jamaludin, M.A. (*Universiti Teknologi MARA, Malaysia; mansur628@salam.uitm.edu.my*).

The strength of small clear specimens of *Dendrocalamus asper* (Bamboo: Buloh Betong) was tested by determining the mode of failure when they were loaded in tension and compression parallel to the grain. Comparison of the mode of failure at different culm portions, and between internodes and nodes were made. The modes of failure were identified through visual examination of the tested sample and were further examined under the microscope. Both tension and compression tests exhibited two modes of failure. In tension, the modes of failure were in brash tension and splintering tension, while the test in compression exhibited a mode of pure compression. Stem strength was related to the modes in tension and compression, and was not significantly different between the bottom-, middle- and top portions. Between nodes and internodes, strength properties were not significantly different. When observed for microscopic failure at the internodes, the failure occurred primarily in the parenchyma region, especially in the radial direction. However, failure at nodes occurred in both vascular bundles and the parenchyma region.

**Fallow-based non-timber forest species of southern Cameroon.** Ngobo, M., Weise, S. (*IITA, Cameroon; m.ngobo@cgiar.org; s.weise@cgiar.org*).

Due to the loss and degradation of natural forests, the importance of fallow systems as sources of non-timber forest products is increasingly acknowledged in the humid forest zone of southern Cameroon. A survey was conducted to ascertain whether differences in resource use intensification in the area were reflected in the type, distribution and abundance of plant species that local farmers value across different fallow classes. Of specific interest was local farmers' identification of key useful fallow species and their various uses. Farmers identified more than 170 useful species of various life forms on farm lands of various age, from which about 58% are found in fallow lands of less than 10 years old (long fallows providing approximately 48% of plants used by farmers in the region). Although various other uses were reported, farmers mostly make use of fallow species in traditional medicine. Although the human utilization of plant species varied between areas and fallow types, the results of this study demonstrated the importance of fallows, and particularly of short fallows in the socio-economic and cultural lives of small-scale rural farmers. These findings provide the major rationale for identifying fallows as individual land use systems with high potential.

**Propagation and conservation of NTFPs: Medicinal plants through *in vitro* culture.** Roy, S.K., Pinaki, S., Sayeed Hassan, A.K.M. (*Jahangirnagar University, Bangladesh; pinakiju@yahoo.com*).

We established protocols for mass propagation of NTFP: three endangered medicinal plants, *Rauvolfia serpentina*, *Gloriosa superba* and *Smilax zeylanica* through *in vitro* shoot tip culture. For shoot induction in *R. serpentina* and *S. zeylanica*, MS basal medium supplemented 1.5 mg/l BAP + 0.5 mg/l NAA and 1.5 mg/l BAP + 0.2 mg/l NAA were

required, in which 95% and 92% cultures regenerated shoots with 3.9 and 6.1 shoots per culture, respectively. Whereas for *G. superba*, B5 basal medium with 0.5 mg/l BAP + 0.5 mg/l Kn + 0.2 mg/l NAA was needed, in which 82% cultures regenerated shoots with 4.4 shoots per culture. Repeated subcultures in the same nutrient medium mentioned above, resulted in rapid shoot multiplication with 25 shoots per culture. For further development of the medium, casein hydrolysate (CH) (50–200 mg/l) and coconut milk (CM) (5–20%) were added individually or simultaneously to the medium for all three species. In vitro propagated shoots rooted on half strength MS medium with auxin. The survival rate of regenerants of *G. superba* was 42%, whereas those of the other two species were 85–90%. The technique described here is a promising method for propagation for sustainable use and conservation.

**Annual forecast and inventory system of wild berry yields in Finland.** Salo, K. (Finnish Forest Research Institute, Finland; [kauko.salo@metla.fi](mailto:kauko.salo@metla.fi)).

A forecast and an inventory system for the most economic and popular berry species, cowberry (*Vaccinium vitis-idaea*), bilberry (*V. myrtillus*) and cloudberry (*Rubus chamaemorus*) occupying various forest site types, began in 1997. The research project is based on a nationwide observation network, consisting of 220 forests and peatlands, including 1100 permanent sample plots. Observations on productivity of each species were sent to the Joensuu Research Centre for data analysis and map publication. Between 1997 and 2004, bilberry yield varied from 84 to 270 million kg and cowberry yield varied from 103 to 227 million kg. The citizens of Finland have the right of free access to outdoor areas, where they can pick wild berries and mushrooms. Two million people, 40 % of the Finnish population, pick berries and mushrooms as a very popular hobby and for supplementary income, and there is considerable demand for yield forecasts and theme maps. The value of wild berries picked on mineral soils and peatlands in a good crop year was calculated to be \$84 million and \$39 million in a poor year.

**Herbicidal potential of lemon-scented eucalypt (*Eucalyptus citriodora*) volatile oil against forest weeds.** Singh, H.P., Batish, D.R., Kaur, S., Kohli, R.K. (Panjab University, Chandigarh, India; [hpsingh\\_01@yahoo.com](mailto:hpsingh_01@yahoo.com); [harminderpal@yahoo.com](mailto:harminderpal@yahoo.com); [daizybatish@yahoo.com](mailto:daizybatish@yahoo.com); [kaur\\_shalu@yahoo.com](mailto:kaur_shalu@yahoo.com); [rkkohli45@yahoo.com](mailto:rkkohli45@yahoo.com)).

Throughout the world, large amounts of synthetic herbicides are used to manage weeds. However, due to their residual activity and the linked toxicological and environmental effects, efforts are being made to search for natural products with herbicidal activity. Natural plant products possess different target sites of action, compared to synthetic herbicides, thereby helping to overcome the problem of increasing herbicidal resistance among weed species. Among natural products, volatile oils possess a wide spectrum of biological activity, including phytotoxicity that can be exploited. Volatile oil from a lemon-scented eucalypt (*Eucalyptus citriodora*), known for its insecticidal activity, was evaluated for possible herbicidal potential against invasive forest weeds viz. *Ageratum conyzoides*, *Lantana camara* and *Chromolaena odorata*. Volatile oil had a profound effect on the growth, development and photosynthetic ability of the target weed species. These caused visible injury on the plants such as necrosis or chlorosis, gradually leading to their complete death. The action of the oils was similar to that of the herbicide, glyphosate. Based on these observations, it is concluded that eucalypt oils possess weed-suppressing ability and can be used as a bioherbicide for the management of weeds.

**Products obtained from the foliage of *Pinus douglasiana* Martinez and *Pinus oocarpa* Schiede in the Western Mountain range of Mexico.** Toledo, S.L., Gallegos R., A., Ochoa, H.G. (University of Guadalajara, Mexico; [sltg@cencar.udg.mx](mailto:sltg@cencar.udg.mx); [gra09526@cucba.udg.mx](mailto:gra09526@cucba.udg.mx); [hochoa@dmcyp.cucei.udg.mx](mailto:hochoa@dmcyp.cucei.udg.mx)), Betancourt, Y., Cordero, E., Orea, U. (University and Pine of the River, Cuba; [betancourt@af.upr.edu.cu](mailto:betancourt@af.upr.edu.cu); [ecordero@af.upr.edu.cu](mailto:ecordero@af.upr.edu.cu); [orea@af.upr.edu.cu](mailto:orea@af.upr.edu.cu)).

The present economic situation forces developing countries to try to take maximum advantage of their natural resources, and make optimal use of all forest products. Tree harvesting in Mexico is an industry that produces large volumes of foliage that, once processed, become an important group of substances that have the potential to generate biological activity. The potential offered by foliage of forest species like the pines, following cutting, is that it becomes a source of raw material for products such as essential oils, chlorophyllin of sodium, chlorophyll paste, carotene, waxes, forage, concentrated provitamins, concentrated fatty acids and resins. The foliage is of great importance for the forest industry, offering alternatives for a variety of products of high added value. The foliage of these pines has been used, empirically, for medicinal and nutritional purposes by the rural communities in Mexico and other countries. With this work, the technological foundations will be laid to establish in the region, an extractive company to process the foliar biomass of pines.

**Sustainable bark harvesting for medicinal use: Experimental strip harvesting from the southern Cape forests, South Africa.** Vermeulen, W.J. (South African National Parks, South Africa; [wesselv@sanparks.org](mailto:wesselv@sanparks.org)), Geldenhuys, C.J. (ForestWood cc, South Africa; [cgelden@mweb.co.za](mailto:cgelden@mweb.co.za)).

In South Africa bark harvested from selected tree species in forest and woodland is a commonly used traditional medicine. This practice became highly commercialized due to increasing urbanization, resulting in the over-exploitation of some

target species and posing a major challenge to forest managers. An experimental bark-harvesting project was initiated in 2000 in the southern Cape forests to develop yield regulation systems and best practices for bark harvesting. *Ocotea bullata*, *Curtisia dentata* and *Rapanea melanophloeos* were selected for the study as they are highly in demand and well represented in the southern Cape forests. During mid-summer and mid-winter, vertical strips of bark, 1m in length and of different widths, were removed from trees of size classes  $\geq 10$  cm DBH. Recovery rates through edge and sheet growth, presence of pinholes, fungi and crown dieback were recorded every six months. The results showed a differential response of the species, with good recovery from *O. bullata* through edge growth, fair recovery from *C. dentata* through sheet growth, but little response from *R. melanophloeos*. The project has since been expanded to other forest and woodland species in Southern Africa. Management strategies need to be different for the different species.

## **Indigenous peoples and commercial enterprises in forestry**

Organizer: George Hoberg *University of British Columbia, Canada; hoberg@interchg.ubc.ca*

**Forest-based commerce within a broad spectrum production system in eastern Indonesia.** Fowler, C.T. (*University of Hawaii – Hilo, USA; cynthiafowler@gmail.com*).

On the western tip of the island of Sumba in eastern Indonesia, the Kodi people manage a broad spectrum production system that includes forestry, horticulture, animal husbandry, hunting and gathering land and marine resources. Overall, the production system has multiple outcomes relating to household subsistence, the market economy, tenure and culture. In the forestry sector, the people engage in the trade of a variety of tree products ranging from fruits to fiber to wood plus other, non-timber forest products. In this paper, I describe forest management, market activities and social organization in Kodi society. The analysis of forest-based enterprises draws from the principles of forestry and ethnographic records of the people's natural resource management and economic strategies. I examine linkages among forests and other parts of the landscape under different kinds of management and the relationships between forest-based commerce and other agricultural sectors to illustrate the integration of forestry with other forms of production in an indigenous economy and society. The diversity of resources and management practices encompassed within eastern Indonesian economies constitute dynamic, hybrid systems that fulfill multiple needs and enable local communities to adapt to changing economic and political circumstances.

**Involving indigenous groups in forest science and forestry: an empirical study in tribal India.** Singh, M. (*India; monikaxing@yahoo.com*).

Tribal lifestyle is either seen as utopian or completely destructive when seen from the conservation point of view. On the other hand, established sustainable management methods are based on forest science. It is seen that communities accepted and followed conservation practices, sometimes by modifying their lifestyle, but not necessarily altering it completely, as advised in scientific forest management. Doing so in an accurate and acceptable manner, greening of degraded forestlands and bare patches of hills ensued. The participatory approach adopted was successful. For example, this included holding participatory meetings, selection of species that are indigenous to the area and also those having significance in the cultural lives of tribal people. Indigenous people have protected their surrounding forest lands, shifting from their own ways of life and devising their own ways of effective preservation. The poster illustrates the process of this change in tribal lifestyle by involving them in forest science and forestry in Western India. Examples of visible changes in lifestyle include housing, fuel wood collection, forest protection, various ceremonies, etc. This longitudinal study over a five-year span also suggests a replicable strategy for other areas where indigenous people reside.

**Finding the right way: Community-based small-scale forest enterprise development with Melanesian customary landowners.** Streil, M. (*Pacific-German Regional Forestry Project, Fiji Islands; markuss@spc.int*).

The Pacific-German Regional Forestry Project assists some Pacific Island countries and their indigenous landowners to apply sustainable natural forest management. In selected model sites, the project facilitates all processes of the community forest enterprise development, and at the same time is generating information for one of the project's final outputs: a Manual for Community Forestry Initiatives. A field facilitator coaches rural villagers in finding their own best approach, through participatory processes such as: participatory rural appraisal (PRA); forest resources inventory; selective harvesting regimes; forest and land use planning; market analysis; and development of forest product enterprise. Main conclusions to date are: participatory forest and land use planning can balance commercial and traditional requirements; cultural and subsistence commitments and traditional attitudes can hinder efficient enterprise operations, and attitudes towards work need to be commercialized; enterprise and community development with traditional management needs separate entities

and structures to avoid friction; pooling resources and efforts and working together makes landowner enterprises more competitive; rural villagers can manage modern user-friendly technology when effective on-the-job-training and coaching is provided; long-term advisory services or coaching needed to sustain initiatives can be provided by an associated central marketing and training facility with support from existing service providers.

**First Nations and commercial enterprises in forestry in Canada: Conditions for success.** Trosper, R., Nelson, H., Hoberg, G. (*University of British Columbia, Canada; ron.trosper@ubc.ca*).

This paper uses survey information to examine several common assertions about the institutional prerequisites for success when a First Nation and a private company join together in an economic enterprise. Is it true that a separation of day to day business management from political influence is necessary? Is it true that goals for both partners need to be clearly articulated, or in agreement? Does management leadership need to be stable, particularly on the side of a First Nation Band or Tribal Council? On the other hand, is business success more readily explained by reference to fundamental economic variables, such as the size of a business and the stability of its wood supply? In the winter of 2004–2005, we interviewed managers on both the First Nations and private sides of joint ventures in Canada to determine what affected their recent profitability experience. We report results of a multivariate analysis of the responses.

**Examining the linkages between conservation initiatives, land-use decisions and forest cover within protected areas: A study of the Community Baboon Sanctuary, Belize.** Wyman, M.S., Stein, T.V. (*University of Florida, USA; mwyman@ufl.edu; tstein@ufl.edu*).

The Maya Forest's natural and cultural resources are today threatened by colonization, a lack of viable socio-economic alternatives to traditional shifting agriculture and illegal logging. In an effort to protect these resources and provide for local populations, conservation initiatives are increasingly including economic development; the Community Baboon Sanctuary (CBS), Belize is one such example. Established in 1985, the CBS consists of seven Creole communities comprising 4800 ha and protects one of the few black howler monkey populations (*Alouatta pigra*) in Belize. Created with local NGO support, CBS landowners have been active in ecotourism and a voluntary pledge to leave forested corridors that provide habitat for howler populations, the main ecotourism attraction. Little is known, however, about the linkages between pledge compliance, ecotourism participation, land-use decisions and forest-cover. At both the individual landowner and landscape levels, this research examines these relationships. Methods include an analysis of socio-economic and ecological factors that influence land-use decisions, an evaluation of perceived costs and benefits to the CBS and ecotourism participation, and a Land-Use Land-Cover Change (LULCC) spatial and temporal analysis using remote sensing and satellite imagery. Collected data on land-use and forest-cover within the CBS will provide base-line data for future evaluation and management.

**'Forestry' for indigenous peoples: Learning from experiences with forest industries**

Organizer: Sue Feary *Australian National University, Australia; sue.feary@anu.edu.au*

**Local institutions and indigenous forest management practices in the Indian Himalayas: A case for linking traditions with technology.** Gupta, H.K. (*Forest Survey of India, India; ghemant\_sml@hotmail.com*), Joshi, M. (*University of Horticulture & Forestry, India; joshi\_manoj1@rediffmail.com*).

Sustainable forest management of pristine forest resources of the ecologically sensitive Himalayas contributes significantly towards ecological stability and the economic development of the area. Examples of traditional systems of management by indigenous local institutions of commercially important forest products yielding edible pine nuts, cumin, morels, medicinal plants, grasses and willow coppice management are discussed. Local institutions play an active role in regulated collection and distribution of these forest products. Traditional initiatives and systems in the participatory and regulated forest products by indigenous communities have implications for policy support and sustainable livelihoods through income generating activities, due to increased pressure on forest resources. All these necessitate strengthening of management practices such as collection, storage and processing of superior propagules, establishment of high quality nurseries, improved plantation technology and value addition of produce through modern post harvest handling techniques, and above all the sensitization of forest dwelling communities in protection and conservational efforts. The analysis of indigenous systems of management through local institutions reveals strong positive relationship between social capital and natural resource management at grass root levels. The importance of indigenous technological knowledge in the socio-economy of the mountain people and need to link it with improved technology and practices is highlighted.

**Maori connections to forestry in New Zealand.** Miller, R. (*Ministry of Agriculture and Forestry, New Zealand; robert.miller@maf.govt.nz*).

Maori connections to forestry and forest land in NZ are strongly cultural and spiritual, as well as commercial. Maori own over 400,000 ha of indigenous forests (7%) and some 238,000 ha of planted exotic forests (13%). These forests contribute significantly to Maori socio-economic development. Maori involvement in commercial forestry commenced over 40 years ago with the planting of pine forests under forestry leases involving the Crown, companies and Maori iwi. These forests are now maturing and Maori participation is moving from being principally a source of labour to a stronger commercial involvement. Currently, forestry comprises 10% of Maori's total asset base. This will grow as Maori take increasing ownership and control of their land and forests. The use of former State-owned forest assets to fund Maori claims under the Treaty of Waitangi could see Maori owning up to 41% of the planted forests in the future. The sustainable management of indigenous forests represents a new and growing opportunity for Maori, both for timber and non timber benefits. Maori owners are a very significant group within this part of the forestry sector.

**Forest futures: Indigenous timber and forestry enterprises on Cape York.** Taylor, D.W. (*Department of Primary Industries and Fisheries, Queensland, Australia; dave.taylor@dpi.qld.gov.au*), Annandale, M. (*Department of State Development and Innovation, Queensland, Australia; Mark.Annandale@sd.qld.gov.au*).

This paper describes development of small-scale sawmill operations in remote indigenous communities of the Cape York Peninsula (CYP), Australia, to supply timber to domestic markets and create local employment. The primary aim was to improve the economic and social well-being of indigenous people through culturally appropriate and sustainable development of forest resources. This paper outlines progress, methods and issues to date. At each of the communities involved to date, small, pilot scale, 'demonstration sites' have been established to evaluate and monitor the effects of harvesting and other silviculture techniques and practices applicable for sustainable forest management. Some initial inventory has also been carried out over the wider resource to quantify available resource and planning for future harvest and management is underway. Based on initial harvest sites, selected logs have been processed on a mobile sawmill and initial grading and testing of the processed timber carried out. Early results indicate a range of material is produced, some of which is suitable for structural purposes and other for landscaping and other purposes. The challenge is to develop this into a viable small business, managing the available forest resources sustainably and maintaining sawn timber supply to develop a reliable market. Successful development of these small pilot industries presents a major opportunity for indigenous involvement in Queensland's forestry industry.

**Indigenous peoples and forestry in Canada: What does "aboriginal forestry" really mean?** Wyatt, S. (*Université de Moncton, Canada*).

The last twenty-five years have seen Canadian First Nations seeking an increasingly significant role in the management of the country's forests. The wide diversity of Canadian experiences highlights several important issues that need to be addressed by forest planners, governments and indigenous peoples themselves. Existing forest management systems have developed reflecting the interests of governments and of the timber industry, and so participation in these systems poses many difficulties for First Nations. Aboriginal rights are formally acknowledged in treaties, in the Canadian Constitution, and in a series of legal judgements, but implementing these rights in forestry planning and harvesting has been slow. Business partnerships and other arrangements provide First Nations with new opportunities to share in economic development and in financial returns, but may also conflict with traditional values, knowledge and uses of forestlands. In response to these dilemmas, First Nations, foresters, policy makers and others are developing new approaches to improving participation and to making forest management more responsive to indigenous understandings of the forest and of forestry. These issues help us to consider what 'aboriginal forestry' could mean, and whether or not it is achievable.

## **Indigenous knowledge and biodiversity conservation**

Organizers: V.K. Bahuguna *Tripura Forest Development Corporation, India; bahuguna\_ifs@yahoo.com*, and Atul K. Gupta *Wildlife Institute of India, India; akg@wii.gov.in*

**Traditional knowledge on shifting cultivation and biodiversity conservation in Northeast India.** Gupta, A.K. (*Wildlife Institute of India, India; akg@wii.gov.in; akphayre@yahoo.com*).

Shifting Cultivation (*jhooming*) is being practiced in many tropical and sub-tropical countries, including India, for centuries. According to an estimate, *jhooming* adversely affects about 20–22% of the total forest cover in Northeast India annually. Many tribal communities are obligatorily dependent on this cultivation, not only for their economy, but

also for fulfilling their various social, cultural and traditional needs. Tripura (10,491 km<sup>2</sup>, 22° 57' – 24° 32' N – 91° 10' – 92° 20' E) is one of the seven northeastern states and supports 19 different tribal communities. All these tribal communities practice *jhooming* as one major livelihood source. There has been a general consensus among the conservationists that *jhooming* and biodiversity conservation may not exist together as the former leads to fragmentation and loss of habitat. However, an in-depth analysis of traditional *jhooming* reveals that with the use of indigenous knowledge, the traditional shifting cultivators never allowed this practice to become unsustainable. This paper presents a comparison between traditional and non-traditional *jhooming* processes to substantiate the above observation as a case study from Tripura.

**The role of indigenous knowledge in forestry assessment and monitoring in Uganda.** Kalwanyi Nanyunja, R., Baguma, T. (*Assessment of Impacts and Adaptations to Climate Change Project, Uganda*; rhobink@yahoo.com; bagumatim@yahoo.co.uk).

There is increasing concern about the deteriorating state of forestry in Uganda. This concern has led to the development of rapid biodiversity assessment approaches based on indigenous knowledge to provide information on biodiversity suitable for use in conservation planning and environmental monitoring. The study, which was funded by UNDP/GEF Cross-Border Biodiversity Project in Uganda and implemented on behalf of MUIENR, was carried out in the communities living in Moroto forest reserve and those living adjacent to the forest reserves of Sango Bay area in Northeastern and Southern parts respectively. It was meant to identify and select indicators for forest assessment and monitoring, and determine their trends from 1950 to 2001 using indigenous knowledge. The criteria for the selection of forest indicators were based on the following resource categories: resources whose alternatives cannot be obtained from outside the forest; medicinal and food plants; resources under considerable pressure from the people; sources of income; rare resources and large mammals. The major output was a forestry assessment and monitoring framework that indicated a loss of forest resources based on the selected categories between 1950 and 2001, mainly due to change in peoples' livelihoods, over-harvesting, policy and institutional failures. The major conclusion drawn from the study was that the use of indigenous knowledge is a cheaper method for forest resource assessment and monitoring, and it encourages participation of local communities in resource management decisions, thus empowering them to undertake sustainable forest management initiatives.

**Threatened tropical forest ecosystems in the south of Vietnam.** Phan Hoang, D., Schüler, G. (*Research Institute for Forest Ecology and Forestry Rheinland-Pfalz, Germany*; pdong@rhrk.uni-kl.de; schueler@rhrk.uni-kl.de).

Different types of threats to tropical forest ecosystems in southern Vietnam require sophisticated concepts to rehabilitate and preserve them with a large number of species. The devastation of mangrove forests along the South China Sea for industrial shrimp production has deprived the coast of its natural protection against erosion. In addition, the species diversity of *Rhizophora* and their specific habitat are being destroyed. Short rotation forest management and plantations exhaust the sensitive, intensively weathered tropical soils. After this, sustainable forest management and every other kind of cultivation will be jeopardized. This leads to a disastrous increase in soil loss by erosion, increased run-off from catchment areas, and to flood disasters along the lower courses of big streams. The destruction of tropical dry forest results in a total degradation of the soils through local climate change combined with water deficiency, desertification and erosion. Effective forest protection measures require local input to develop silvicultural concepts that are suitable for different site conditions, while preserving indigenous tree species and their genetic diversity. This paper raises awareness of the high variation in forest types and the risks of management measures.

**Phytodiversity of medicinal and aromatic plants in Parvati Valley of the Western Himalayas.** Sharma, P.K., Chauhan, N.S., Punam (*Department of Agroforestry and Environment, Himachal Pradesh, India*; praveenkumarsharma11@rediffmail.com).

The knowledge of natural resources of an area, their enumeration, evaluation of their potential and the life styles of inhabitants are prerequisites to standardize any systematic exploitation. The inventory and documentation of existing resources are necessary for the success of any conservation and management strategy. A study was conducted to list the prevalent medicinal and aromatic plants in the Kullu district of Himachal Pradesh, India. A total of 266 plant species belonging to 180 genera and 71 families were collected. On the basis of their utility, they were further classified as medicinal and aromatic (184), fodder (53), fuel (45), timber (21), fibre (9), tans & dyes (27), gums and resins (4), bee flora (31), edible (43), ornamental (123), species of ethno-botanical importance (24) and oil yielding (41). About 100 plant species were used locally in a traditional manner. Of these, 59 plant species were used as general medicines, 5 for bone or joint healing, 3 as tans and dyes, 4 as insect repellent, 3 against snakebites, 6 to heal reproductive system, 8 in religious ceremonies and 6 in animal husbandry. This basic approach to local inventory contributes to the global effort of biodiversity conservation.

## **Co-management agreements between indigenous peoples and others**

Organizer: Marc Stevenson *Sustainable Forest Management Network, Canada*;  
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**Moose habitat project: native collaborative approach to support a culturally appropriate management of Waswanipi Cree hunting grounds (Waswanipi Cree Model Forest).** Jacqmain, H., Bélanger, L. (*Laval University, Canada*; *hugo.jacqmain@sbf.ulaval.ca*; *louis.belanger@sbf.ulaval.ca*), Beckley, T. (*University of New Brunswick, Canada*; *beckley@unb.ca*), Courtois, R. (*Québec Ministry of Natural Resources, Wildlife and Parks, Canada*; *rehaume.courtois@fapaq.gouv.qc.ca*).

First Nations involvement in forest management is a requirement to reach sustainability, particularly in northern Québec (Canada) where the Crees have constitutional rights on land resources. Because of its importance for the Crees and its interest as a representative species of the black spruce forest ecosystem, the moose has been selected to implement a collaborative approach for improving forest management on Eeyou Astchee (Cree land). The research project aims to combine indigenous and scientific knowledge with principles of land management to build a common vision of moose habitat. Cree knowledge about moose needs is gathered through interviews with tallymen and hunters. In collaboration with the Crees, a scientific moose habitat evaluation is implemented by a three-year global positioning system radio collar telemetry program on 15 moose. Those two sources of information will be jointly analyzed to propose socio-ecological adapted management strategies. The involvement of principal stakeholders (Cree, government representatives, industries and researchers) and the recognition of respective knowledge will overcome mistrust, as well as communication, cultural and ideological barriers. It will also promote results implementation. This project will contribute to sustaining the Cree way of life and will serve to better define 'how' to bridge indigenous and science based management systems.

**Managing aspiration for fairness: the case of local forest management in Jambi, Indonesia.** Nurrochmat, D.R. (*IPB, Indonesia*; *dnurroc@gwdg.de*), Krott, M., Birner, R. (*University of Göttingen, Germany*; *mkrott@gwdg.de*; *rbirner@gwdg.de*).

Decentralization is one of the most important issues on the political agenda of post-reform Indonesia. Through the enactment of the new decentralization law named regional autonomy, many forestry matters are decided locally, and the decisions can be taken at the lowest effective level, offering the opportunity for local people to manage their forests. However, fairness is not always in line with equality. Regional autonomy implies that the benefits from forest resources are distributed unequally by giving priority to the ownership region and local people. The evidence of Jambi province shows that after decentralization, regional income and per capita income of the local people are higher than during the centralized period, while simultaneously the income disparity increased. Moreover, removal of central control over forest resources to the local authorities led to virtually no control at all. It is estimated that more than 73% of the logs in Jambi come from the illegal sources. After regional autonomy, the deforestation rate also increased sharply from 1.3 to 7.3% annually. The paper presents the evidence of forestry decentralization in transferring benefits to the local communities and its challenge for sustainability.

## **Sub-theme: Increasing the Value of Forests Through Innovative Products and Technologies**

### **Increasing the value of forests through innovative products and technologies**

Organizer: Hans-Rudolf Heinemann *Swiss Federal Institute of Technology (ETH), Switzerland;*  
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**Innovation in forest management for new economic streams.** Campos, J.J., Stoian, D., Villalobos, R.  
(*CATIE, Costa Rica; jcampos@catie.ac.cr*).

Increasing changes in technology, trade, society values and global concerns demand continuous innovation in forestry. In recent decades concepts such as sustainable forest management, multifunctionality, landscape-scale management, value chains and ecosystem and livelihoods approaches *inter alia* have been developed. However, this paper argues that forestry needs to innovate further to satisfy new demands, linking scientific and traditional knowledge. Markets have new demands in terms of quality and social and environmental performance (e.g., certification) but also offer new opportunities for eco-enterprises and environmental services. Innovation requires people and organizations willing to learn and collaborate, access to and use of technologies of communication and information, solid conceptual frameworks to guide actions, new ways of thinking to deal effectively with complexity (e.g., ecosystem approach, livelihoods approach and value-chains), collaborative action-research, and proper communication to stakeholders. Some examples where innovation has taken place in developing regions are presented. It is stressed the need to substantially increase investments to enhance innovation, particularly in developing countries, in areas such as human capital development, knowledge generation, financial mechanisms, and proper institutions and policies. Innovation requires enabling environments that take into consideration specific “systems” such as territories/landscapes or production chains; for a component of the system to be competitive and sustainable, the whole system of which that component is part of has to be competitive, including among others adequate infrastructure, incentives and institutions. There is a need for innovation in forestry education to train professionals that understand whole systems but still are able to provide specific solutions to problems in a constantly changing world and to lead the changes that are required to reposition forestry in society.

**Forests are more than just wood from the trees.** Geldenhuys, C.J. (*Forestwood cc, South Africa;*  
*cgelden@mweb.co.za*).

Forests provide livelihood options to many people. Traditionally timber from some tree species formed the backbone of large industries, and sophisticated technologies were developed for resource management, product enhancement, processing and marketing. However, many more people benefit from the medicine, food, shelter, crafts and other products that can be obtained from forests. Some of these products were turned into viable and lucrative industries, but others not. What can be done to improve the livelihood of poor people in rural areas through small enterprises based on the products traditionally used from forests for daily subsistence livelihoods? The South African Innovation Fund Project ‘Commercial Products from the Wild’ addressed this question through a systematic survey of existing products used from forests and woodlands in South Africa. This information was distilled into four key product areas for development over 3 years (2000–2002): fruits for juices and jams; fibres for crafts; roots, bulbs and herbs for traditional medicine; and bark for traditional medicine. The focus was on research and development of some or all aspects of sustainable resource use practices in natural areas, cultivation of alternative resources, domestication and commercialisation of some species in high demand, product development, feasibility studies for the species and developed products, and small business development approaches at grass roots level for economic development. Some of the main outputs during this period included the development of 26 new fibre products, 14 medicinal products and 6 fruit products; establishment of two fibre craft enterprises and one large fibre craft co-operative; establishment of two medicinal enterprises; establishment of a medicinal bark harvesters association with the legal rights to harvest bark from natural forests; empowerment of eight small-scale farmers, trained in the cultivation of indigenous fruit trees and processing of indigenous fruit products; and delivery of more than 60 reports and publications. When the CP Wild Project came to an end, the concepts were taken further into southern Africa in separate projects with separate funding. These include the use of tree leaves instead of the bark for traditional medicine and the integrated use of wood, bark and fibre products from trees harvested in timber concessions. The concepts and integrated approaches to innovative technology development and implementation will be presented.



**Environmentally sound and effective processing technologies.** Risbrudt, C. (*USDA Forest Service, USA; crisbrudt@fs.fed.us*).

The mission of the USDA Forest Service Forest Products Laboratory is to use science and technology to conserve and extend the nation's wood resources. FPL researchers produced the experimental data that led to building codes and standards and the development of construction technologies and techniques incorporated in virtually every home built in the USA, and to improved and more efficient production of paper and other wood-fibre products. For decades, FPL's scientists and engineers concentrated on improving preservatives, analyzing the engineering performance standards of the country's changing lumber supply, developing and testing and improving wood and wood-based products for construction, developing more efficient pulping, papermaking and recycling technologies. In recent years, FPL has expanded efforts to develop value-added applications for small-diameter trees and other forest biomass in papermaking, engineered wood products and composite materials and as a source of ethanol. FPL increases effectiveness and research synergy and speeds the diffusion and application of research findings through a variety of partnership arrangements with industry and academia. Such coalitions and other cooperative relationships help FPL focus on issues that advance FPL's mission while being relevant to end-users in the pulp and paper industry, home construction and maintenance, and wood-based composites.

**E-business: Opportunities and realities.** Vlosky, R.P. (*Louisiana State University, USA; vlosky@lsu.edu*).

In order to maintain a competitive edge, companies are continually looking for ways to improve communication and relationships with exchange partners, improve information quality and reliability, reduce costs and increase profitability. The Internet is a market space that can accomplish all of these business objectives. Overall, the Internet offers a revolutionary tool for business development and management. As is the case with other industrial sectors, the global forest products industry is rapidly expanding its use of the Internet to conduct business. Through the Internet, many market barriers can be reduced or eliminated. It can also level the playing field, allowing small and large firms alike to be visible and accessible. The Internet offers several tools and options ranging from e-mail to a completely integrated supply chain. Two of these Internet tools, e-mail and the World Wide Web (also known as the Web), have become entrenched in the business environment, facilitating either marketing campaigns, communication with partners and suppliers, or process applications inside and outside of the enterprise. In addition to being useful to individual companies, the Internet is also being used to build on-line communities and to foster forest industry business development. This presentation will include an overview of e-markets, business-to-business (B2B) models and examples from the forest industry sector.

**Markets for ecosystem services: Implications for agroforestry.** Whitten, S.M., Shelton, D., Coggan, A. (*CSIRO Sustainable Ecosystems, Australia; stuart.whitten@csiro.au*).

Agroforestry and other woody perennials may provide a number of important ecosystem services including biodiversity, groundwater management, aesthetic benefits and nutrient and sediment reduction. These ecosystem services are important to maintaining environmental and economic sustainability in rural areas. Yet markets, such as those for timber and those emerging for oil and energy products, generally only reward individuals and communities for food and fibre products. In this paper we report three case studies developed within the JVAP funded 'markets for ecosystem services project' that have the potential to provide incentives for at least one ecosystem service generated by agroforestry: 1) recharge credits for managing irrigation induced waterlogging and salinity; 2) perennial plantings for protecting road infrastructure; and 3) development offsets in rural areas. In each case we identify the ecosystem service provided and the potential agroforestry opportunities that result. Our focus is on identifying and developing the institutional and policy context that would facilitate a market for the ecosystem service provided and the resultant incentives for agroforestry managers. We conclude that markets for ecosystem services may offer a variety of opportunities for agroforestry managers and that the nature of these markets is, in part, dependent on the ecosystem service drivers.

## **Utilizing small-diameter trees and solving forest resource problems**

Organizer: Frank Beall, *University of California, USA; frank.beall@nature.berkeley.edu*

**A new method for processing wood from the oil palm tree.** Anim, A. (*Radebs Wood Enterprise Products Limited, Ghana; alexanim2002@yahoo.com*).

Because of increased population in Ghana, conventional timber industries cannot meet the demand for wood. The oil palm tree *Elais guineensis*, which is a small diameter log, has recently gained increasing popularity in Ghana due to a Presidential initiative on the use of extracted oil from the oil palm tree. The oil palm is regarded as a promising species to meet the timber demand of the industry. In the past, it was felled purposely for the extraction of its juice for

the manufacturing of alcohol. Several studies in Indonesia and Malaysia have reported difficulties encountered in the processing of the oil palm. In this study, cutting tool wear and mechanical strength properties of the oil palm tree were examined to determine its potential as raw material for the downstream processing sector. It was observed that cutting tool wear was reduced when the oil palm tree was heated before processing. Productivity was also found to have increased when the oil palm was heated before processing. There was however a slight reduction in the modulus of rupture and modulus of elasticity when the oil palm tree was heated before processing.

**Processing and utilizing small trees in Canada.** de la Roche, I., Levesque, Y. (*Forintek Canada Corporation, Canada; idlr@van.forintek.ca*).

In the 1970s, stem volumes in Eastern Canada averaged 0.71 m<sup>3</sup> and it took close to 5.66 m<sup>3</sup> of round wood to produce 2.36 m<sup>3</sup> of lumber. By the 1990s, the trees averaged 0.1 to 0.14 m<sup>3</sup> per stem, yet wood consumption had dropped to 3.99 m<sup>3</sup> round wood per 2.36 m<sup>3</sup> of lumber. These gains were based on new technology, supported by research and innovative equipment suppliers. Advances in information processing, image analysis and automation made it possible to better control handling-related damage, optimize key sawmilling operations and model the effects of production decisions on products and financial results. This helped operators meet increasingly diverse market demands without compromising the benefits from mass production. The development of machine stress rating and engineered wood products created further opportunities for small wood products. In 2005, the potential for additional improvement may be based on new concepts, but knowledge and technology will continue to fuel productivity and profitability gains in small-wood processing and marketing.

**Mechanical grading of small-diameter logs for engineered roundwood structures.** Green, D.W., Gorman, T.M., Evans, J.W., Murphy, J.F. (*U.S. Forest Products Laboratory, USA; dwgreen@fs.fed.us; jwevans@fs.fed.us*).

There is increasing interest in the United States in using logs 100 to 175 mm in diameter in engineered roundwood structures. Using logs as structural elements provides additional value-added opportunities for material mechanically thinned from at-risk forest in western United States. Compared to sawing lumber from small-diameter logs, logs are less susceptible to warp during drying, have lower processing costs and may have a much higher economic value. However, traditional visual grading methods may be overly conservative, and provide inadequate reliability, for more highly engineered structures such as community centers, libraries and cable suspension bridges. Research has established the technical basis for mechanical grading of small-diameter logs, using modulus of elasticity determined in transverse vibration. Relationships between modulus of elasticity and strength in bending and compression parallel to the grain have been established, and the effect of change in moisture content and mechanical processing investigated. The system has been used to grade 150 mm lodgepole pine for a 150-meter span cable suspension bridge.

**Use of small diameter timber resources for light timber frame constructions, emergency shelters, small industrial buildings, furniture and assorted wood products.** Haviarova, E., Eckelman, C.A. (*Purdue University, USA; ehaviar@purdue.edu; eckelmac@purdue.edu*).

Locally available small diameter timber resources, either plantation thinnings or naturally grown small diameter timber, can be used for light timber frame construction, furniture and other wood products. Design elements of these products are standardized, modular, simple, durable, attractive, cost effective, structurally proven by testing, specifically adapted to local areas, materials and production processes. Light timber frames for emergency shelters, small houses, small schools, farms and light industrial building frames, institutional furniture, household furniture, furniture for special needs, playgrounds and other products can be manufactured by cottage type industries or advanced factories, using the simplest manufacturing techniques, a few tools and limited worker skills. Round mortise and tenon joinery is used as the main means of assembly. This project demonstrated the ease and simplicity of construction and rapid rate of assembly where, for example, a crew of two people can assemble a 16ftx12ft frame building kit in 1/2 hour. Variable designs were developed, tested and ready to be adopted by appropriate agencies, user groups, or individuals.

**Delayed thinning of native species plantations in the Atlantic Lowlands of Costa Rica for provision of small-diameter timbers and enhanced plantation productivity.** Jacobs, D.F., Wightman, K.E. (*Purdue University, USA; djacobs@purdue.edu; kevin\_wightman@hotmail.com*), Hagggar, J.P. (*Tropical Agricultural Research and Higher Education Center (CATIE), Nicaragua; jhagggar@ibw.com.ni*).

Pressures on dwindling timber supplies from native Costa Rican forests have promoted the establishment of plantations to help sustain timber flow and restore degraded lands. Though reforestation has traditionally involved use of fast-growing exotic species, a variety of native species have been identified which equal or exceed performance of exotics. Following establishment, many of these native species plantations fail to receive silvicultural interventions which may provide intermediate timber resources and sustain rapid plantation growth. We studied response of four native species to delayed

(eight to nine years since establishment) plantation thinning (50% of original density). Volume extracted from thinned trees of *Calophyllum brasiliense* and *Hyeronima alchorneoides* primarily consisted of pole logs (38–46 m<sup>3</sup>/ha), while *Terminalia amazonia* and *Vochysia guatemalensis* produced both pole logs (50–72 m<sup>3</sup>/ha) and merchantable sawlogs (26–60 m<sup>3</sup>/ha). After one year, all species responded similarly to the thinning treatment, with no significant increase in total height, but significant increases in bole diameter (56–66% gain). Crown height was not affected by thinning, but crown width increased for all species except *H. alchorneoides*. Our data demonstrate the value of intermediate plantation thinning, even when delayed, for provision of timber and to maintain plantation productivity of these species.

**Effect of bamboo growing sites and ages on properties of homogenous particleboards made from Ethiopian highland bamboo (*Yushane alpina*).** Kelemwork, S., Tahir, P.Md., Wong, E.D., Rahim, S. (*Universiti Putra Malaysia, Malaysia; eyoum88@hotmail.com*).

Culms of one-, two- and three-year old bamboo collected from three different growing sites in Ethiopia were used for manufacturing homogenous particleboards. Two types of boards with fine and coarse particle sizes (0.5–1 mm and 1–2 mm) at 600 and 750 kg/m<sup>3</sup> target density were fabricated to evaluate the effect of bamboo from different sites and ages on particleboard properties. Density of bamboo (harvested from three different sites) and board density had significant effect on mechanical properties and dimensional stability. The results revealed that the interaction of age, particle size and board density had significant effects on bending, stiffness, internal bonding and thickness of swelling. Except for boards made from three-year old bamboo, all boards made at 750 kg/m<sup>3</sup> target density met the minimum requirements of ISO standards for general purpose particleboard.

**Predicting stress distribution of spruce I-beam cross section by finite element analysis.** Lee, S.-H. (*National Chiayi University, Chinese Taipei*).

A finite element (FE) analysis was conducted to investigate the stress distribution of I-beam cross section for the application of a flooring system with spruce. Two configurations of I-beam were examined. Two sizes of flange member were 40x120 and 40x160 mm and one size of web member was 40x220 mm. An I-beam of 3600 mm in length subjected to four-point loading for a static bending test was assumed. The flexural behaviour of I-beam is modeled with solid element of ANSYS software. The simulation on the stress distribution of I-beam cross section at 800 mm from the support within the shear span was taken. The maximum bending stress,  $\sigma_{xx}$ , occurred in the top and bottom of each flange member. The maximum shear stress,  $\tau_{xy}$ , occurred in the middle of the web member. The shear stress,  $\tau_{xy}$ , on the web member near the interface between flange member and web member was reduced to about 72% of maximum shear stress,  $\tau_{xy}$ . The shear stress,  $\tau_{zx}$ , on each flange member was also evaluated.

**Opportunities and barriers to utilizing small diameter material.** LeVan, S. (*U.S. Forest Products Laboratory, USA; slevan@fs.fed.us*).

Significant volumes of small diameter exist throughout the West. Many of these overstocked stands contribute to the catastrophic wildfires in recent history. To reduce the threat to our nation's forests, these stands need to be thinned. However, the cost of removal often ranges from \$1235 to \$3705 per ha depending on slope, treatments and stocking density. If some economical value for these thinnings can be achieved, the cost of fuel reduction treatments could be offset. The USDA Forest Products Laboratory has been working on developing new uses for thinning material. This presentation will discuss potential opportunities that exist, current demonstration projects underway, and some of the barriers to utilization of this material.

**Utilization of coconut wood (*Cocos nucifera*) infested with the Cape St Paul wilt disease.** Okai, R. (*University of Education, Winneba, Kumasi Campus, Ghana; reynoldsokai@yahoo.co.uk*), Frimpong-Mensah, K. (*Kwame Nkrumah University of Science and Technology, Ghana; frimpongmensah@yahoo.com*).

Lethal yellowing disease, also known as Cape St. Paul Wilt disease, is a pandemic disease in Ghana, and it affects the coconut palm (*Cocos nucifera*), a small diameter log. The disease is characterized, in the early stages, by premature drop of most of the fruits regardless of their development stage. Some of the progressive symptoms of the lethal yellowing disease are the death of the leaves, with possibly a few green leaves remaining, and the fall of the whole crown, leaving a bare trunk. After the coconut plant has been infested, it is declared useless and left to rot. However, in the early stages of infestation, only the leaves and fruits are affected. It is therefore imperative that studies be conducted on the milling characteristics and mechanical strength of coconut wood infested with the Cape St. Paul Wilt disease to determine its potential for utilization as lumber. Experimental results from lumber yield, modulus of elasticity (MOE) and modulus of rupture (MOR) indicate that coconut wood infested with the Cape St Paul Wilt disease can be utilized to help meet the timber demands of the downstream processing sector.

**Added-value alternatives for wood forest activities in small enterprises.** Stinghen, A.B.M. (*Universidade Federal do Parana, Brazil; andreaberriel@ufpr.br*), Povoá de Mattos, P. (*Embrapa Florestas, Parana, Brazil; povoa@cnpf.embrapa.br*).

A serious problem that increases rural emigration is related to the degraded productive structure of the rural communities. There is a continuous search for economical sustainability of small- and medium properties, leading to improvement of rural communities. According to many specialists forest activities can be a contribution to minimize poverty and to improve the quality of life of rural communities. The future tendency will be to increase, rapidly, the transformation of high value-added wood products. In the current research, a project for a modular wood house construction was developed to use wood from forest plantations. This work aims to add value to the activity of forest exploitation through primary mechanical processing, using a portable sawmill. The modular house project shows that by simple project decisions, it is possible to improve the performance and durability of renewable materials. In addition, there are alternatives for mechanical processing of small wood pieces. Furniture projects, including details of construction, are presented as alternatives for small sawmills that do not have sophisticated tools and high technology. Furthermore, local talent could be stimulated to create furniture projects and manuals, as an alternative to professional training of young people from rural communities.

**Profitable raw material – processing -product chain for saw milling of Scots pine from thinnings in Finland.**

Verkasalo, E. (*METLA The Finnish Forest Research Institute, Finland; erkki.verkasalo@metla.fi*), Wall, T. (*METLA The Finnish Forest Research Institute, Finland; tapio.wall@metla.fi*), Fröblom, J. (*VTT Building and Transport, Finland; jorma.froblom@vtt.fi*).

Mechanical utilization of small-sized Scots pine from thinning stands (age 25 to 60 years, dbh 11 to 25 cm) for both solid wood and composite products has increased owing to development in milling and wood harvesting techniques, new processing methods and greater quantities of thinnings from silvicultural treatments. Also, weak demand for pulpwood and bioenergy material has focused attention on utilization of small-sized wood. This paper provides information on the wood and timber properties, and the technical and economic suitability of commercial thinnings for sawn timber and processed wood products. Using 8058 trees from 203 stands, the profitability of processing conventional logs (length 3.1–4.3 m) compared to short logs (length (2.4–3.0 m) was studied. Log diameter limits of profitable saw milling, procurement and processing of small dimensioned and conventional logs, impacts of ‘short-log technique’ on equipment productivity and cost sensitivity were determined. Techniques such as custom-made simulation of cross-cutting and CT-scanning of logs followed by simulated sawing were also used. Selection criteria of stands and stems were developed for profitable saw milling. Instructions for product-based log procurement and sawing were provided and profitable end products were defined.

**Fuel characteristics of selected tree species in Ethiopia.** Woldeyohanes, F., Nuruddin, A.A. (*Universiti Putra Malaysia, Malaysia; woldeyohanes@yahoo.com*).

Much anecdotal evidence exists on the relative quality of fuelwood, but no objective measure is available to compare the fuel characteristics of various tree species in Ethiopia. This information is vital to afforestation programs for fuelwood production in rural and urban areas as well as industrial processes for energy recovery from wood residues. The most commonly used parameter for comparing alternative fuels is calorific or heat value. Calorific values of wood generally vary little; moisture content (MC) along with density (D) are the most important properties in ranking fuelwood species. Since determination of these basic fuelwood properties is straightforward, the information was used to produce fuel value index (FVI), a commonly recommended quantitative measure for comparison of fuelwood species. In the study of fuelwood properties, characteristics such as moisture content (MC), basic density (D), volatile matter content (VM), fixed carbon content (FC), ash content (AC) and gross heat value (GHV) were determined. The effective heating value depends on MC, D and AC; FVI was calculated using these parameters and the species were ranked according to the calculated FVI in ascending order of desirable fuelwood properties: *Eucalyptus globulus*, followed by *E. grandis*, *E. saligna*, *Acacia tortolis*, *A. seyal* and *A. abyssinica*.

**Aboveground biomass functions of selected tree species grown in Ethiopia.** Woldeyohanes, F., Nuruddin, A.A. (*Universiti Putra Malaysia, Malaysia; woldeyohanes@yahoo.com; aiuddin@forr.upm.edu.my*).

In Ethiopia, the establishment of forest plantations for energy and industrial use has been accelerated, owing to concern for the dwindling wood supply and the rate of exploitation of the forests. Towards this end, accurate strategies for estimating biomass values of these plantations for effective management and rational utilization are necessary. This study attempted to determine regression models for estimating aboveground biomass (AGB) and fuelwood properties of six tree species; commonly used as fuelwood. These are *Eucalyptus globulus*, *E. grandis*, *E. saligna* among exotics and *Acacia abyssinica*, *A. seyal* and *A. tortolis* among indigenous species. Biometric data of selected trees were obtained by non-destructive methods. The ANOVA and prediction equations were developed using base-10 log-transformed dry weights (Kg) of components of trees and their corresponding log-transformed diameter at breast

height (DBH), squared diameter at breast height (DBH<sup>2</sup>) and DBH\*H. The allometric equation with DBH<sup>2</sup> as predictor variable over-weighed other growth parameters. Using total height (H) as an independent variable did not explain much variation in biomass. Since DBH can easily be measured with good accuracy and provides accurate estimates of AGB and its components, it was not necessary to include additional variables.

## **Role of genetics in manipulating wood quality**

Organizer: Harry Wu, *CSIRO, Australia; Harry.Wu@csiro.au*

**Genetic control in the time of transition from juvenile to mature wood in *Pinus radiata* D. Don.** Gapare, W.J., Wu, H.X., Abarquez, A. (*CSIRO, Australia; Washington.Gapare@csiro.au*).

Juvenile wood properties in *Pinus radiata* are known to be limiting in factors such as low density, spiral grain, fibre length and compression wood. Juvenile wood quality may be improved by breeding for increased stiffness of juvenile wood or an early transition age from juvenile wood to mature wood. The objective of this study was to investigate the age of transition from juvenile to mature wood and quantify genetic control in time of transition from juvenile to mature wood in *P. radiata*. We used genetic material from 87 full-sib families from two 16-year old Australia-Wide Diallel (AWD) tests and 30 old open-pollinated (OP) material aged 28 years. An important finding of this study is the difference in transition age between tests in Gippsland (mean = 7 years) and Tantanoola (mean = 13 years), which suggests that site had a major effect on juvenile-mature transition in *P. radiata*. We detected moderate genetic control in latewood density transition age that would allow for family ( $h^2_f = 0.61$ ) and within-family selection ( $h^2_w = 0.32$ ) which would decrease transition age by almost 22 months. These results suggest there may be an opportunity to select for a reduction in transition age and therefore, reduce the difference between juvenile and mature wood density.

**Incorporating wood quality breeding and screening into a hybrid pine tree improvement and clonal forestry program in Queensland, Australia.** Harding, K.J. Copley, T.R. (*Department of Primary Industries and Fisheries, Queensland, Australia; Kevin.Harding@dpi.qld.gov.au*), Dieters, M.J. (*University of Queensland, Australia*), Peters, R.F. (*Department of Primary Industries and Fisheries, Queensland, Australia*).

Wood quality screening of parents used in a clonal forestry program for slash × Caribbean pine hybrids is needed to improve the potential for tests to produce superior clones. However, estimating breeding values for a range of wood properties has been financially prohibitive. Grafted ramets in seed orchards were used to rank parents to reduce the influence of site and age variation. Improvements in non-destructive evaluation tools provide economically significant opportunities to use acoustic technologies to indirectly estimate breeding values for timber stiffness, a critical trait. Improved classification of the genetic value of parents and higher selection intensities applied to tests will make clonal forestry more economical by delivering higher gains at reduced assessment/screening costs. Incremental improvements in the amount of wood property information available on pedigrees/parents over time will be described. Each cycle of clonal tests covers about five years and experience from five cycles will be used to discuss the increasing opportunities to produce and deploy superior clones from each new series of tests. Examples will highlight why the latest generation of non-destructive assessment tools provides important opportunities to breed and select for wood quality that should be incorporated into all tree improvement programmes.

**Estimation of economic weights for breeding objective traits affecting profitability of solid wood production for *Pinus radiata*.** Ivković, M., Wu, H.X. (*CSIRO, Australia; Milosh.Ivkovich@csiro.au*), McRae, T.A. (*STBA, Australia; tmcrae@stba.com.au*).

Production systems of eight Australian companies involved in growing and processing of radiata pine solid wood were examined. A bio-economic model, linking four breeding objective traits (MAI – mean annual increment, SWE – stem straightness, BRS – branch size and MOE – modulus of elasticity) with the different production systems, was constructed using industry and published data. Economic weights for breeding objective traits were determined based on impact of improvement in a trait on overall profitability of plantation growers, sawmills and integrated companies. The single most important trait for improvement for a plantation grower was MAI. The single most important trait for improvement for a sawmill was MOE. The most important two traits for improvement for an integrated company were MOE and MAI. The correlation between breeding objectives for individual companies was high among plantation growers. However, the correlation between objectives of plantation growers and integrated companies was only intermediate. Unless sawmills introduce differential rates for sawlogs of different MOE, different trees may be preferred by plantation growers, sawmills and integrated companies.

**Breeding for profit and end-product in Radiata Pine in Australia.** Wu, H.X., Matheson, A.C., Ivkovič, M., Gapare, W.J. (CSIRO, Australia; [harry.wu@csiro.au](mailto:harry.wu@csiro.au)), McRae, T.A., Powell, M. (STBA, Australia; [tmcrae@stba.com.au](mailto:tmcrae@stba.com.au)).

Current Radiata pine planting stock from the Australia national breeding program comes from two-generations of intensive selection and breeding. Breeding for growth rate and tree form has brought two major consequences: reduced wood density and increased juvenile wood. The breeding objective method selects trees for overall profit in an enterprise. To breed for overall profit and to improve specifically for juvenile wood, several major projects have been initiated in CSIRO in conjunction with radiata pine industries and the Southern Tree Breeding Association (STBA). The purposes are (1) to examine the inheritance of wood quality traits and genetic correlation between growth, quality and end-product traits, (2) to evaluate age-age genetic correlation and the efficiency of early selection, and (3) to develop economic weights for important breeding objective traits. The results showed that (1) there were considerable genetic variation and heritability for most of wood quality and end-products traits, (2) heritabilities of wood quality traits were usually higher than growth and form traits, (3) there were strong genetic correlations for wood quality traits between early and rotation ages, and (4) there were genetic correlations between component traits such as growth, density and end-product traits and stiffness. Overall approaches and philosophy in breeding for stiffness for Australia radiata pine were discussed.

**The use of linear mixed model theory for the genetic analysis of repeated measures obtained from wood samples.** Zamudio, F. (Universidad de Talca, Chile; [fzamudio@utalca.cl](mailto:fzamudio@utalca.cl)).

Data collected from wood samples obtained from progeny tests can become more complex to analyze because of two reasons. First, data from different progenies established in field trials are usually unbalanced, due to the expected mortality rate. Second, wood properties are normally assessed at several places within the stem of a tree, such as wood density recorded at different heights or cambial ages. Therefore, the statistical analyses must allow the use of repeated measures obtained in a spatial or time sequence. There has been a considerable work on linear mixed model (LMM) theory in the past twenty. As a result, current LMM methodology not only permits the presence of heterogeneity of variance in the linear model (still assuming normality) but also allows the geneticist to directly address the covariance structure of the data. Modelling the covariance structure improves our ability to analyze repeated measurements by providing efficient statistical tests and allowing the estimation of more genetic parameters. This paper reviews the LMM methodology that is suitable for the genetic analysis of repeated measurements collected from wood samples. Wood density records obtained from a radiata pine progeny test established in the south of Chile are used as an example.

**Breeding for quality wood production: Challenges and opportunities.** Zhang, S.Y. (Forintek Canada Corp., Canada; [Tony.Zhang@qc.forintek.ca](mailto:Tony.Zhang@qc.forintek.ca)).

Tree breeding programs have traditionally been focused on selection for tree growth. With the worldwide move in forest management to shorter rotations and an increasing proportion of wood supply coming from improved and intensively managed resources, wood quality has become a concern to the forest products industry. Faced with this concern, wood quality is becoming an integral part of tree breeding programs where wood is to be the end product. To incorporate major wood quality traits into tree breeding programs, numerous studies have examined the genetics of wood quality traits in many commercial timber species around the world. However, there are still challenges to be addressed. This paper reviews the challenges and opportunities in terms of incorporating wood quality traits into tree breeding programs for quality fibre production and maximum gains. The potential solutions and needs for future research are also discussed.

## **Strengthening collective innovation capacity of forest stakeholders in research and development**

Organizers: Cynthia Miner *USDA Forest Service, USA*; [clminer@fs.fed.us](mailto:clminer@fs.fed.us), James Johnson *Virginia Polytechnic Institute and State University, USA*; [jej@vt.edu](mailto:jej@vt.edu), Michael Kleine *IUFRO, Austria*; [kleine@iufro.org](mailto:kleine@iufro.org), and Oudara Souvannavong *FAO, Italy*; [Oudara.Souvannavong@fao.org](mailto:Oudara.Souvannavong@fao.org)

**Balancing tradition and innovation: Collaboration in knowledge transfer and extension under changing frameworks: a Central European perspective.** Begus, J. (Slovenia Forest Service, Slovenia; [jurij.begus@zgs.gov.si](mailto:jurij.begus@zgs.gov.si)), Beck, R. (Technical University of Munich / Bavarian Forest Institute, Germany; [beck@forst.tu-muenchen.de](mailto:beck@forst.tu-muenchen.de)).

Forestry extension work in central Europe is traditionally characterized by forest service domination. Societal changes such as institutional reform, debate on the role of the state in forest ownership and urbanization have led to efforts to

change the existing structure of state ownership. Stronger involvement of multiple partners like active forest owners, entrepreneurs, liability institutions, farmers and forest-owner organizations etc. have evolved and new information networks have been formed. Participatory approaches in setting objectives, program formulation, design and implementation of extension projects on local and regional levels have shown promising results. Forest owner organizations, especially, play a growing role by linking forest extension efforts to the marketing of forest products. Though part of the knowledge triangle 'Education, Extension and Research' (forest) science in Central Europe other than in Anglo-Saxon countries has to play a more active role with respect to forest extension. Greater emphasis on extension research, including education and information needs, communication preferences and barriers for forest owners, extension specialists and the general public is needed. Participatory approaches to research, involving multiple partners in project formulation, conduct and evaluation and integration of activity to monitor utilization of results bear high potential for the adoption of innovation.

**Experiences in multi-stakeholder cooperation in Central America in the generation and utilization of knowledge.** Galloway, G. (*Tropical Agricultural Research and Higher Education Center (CATIE), Costa Rica; galloway@catie.ac.cr*).

During the last 15 years, a number of multi-stakeholder platforms have been formed in Central America to augment cooperation among diverse entities in the generation and utilization of knowledge. Since the inception of this type of cooperation, a number of innovations have been made to increase the effectiveness of multi-stakeholder cooperation. Examples of important innovations include: a broadening of the types of entities taking part in these multi-stakeholder platforms; a structuring of these platforms to better address the diverse dimensions of sustainable forest management; shared strategic planning to establish long-term strategic objectives; the utilization of strategic plans as a basis for operational planning; and greater attention to policy and governance issues. Examples of progress, as well as problems limiting success, will be addressed in the presentation.

**Socio-economic impact of environment and natural resources training programs to upland communities/farmers in Benguet, Cordillera Administrative Region, Philippines.** Maddumba, H.A., Mapanao, J.S. (*Department of Environment and Natural Resources – Cordillera Administrative Region, Philippines; erds-car@mozcom.com*).

The research study was conducted in 2001 in the five barangays of Benguet where training programs were conducted. It aimed to determine the benefits and impacts of environmental- and natural resources training programs, reasons for non-adoption and training needs of upland communities. The people received training in several technologies such as bamboo propagation, wild food and fruit processing, solid-waste management, nursery and plantation establishment, soil conservation, tiger grass production and other projects that contributed to their livelihood. Technologies with economic benefits were adopted more quickly than those that offered ecological benefits. However, impacts of training programs on their social condition were recognized. They are now more informed on forest and environmental issues; friendship and cooperation among trainees and respondents was enhanced and strengthened. Some of the reasons for low rates of adoption of technologies include lack of immediate economic benefits, non-applicability to the local area and an attitude of being suspicious of unproven methodologies. Comments and suggestions made by respondents to improve the delivery of training programs include information on income generating activities, follow-up training and consultation with regard to training needs.

**Documentation of indigenous and introduced environment and natural resources (ENR) management technologies/practices in selected barangays of Itogon, Benguet, Cordillera Administrative Region, Philippines.** Maddumba, H.A., Salvatera, M.E., Estigoy, D.A. (*Department of Environment and Natural Resources – Cordillera Administrative Region, Philippines; erds-car@mozcom.com*).

Documentation of indigenous and introduced environment and natural resource (ENR) management technologies and practices was done in selected sites in Itogon, Benguet to highlight successful ENR management practices and determine reasons for their success. The most commonly applied ENR practices and technologies are in agroforestry; contour planting with hedges and with components of fruit trees, forest trees and medicinal and cash crops are used. The second most adopted practice is in reforestation and tree planting with activities in nursery establishment, seedling production and plantation establishment. Livelihood concerns, including tiger grass production and bamboo propagation were also documented. Soil and water conservation measures such as wattling, riprapping, cover cropping and construction of checkdams were noted. Assessment of successful ENR management practices and technologies was conducted among twelve selected respondents and showed that the most successful were related to land ownership, simplicity of implementation, economic benefits and the attitude of extension personnel. Respondents also shared their suggestions on how to improve the adoption of technology and its subsequent implementation.

**The role of networks in information exchange: The case of the Network for Natural Gums and Resins in Africa (NGARA).** Mbiru, S.S. (*The Network for Natural Gums and Resins in Africa (NGARA), Kenya; sheilambiru@ngara.org*).

The Network for Natural Gums and Resins in Africa (NGARA) was established in May 2000 to assist African producing countries and partners to formulate a coordinated strategy for the sustainable development of their natural gum and resin resources, for improving livelihoods and environmental conservation. The Network has 14 member countries in Africa, each with National Focal Points and a Secretariat based in Kenya. In response to the United Nations Conference on Environment and Development, initiatives to develop databases, improve information sharing and facilitate communication among member countries were established. Providing access to relevant, up-to-date information by stakeholders on production, marketing, processing and quality control of gums and resins in African producing countries is considered a very important and crucial part of NGARA activities. However, the effective dissemination of information to intended users is not always easy to achieve. This paper will examine this crucial role using NGARA as a case in point.

**Stakeholders as full partners in creating, transferring and applying new knowledge – some North American experiences.** Norland, E.R. (*U.S. Department of Agriculture – Cooperative State Research, Education and Extension Service, Washington, D.C., U.S.A.; enorland@csrees.usda.gov*).

Serving the needs of people through research-based, non-formal education programs has been the foundation of the extension work in the United States. This cannot be done effectively without involving all who have an interest in the programs. Since its formal inception in 1914 with the passage and enactment of the Smith-Lever Act by the U.S. Congress, the Cooperative Extension System has engaged people in programs in various roles. The term 'stakeholder' has different connotations for different people, depending on local cultures, experiences and perspectives. In the context of extension work in the U.S. it is broadly and inclusively defined as all who have an interest in the extension system and its programs. Thus it includes individuals and organizations that: 1) participate in programs; 2) collaborate in planning and conducting programs; 3) provide funding and other resources for programs, and 4) conduct extension programs. Stakeholder involvement is not only a tradition and a best practice in the U.S. extension system, it is also mandated in federal legislation in order to ensure that programs are meeting the needs of those who would benefit from the programs. The various roles of extension stakeholders and mechanisms for their participation are presented, along with perspectives and examples from the U.S. experience.

**Linking research, development and implementation in forestry**

**Organizers:** Palle Madsen *Danish Centre for Forest, Landscape and Planning, KVL, Denmark; pam@kvl.dk*, and John Stanturf *USDA Forest Service, USA; jstanturf@fs.fed.us; drdirt\_ms@yahoo.com*

**How can forest management and society get more out of forest research? The Danish example.** Koch, N.E. (*Danish Centre for Forest, Landscape and Planning, Denmark; nek@kvl.dk*).

Research and practice are mutually dependent on each other, both in the public and private sectors. If one of them fails to prosper, it will in the long run have detrimental consequences on the other. The objective of this paper is to illustrate the possibilities of co-operation that would enable forest management to make better use of forest research to the benefit of both, and, by that, to the benefit of society. The paper is structured around 5 main headings: 1) research definition, 2) problem description, 3) participation in problem-solving, 4) communication, and 5) knowledge accumulation. It includes a number of recommendations for both practice and research.

**From forest science to "brain" research: Development and implementation of near-to-nature management in Danish forestry.** Larsen, J.B. (*Forest & Landscape, Denmark; jbl@kvl.dk*).

The political decision to implement near-to-nature management in the Danish state forests by 2005 necessitated a total shift in management and planning methods. In order to facilitate this swift transition, close cooperation between science and practice was established by 'smuggling' a forest professor into the state forestry organisation. In the following process – with the practitioners defining the problems and also in part giving solutions and with the scientist mostly observing and reporting – management goals (forest development types), planning and controlling procedures, as well as transformation tools (silvicultural methods and techniques) were developed communally, thereby creating ownership throughout the whole organisation. As a consequence of this close cooperation between science and practice the implementation of the results was achieved instantaneously – and the transfer of research into the brains of the practitioners bestowed the professor an important lesson.



**Linking stakeholder research needs and the Federal Data Quality Act: A case study of an endangered forest shrub in the southern United States.** Lockhart, B.R., Gardiner, E.S., Leininger, T.D., Connor, K.F., Devall, M.S., Hamel, P.B., Hawkins, T., Schiff, N.M., Wilson, A.D. (*USDA Forest Service, USA; blockhart@fs.fed.us*).

The need for knowledge, ranging from development of new products or processes to the effects of specific actions on the environment, is greater now than at any point in the past. The greater need for research has generated increased public and stakeholder involvement in the research process. As a result, all facets of research, from planning through publication of results, are often scrutinized by stakeholders with a specific interest. While the basic nature of scientific inquiry has not changed, now more than ever, the credibility of scientific results is based on thorough planning, peer reviews of experimental designs and analytical approaches, and assuring that data are of the highest quality. Public interest in the quality and accuracy of federal research rose to a level that resulted in the Data Quality Act of 2001. The act required the establishment of guidelines for Federal research organizations. We present a case study within the US Forest Service, where policies, statements and plans for research quality assurance and quality control have been developed. The paper discusses these applications to comprehensive research on the federally endangered forest shrub, pondberry (*Lindera melissifolia* (Walt.) Blume).

**Lessons learned from a boom and bust and continuing forestry research cooperative.** Robison, D.J. (*North Carolina State University, USA; dan\_robison@ncsu.edu*).

The North Carolina State University Hardwood Research Cooperative (HRC) was formed in 1963 as an extension of the six-year-old and already successful Tree Improvement Cooperative which was focused on loblolly pine. The aim of HRC, initially, was genetic improvement of hardwood species for planting in the U.S. south, as was being done for loblolly and slash pines. However, while the TIP remained focused on loblolly pine, the HRC initiated work on 25 hardwood species and was unable to sustain much progress. Over the years the HRC changed from a focus on genetic improvement, to silviculture in natural stands, plantation silviculture, harvesting impacts and wetlands issues, among others. The attempt to be all things to all forestry sectors, coupled with the relatively low value of hardwoods due to large accessible inventories, led the HRC to be a leader in research ideas and demonstration trials, but not a producer of detailed ecological or applied research findings which user groups could put into practice, nor did it develop genetically improved seed. However, the HRC declined rapidly after 2001 because of a more restrictive economic climate throughout the forestry sector, lack of a 'marketable' product and profitable returns on pine.

**Silvicultural research strategy in Iran and adjacent regions.** Sagheb-Talebi, K. (*Research Institute of Forests & Rangelands, Iran; saghebtalebi@rifr-ac.ir*).

Iran is a Middle Eastern nation that covers an area of 1,648,000 km<sup>2</sup>, which is generally known as a dry and semi-dry country. Its geological past and geographical location resulted in open landscapes with vast mountain ranges, wide plains, uncultivated deserts, fertile plains, large swamps and forests. Forests of Iran with an area about 12.4 million hectares comprise 7.4% of the whole country area, therefore Iran is a Low Forest Cover Country (LFCC) under UN and FAO definitions. Deciduous forests that were destroyed by glacial advances in Europe and northern Asia survived in Iran. The outlook for these broad-leaved forests is very similar to that of central and eastern forests of Europe. Silvicultural research in this region is generally concentrated on protection of these genetic resources. Natural succession in virgin forests, natural regeneration in beech stands, silvicultural intervention in uneven aged stands, rehabilitation of degraded areas and conservation of biodiversity are being studied. In other ecological regions, silvicultural research should answer questions concerning site demands and ecological requirements, forest protection, rehabilitation of degraded forest lands and plantation methods for suitable native and adapted species. Besides population studies, a research program is needed for conservation and extension of forest areas.

**How managers obtain new technical information: Knowledge acquisition by professional foresters in the United States.** Stanturf, J.A. (*USDA Forest Service, USA; jstanturf@fs.fed.us*), Fowler, C.T. (*University of Hawaii – Hilo, USA; cynthiafowler@gmail.com*), Reitz, R. (*USDA Forest Service, USA; rreitz@fs.fed.us*), Finley, J.C. (*The Pennsylvania State University, USA*), Neznec, R. (*Society of American Foresters, USA; neznekr@safnet.org*), Araman, P. (*USDA Forest Service, USA; paraman@vt.edu*).

In today's constantly changing professional environment, it is important for foresters to obtain new knowledge in order to stay competitive, increase productivity, or comply with regulations. We sought to understand how new knowledge—innovative techniques and improved technology—reach forestry professionals in the United States. In cooperation with the Society of American Foresters, the professional society that also certifies university programs in forestry and related natural resources fields; we surveyed both members and eligible non-members using a 23-question on-line survey with mailed follow-up. Our ultimate goal is to improve mechanisms for diffusing innovations in the profession. Specific objectives of the survey were to discover the degree of effort foresters will expend to become aware of changes, how they seek to answer specific management questions and whether valuable and credible sources of information are readily available to them.

A secondary objective was to examine relationships between individual learning styles and preferences for types of technology transfer. The survey instrument was pre-tested by individuals from the target population in two focus groups. This presentation will focus on early results of the analysis, focusing on the respondents that indicated regeneration and restoration were important technical topics for which they sought information.

**Networking for sustaining the alpine forests: Innovative knowledge transfer in European forestry.** von Teuffel, K.F. (*Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Germany; Konstantin.Teuffel@forst.bwl.de*).

The complexity of multifunctional forest management (storms, avalanches and climate change effects), structural transformation (traffic, commerce, services) and economic challenges, can only be faced by specialized knowledge. Initiatives in knowledge transfer on different scales are confronted with severe capacity problems. Compiling and working out the supply of strictly user-orientated information is beyond the capacities of single institutions. To obtain synergies, and to exchange expert knowledge, it is necessary to bind existing knowledge and to disseminate information within transnational joint activities. The joint initiative, 'KnowForAlp', a partnership network consisting of 19 institutions from the seven Alpine Space countries, is presented as an example of innovative knowledge transfer, with the task of integrating scientists, practitioners and decision makers in central European forestry. The main goal is information exchange and co-operation for addressing transnational problems and challenges concerning forest management. All relevant institutional levels are taking part as partners (administration, research institutions, forest owner associations, professional organisations, other NGOs) and guarantee an efficient implementation of the project's objectives. The KnowForAlp initiative is characterized by three main activities: a) a detailed inventory and analysis of existing knowledge transfer, b) expansion of internet-based communication links, and c) the establishment of pilot measures and services.

## **Innovation and entrepreneurship – rural development and forest sector competitiveness**

Organizers: Ewald Rametsteiner *BOKU-University of Natural Resources and Applied Life Sciences, Austria; ewald.rametsteiner@boku.ac.at*, Anssi Niskanen *University of Joensuu, Finland; anssi.niskanen@joensuu.fi*, and Eric Hansen *Oregon State University, USA; eric.hansen2@oregonstate.edu*

### **Communities of practice and their contribution to knowledge transfer and capacity building in rural areas.**

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Increasing globalization of markets, the complexity of linked economic relationship structures and modern information and communication technologies have led to radical change in business and social life in many sectors, and particularly in forestry. This structural change and technological development leads to an increasing significance of capabilities for learning and capacity building, particularly for people employed in the forestry-contracting sector, a target group that is hard to reach by formal qualification. The forestry contracting sector is characterized by their 'loose' organizational structure, a high variability of working objects, their isolated worksites, their precarious financial situation, but also by their use of modern technology. However, there is still not much known about knowledge transfer and capacity building in the forestry contracting enterprises. It can be shown that informal, social networks in terms of Communities of Practice (CoPs) represent a crucial function for knowledge transfer and learning. Using a qualitative methodological approach CoPs in the forestry contracting sector are identified. The function of CoPs for capacity building and knowledge transfer in small enterprises in the forestry contracting sector and their impact on formal organizations is described. This leads to a theoretical concept for capacity building in small enterprises in rural areas.

**Strategies of forestry contractors coping with structural change.** Brogt, T. (*Albert-Ludwigs-University Freiburg, Germany; thomas.brogt@fobawi.uni-freiburg.de*), Kastenholz, E. (*Office for Occupational Safety and Work Organisation, Germany; edgar.kastenholz@enfe.net*).

Forestry contractors are faced with a dramatic change of the political, economic and social framework, heralded by the globalization of timber markets, reformed political regulations, new technologies and changing values in rural societies. Qualitative interviews with forestry contractors in the field of mechanized timber harvesting in Germany show that the majority of these enterprises, which are generally small family enterprises and self-employed contractors, have to cope with specific problems deriving from the on-going structural change. The economic and political framework, e.g. the requirements of forest certification in some federal states and the conditions for contracting (terms of tendered contracts), often is rigid and leaves not many opportunities for contractors' development. Still, to a certain extent, contractors find

ways to act pro-actively. First results indicate that contractors use a variety of action strategies, e.g., avoiding growth, searching for new market niches, diversification or even expansive strategies. Of major importance are informal co-operations, personal networks and the personality of the contractor. The results help to understand the framework in which contractors are situated and to identify limiting and supporting factors for their activities.

**Wood product innovations: the effect of the product, market and firm attributes on commercial success.** Bull, L. (*University of Melbourne, Australia; l.bull@pgrad.unimelb.edu.au*).

Wood product innovations are usually developed in response to market need, a change in the supply of raw materials or a chance scientific discovery. Like all industries, some innovations have been successful while others have failed. When successful, product innovation has the potential to increase profits and expand market share. The Australasian (Australia and New Zealand) wood products industry has developed and commercialized a number of wood product innovations in the past 20 years. These have been taken to market in a variety of ways with differing outcomes. Similarly, the North American wood products industry has developed a number of wood product innovations. Some of these have remained in North America and some have entered and been produced locally in other markets. Like the Australasian innovations some are successful in their quest for market share while others are not. This study analyzed a series of wood product innovations in Australasia and North America to determine what allowed some innovations to be successful while others failed. More specifically it seeks to understand the effects that the product, market and firm attributes have on the outcome for wood product innovations in two different geographic settings.

**Innovation in the North American softwood sawmilling industry.** Crespell, P., Knowles, C., Hansen, E. (*Oregon State University, Oregon; pablo.crespell@oregonstate.edu; chris.knowles@oregonstate.edu; eric.hansen2@oregonstate.edu*).

The North American forest products industry has traditionally maintained a production orientation and a commodity mentality toward its operations. The majority of the industry follows a low-cost strategy with efforts concentrated on increasing fiber utilization. Innovation is one approach for enhancing competitiveness. The three general forms of innovation are product, process and business systems. To assess industry practices with respect to innovation, U.S. and Canadian softwood sawmills were surveyed. Mills rated themselves most innovative with respect to process innovation. Product and business systems innovation were ranked significantly below the midpoint of the scale. Respondents' rating of innovativeness increased as mill size increased. When products were divided into three categories: commodity, specialty and custom-made, process innovation was most highly rated in all three categories. Upper management, competitors and retailers were rated as major drivers of innovation. As for sources of innovation, upper management and customers were rated as major originators, regardless of product orientation. A formal new product development process was positively correlated to innovativeness and new product development. Market orientation, especially competitor orientation was significantly correlated to innovativeness as well. A further analysis was performed between highly innovative mills and the rest.

**Competitiveness of wood industry in Europe and the need for innovative business concepts.** Enroth, R.-R. (*Finnish Forest Research Institute Metla, Finland; raija-riitta.enroth@metla.fi*), Toivonen, R., Järvinen, E., Rämö, A.-K. (*Pellervo Economic Research Institute PTT, Finland; ritva.toivonen@ptt.fi, erno.jarvinen@ptt.fi, anna-kaisa.ramo@ptt.fi*).

With over half of the population in EU-25 living in rural areas, forestry and the wood industry are of great importance for rural communities. However, oversupply in Europe, competitive threats posed by growing production e.g. in Russia, and the fragmented structure of the industry result in the need to increase the consumption of wood, to add value to the products and to broaden markets. This paper describes a set of projects concerning competence of the wood industry during 2001–2004, and its role in rural economies. The studies focused on competitiveness of wood on European markets, the outlook for engineered wood products and markets in China. The results indicated that general competitiveness of wood is good in Europe, and the Chinese markets seem promising, regarding high quality interior products. However, for mainly small European wood-industry companies, it is necessary to create not only new far-processed products or new processes but also to develop innovative marketing and service concepts to remain globally competitive. This is a key question also for rural development, and a major future issue for research. One corner stone for positive development is better understanding of consumer needs.

**Process integration from manufactured lumber to consumer.** Haartveit, E.Y., Hoem, L. (*Norwegian Forest Research Institute, Norway; erlend.haartveit@skogforsk.no; line.hoem@skogforsk.no*).

Mergers and acquisitions have led to an increase in company size for manufacturers as well as for distributors and retailers of structural lumber. The effect of this mutual dependency in customer-supplier relationships increased,

presenting opportunities to search for efficiency improvements across company borders. This article reports the findings from a case study involving a major lumber manufacturing corporation in Norway and its largest customer, a vertically integrated distributor and home improvement retailer. In particular, the order process extending from identification of demand at the retail store to fulfillment of demand was comprehensively mapped, and possible areas for improved efficiency in the supply chain were identified. Using this approach, simple solutions for process improvement are commonly found, simply because individual actors rarely focus on optimizing the complete supply chain, but rather sub-optimize a small fraction of the chain. The article also discusses some of the problems encountered when developing measures of performance intended to monitor and improve the process across company borders. Creating measures for monitoring performance is technically and methodologically difficult when dealing with several actors in a complex organization, using different business systems. The challenge greatly increases when the actor's business objectives and philosophies are traditionally conflicting.

**Current state-of-knowledge: Innovation research in the global forest sector.** Hansen, E. (*Oregon State University, USA; eric.hansen2@oregonstate.edu*), Rametsteiner, E. (*BOKU University of Natural Resources and Applied Life Sciences, Austria; ewald.rametsteiner@boku.ac.at*), Bull, L. (*University of Melbourne, Australia; l.bull@pgrad.unimelb.edu.au*), Korhonen, S. (*University of Helsinki, Finland; sikorhon@mappi.helsinki.fi*), Segura-Bonilla, O. (*Universidad Nacional Costa Rica; osegura@una.ac.cr*), Shook, S. (*University of Idaho, United States; Shook@uidaho.edu*).

In recent years, countries with fast-developing economies, change in technologies, especially ICT, changing consumer markets and other factors have had a dramatic impact on forestry and forest-based manufacturing sectors in many parts of the world. As a result, there has been a renewed interest in innovation and innovativeness as a means to maintain global competitiveness and assure healthy economic growth. We discuss findings from a recent multi-authored white paper on innovation in the forest sector. The paper reviews the main concepts applied in contemporary innovation research and related findings, discusses the situation of innovation research (concepts applied, related findings) in the forest sector, identifies future research needs and problems to tackle as well as proposals for further work/ways to strengthen the field. Our goal is to provide a forum amongst global researchers on innovation in the forest sector leading to enhanced networking and discovery in this field.

**A non-parametric approach to analyze productive efficiency, competitiveness and innovation in Spain's wood and paper industry.** Herruzo, A.C., Diaz-Balteiro, L., Martinez, M., González-Pachón, J., Romero, C. (*Technical University of Madrid, Spain; herrzc@montes.upm.es*).

In Spain, previous studies have found a lack of significant links between the efficiency of the timber and paper industries and R&D activities both at the aggregate and industry group levels. This outcome is consistent with the innovation strategy followed in the past by many Spanish industries, based on the acquisition of embodied technology available in international markets and a low entrepreneurial priority toward research and innovation activities as a means to achieve competition. This paper intends to discuss these conclusions in more detail by analyzing the relationship between competitiveness, efficiency and innovation activities in Spain's wood and paper industries. This is accomplished by using a non-parametric technique (data envelopment analysis, DEA), incorporating several inputs and outputs associated with the abilities of these enterprises.

**Threads for the development of forestry contractors in Central and Eastern European countries: The Hungarian case.** Major, M. (*Albert-Ludwigs-University, Germany; matyas.major@fobawi.uni-freiburg.de*), Kastenholz, E. (*Office for Occupational Safety and Work Organisation, Germany; edgarkastenholz@enfe.net*), Lewark, S. (*Albert-Ludwigs-University, Germany; siegfried.lewark@fobawi.uni-freiburg.de*).

The transition of Central and Eastern European countries from centrally planned to market economies led to radical changes. In Hungary, rationalization in the still-dominant state forest enterprises led to the dismissal of almost all directly-employed forestry workers. Workers were offered job opportunities, but now as independent contractors. To describe development tendencies an inquiry using a standardized questionnaire among all Hungarian state forest enterprises (return rate 35%) and 700 forestry contractors (return rate 20%) was carried out. First results indicate that many contractors would strive for economic development, but that their own possibilities for influencing the recent situation are limited. Factors such as precarious economic conditions, insecure future job perspectives, lack of possibilities for decent loans, high taxes and insurance rates and competition by contractors using illegal workers are among the issues that have posed severe threats for enterprises that have been established recently. It is crucial to find solutions for these problems on the level of individual contractors as well as to identify appropriate political and economic instruments to avert the ruin of many contractors, which would lead to the loss of experienced forestry workforce, and threaten Hungarian forestry as a whole.

**Forest sector entrepreneurship and rural development.** Niskanen, A. (*University of Joensuu, Finland; Anssi.Niskanen@joensuu.fi*), Lunnan, A. (*Norwegian Forest Research Institute, Norway, and Agricultural University of Norway, Norway; anders.lunnan@skogforsk.no*).

Entrepreneurship can be defined as perception of new economic opportunities and the subsequent introduction of new ideas in the markets. It has become the engine of economic and social development throughout the world. Rural areas have some fundamental disadvantages for enterprises and entrepreneurship: they provide less skilled labour, less non-traded inputs to industry and at a higher cost and, most importantly, rural areas are less attractive in terms of access to knowledge and information than concentrations of industries and population. Often the actions for new entrepreneurship in rural areas are targeted to the production and use of natural resources e.g. in agriculture, forestry, processing and nature-based tourism. Entrepreneurship policies can promote either demand activities such as deregulation and privatization, or supply activities in which the capabilities of individuals and firms are emphasized. The aim of this paper is to consolidate the knowledge of applied entrepreneurship policies in the forest sector in different parts of the world. Also, the paper aims to identify research needs and knowledge gaps in forest-sector entrepreneurship and suggest approaches for future research.

**Comparison between Italian and Finnish wood-processing SMEs: Possibilities for enhancing competitiveness.**

Packalén, K. (*Finnish Forest Research Institute (METLA), Finland; katja.packalen@metla.fi*).

Woodworking SMEs (small- and medium-scaled enterprises) have significant potential to enhance employment and rural development in Europe. Yet more information on the critical success factors is needed for supporting future competitiveness. By making comparisons between firms with very different enterprise characteristics new perspectives, learning possibilities and options for creating more value-added can be found. This study compares woodworking firms in Italy and Finland by concentrating on business models, in particular the tangible and intangible resources important for success in different types of businesses. Data consists of literature and interviews made for the organizations representing wood-processing SMEs in both countries. SMEs have an important role in the woodworking sector both in Italy and Finland, but their strategic characteristics at firm-level are very different from each other e.g. in regard to enterprise culture and products manufactured. The study sheds light on the present development needs, and provides practical solutions for enhancing competitiveness, e.g. in resource acquisition, know-how development and collaboration.

**Creating value with innovation: From centre of expertise to the forest products industry.** Van Horne, C., Frayret, J.-M., Poulin, D. (*Université Laval, Canada; connie.van-horne@forac.ulaval.ca*).

The specific missions and objectives of forestry centres of expertise vary according to the sources of their funding and their targeted audience. However, a common objective can be extrapolated. That is, to create value using research and innovation in order to achieve sustainable development and growth. The great number and varied nature of centres of expertise in the forest products industry illustrate their importance for the diverse actors of the industry. Their role is analyzed in this paper from the perspectives of innovation and value. Through an exploratory study of two centres of expertise working in the industry, a generic innovation value network model is proposed. This model includes findings from other authors and proposes a new perceptible related to the value perceived and effected by the actors involved in an innovation process. Through this study the authors examine the different actors' understanding of innovation and value. We believe that by improving the understanding of the concept of value creation from innovative knowledge, centres of expertise can develop a better understanding of their own processes and in turn develop better tools to transfer knowledge and create effective value for the forest products industry.

**Innovation in non-timber products and services in Norwegian forestry. Past experiences and future development.**

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Income from non-timber products and services is expected to grow in Norwegian forestry in the coming decades. As the forest holdings in Norway are relatively small, formalized cooperation between forest owners is essential to be able to create value from non-timber products and services. Theories of social capital and rural capital are used to create hypothesis on the importance of local networks and business climate. Entrepreneurship theory is used to explain innovation behaviour of forest owners. Theories of innovation systems are used to study the importance of institutional factors and actors. We tested our theory-based research questions with new survey data on the experience of Norwegian forest owners with innovation in non-timber products and services. We also present two case-studies from the Agder-Telemark district in Norway where we analyze factors explaining innovation success in non-timber products and services. The forest owners associations play an essential role in facilitating non-timber value-added activities and the article concludes with some recommendations on how these associations could be more effective in promoting innovation in non-timber products and services.

## Fire safety of wood structures

Organizer: Robert H. White *USDA Forest Service, USA; rhwhite@fs.fed.us*

**Development of UWI fire standards for the California building code.** Beall, F.C., Quarles, S.L. (*University of California at Berkeley, USA; frank.beall@nature.berkeley.edu; steve.quarles@nature.berkeley.edu*).

Standards for building sub-assemblies have been developed through the Office of the State Fire Marshal, based on previous research at the University of California Forest Products Laboratory. The standards will appear as an addendum to the California building code. Included in the standards are a test protocol and a rationale for the development and results from the protocol. The standards include tests for roofs, windows, decks, exterior siding and eaves. They will be limited to very high hazard areas in the urban-wildland interface, and for new construction. However, it is expected that many of these standards will be applied to existing structures. New proposals are under consideration for funding to expand the scope of the standards and the results from this can be added to the code by amendment.

**Fire retardant treated Western Red Cedar for the Japanese market.** Ieyama, H. (*Channel Original Co. Ltd., Japan; ieyama@channel-o.co.jp*), Wang, Y. (*Chemco Inc., USA; ywang@chemco.us*).

According to the Building Standards Act of 2000, all exterior wall covering material has to be performance tested for use in a Fire Risk Area. Built to conform to actual construction methods, the exterior of the wall assembly was exposed to fire and heated from a vertical furnace under live loads that are typical of multi-story buildings. The interior side of the wall assembly need not be tested if the walls are assembled in accordance with the prescribed construction methods. In most wall tests, not only did fire retardant-treated wood siding outperform some of the most recognized non-combustible cladding materials, it also enabled the simplification of fire-resistance wall assemblies, such as use of the single layer of Gypsum board instead of two layers prescribed in the Building Codes.

**Developing exterior fire retardant treated wood in compliance with AS 3959.** Janssens, M., Carpenter, K. (*Southwest Research Institute, USA; marc.janssens@swri.org*), Wang, Y. (*Chemco Inc., USA; ywang@chemco.us*).

Australian Standard AS 3959 Construction of Buildings in Bushfire-prone Areas requires that all exterior wood building materials have limited combustibility in medium to high fire risk areas. The combustibility is determined on the basis of Cone Calorimeter testing according to *AS 3837 Test for Heat and Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*. In addition to combustibility requirements, the use of wood in exterior building applications also needs preservation treatment. This paper describes the development of fire retardant treatments for two wood species, Radiata Pine and Western Red Cedar, to meet the AS 3959 combustibility requirements. Radiata Pine, a locally abundant species, was treated with preservatives (CCA, CBA) and fire retardants. The dual-treated samples, after accelerated weathering, were tested for compliance with AS 3959 fire performance standards. Western Red Cedar is a naturally durable species that does not require preservation treatment.

**Fire performance of connections in laminated veneer lumber (LVL).** Lau, J., Harris, S., Lane, W., Buchanan, A., Moss, P. (*University of Canterbury, New Zealand; peter.moss@canterbury.ac.nz*).

This paper describes an investigation into the fire performance of connections in LVL made from radiata pine. To determine charring rates, cone calorimeter tests were conducted on samples with various grain orientations and heat flux exposures. Load-bearing fire resistance tests were carried out on LVL beams in a 3 m x 4 m furnace, following the ISO 834 curve. Charring rates were similar to solid wood or glulam. To determine connection performance, an investigation was carried out on the axial tensile strength of a connection that utilized a threaded steel rod bonded into the timber using three different epoxy resins. Some specimens were tested at a constant elevated temperature and others were tested in fire conditions while under constant load. Three resins gave different connection strengths at ambient temperatures and different strength losses at elevated temperatures. Other connections involving lapped splices and a range of different connectors such as screws, bolts, dowels and proprietary connectors are being tested in both ambient and fire conditions to determine their axial tensile strength capacity. The capacity of the connections depends on the shear between the wood members which in turn depends on the embedding strength of the wood and on the yield moment of the connectors.

**An outlook for future repair methodology of traditional timber-frame buildings in Japan.** Osawa, Y., Goto, O. (*Kogakuin University, Japan; yuosawa@aol.com; ogoto@cc.kogakuin.ac.jp*), Trifkovic, S., Yamamoto, H. (*University of Tokyo, Japan; stanko@uf.a.u-tokyo.ac.jp; yama@uf.a.u-tokyo.ac.jp*).

Timber-frame buildings are a cultural heritage of Japan and require scheduled maintenance and restoration to retain their condition and structure. The purpose of this study is to find a new methodology for preservation of traditional timber-frame buildings by investigating the Horyuji Temple complex. It is the oldest wooden heritage building in the world, and has kept the same appearance for 1300 years. The temple has repeated large-scale maintenance at 300-year intervals and small ones at 80-year intervals since it was built, and this maintenance schedule plays an integral part in the longevity of the temple. Our investigations reveal the needed amount, size and type of replaceable timbers for future maintenance. Considering the low productivity of forests in Japan, the definitions and principles that are specified by ICOMOS for preservation of timber-frame buildings at World Heritage sites should be revised. Alternative forest-resource management systems, including the growth cycles of needed replacement timber and the effective utilization of thinned forests should be introduced. The correct understanding of repair methodology and the improvement of the definitions and principles will also lead to more sustainable conditions of traditional timber-frame buildings as well as forests.

**Fire performance of composite lumber products.** White, R.H. (*USDA Forest Service, USA; rhwhite@fs.fed.us*).

Composite lumber products are increasingly used to replace solid lumber products in structural applications. With this increased use, questions about their fire performance are raised more frequently. Two aspects of fire performance are generally regulated. For structural applications, requirements for exposed wood members may include the ability to maintain structural integrity during exposure to the standard fire exposure. A series of tests were conducted to determine the rate of charring during standard fire exposure. Due to their higher density, the charring rate for the composite lumber products was comparable to solid lumber. These tests were followed by a series of tests of large members subjected to both tensile load and fire exposure. Results were compared to the code-approved methodology for calculating the fire resistance rating of structural lumber products. Regulations also address surface flammability. Ignition characteristics and heat release rates are related to surface flammability. A series of cone calorimeter tests were conducted on the composite lumber products to determine their ignition characteristics and heat release rate for various constant heat fluxes.

**Home landscaping in the wildland-urban interface.** White, R.H., McPherson, G., Weise, D.R. (*USDA Forest Service, USA; rhwhite@fs.fed.us; egmcpherson@ucdavis.edu; dweise@fs.fed.us*).

Homeowners in the wildland-urban interface are often advised to control the vegetation near their home to reduce the likelihood of their home being ignited from a forest fire. This poster will discuss cooperative studies being conducted by the Forest Products Laboratory, Madison, WI; the Center for Urban Forest Research, Davis, CA and the Forest Fire Laboratory in Riverside CA to improve the range of alternatives that homeowners have to improve their home and the technical basis for the recommendations. One study was the evaluation of the cone calorimeter test as a methodology to determine the relative flammability of vegetation. A number of ornamental plants were tested. On-going efforts include studies to improve the initial ecoSmart-Fire computer model ([www.ecoSmart.gov](http://www.ecoSmart.gov)) of the Center for Urban Forest Research.

## **Remote Sensing in Forestry: Recent developments of forest remote sensing**

Organizer: Tomasz Zawila-Niedzwiecki *University of Applied Sciences, Germany; tzawila@fh-eberswalde.de*

**Change detection in Ilginehchay Basin (Arasbaran Forests, north-west Iran) using RS and GIS.** Akbarzadeh, M., Kafaki, S.B. (*Islamic Azad University of Tehran, Iran; Mandegarana20@yahoo.com*).

Arasbaran is located in the northern part of East Azerbaijan province and on account of mountainous forests and special stand conditions, with time there was destruction of the fragile ecosystem. Ilginehchay is one of important basins in this region; it is forested as seen from land use maps prepared for forest managers. The combined use of these traditional maps and aerial photographs has been more costly and time-consuming. Satellite data with extensive electromagnetic spectra and repeatable images is suitable for this work. In this research, changes in the Ilginehchay basin, using satellite data and remote sensing techniques, were studied. For the purpose of land use planning, it was necessary to remove differences between the present- and optimum states for rangeland and forests. For these reasons, satellite TM and ETM+ data have been provided by the Iran remote-sensing center from 1987 to 1998. Finally, land use and land cover maps were provided. Comparison between these maps has shown that in this ten-year period, sparse forests and farmlands were reduced by 9.3 ha and 19 ha, respectively. These results showed that stocking rates and soil poverty of the area have increased.

**Study on the leaf pigment content and surface spectral reflectance in different terrain and tree species in Kenting national park of Taiwan.** Chen, J.-C. (*National Pingtung University of Science and Technology, Chinese Taipei, and Academia Sinica, Chinese Taipei*), Wu, S.-T. (*Shih Chien University, Kaohsiung, Chinese Taipei*), Yang, C.-M. (*Academia Sinica, Chinese Taipei*), Chung, Y.-L. (*National Pingtung University of Science and Technology, Chinese Taipei; cct@gisfore.npust.edu.tw*).

This study focused on the leaf pigment content and surface spectral reflectance in different terrain and different tree species in the Nanjenshan Reserve of Kenting National Park, Southern Taiwan. The tree species composition and forest types were changed by an intense northeast monsoon in this area. Generally, the variation of habitat changes the plant characteristics in plant physiology and exterior pattern. In this study we used several common indices of remote sensing techniques to analyze the spectral reflectance data which was collected from a portable spectroradiometers – GER 1500 (Spectra Vista Con.), and biochemical analysis method to estimate the leaf pigment content. Generally, all the vegetation indices apply to single species, especially when the research correlates with biochemical analysis of leaf pigment content. The objective of this study is to develop spectral indices for determination of leaf pigment content in different species and spectral reflectance due to terrain.

**LiDAR: An overview of the technology and its potential in forest resource assessments.** Evans, D.L. (*Mississippi State University, USA; dle@rs.cfr.msstate.edu*).

LiDAR (Light Detection and Ranging) is a relatively new remote sensing tool that has enormous potential in forest resource assessments. This technology utilizes laser ranging to directly measure, with high precision, distances from aerial platforms to the ground. The data have a number of applications in natural resource analysis including, most notably, tree/stand measurements and terrain mapping. This presentation will introduce LiDAR as a viable measurement tool for forestry applications. An overview of characteristics of the present system will be given. This will be followed by discussion of examples of applications from research projects that have been completed or are still underway at Mississippi State University. These include 1) a forests inventory protocol, 2) forest structure analysis, 3) forest typing, 4) LiDAR and satellite data for regional forest assessments, and 5) stand visualization based on LiDAR measurement data.

**Is Near-Infrared Reflectance Spectroscopy (NIRS) suitable to predict the influence of species on litter decomposition rates in mixed stands?** Gruselle, M.-C., Bauhus, J. (*Albert-Ludwigs-University Freiburg, Germany; marie.gruselle@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de*).

Botanical composition of litter mixtures affects composition, richness and activity of the soil decomposer community. The influence of litter proportions from different species has never been determined in litter decomposition studies in mixed forests. Since the conditions for litter decomposition differ from one point to another in mixed stands, the study of the impact of individual species on litter decomposition and nutrient release requires a large number of samples. Moreover, sample processing to separate species in the mixture is time consuming, and is almost impossible for material at advanced stages of decomposition. The suitability of NIRS will be tested in predicting the botanical and chemical composition of forest floor samples coming from nine selected mixed stands on four soil types. Spectra of litter samples collected in mixed stands will be compared with spectra of artificial litter mixtures. This method has shown promising results when the botanical composition of mixed litter samples coming from one mixed spruce-beech stand was calibrated against artificial spruce-beech litter mixtures. Here the relative proportion of both species in mixed litter from the L and F forest floor layer could be predicted with an acceptable degree of accuracy.

**A rugged low-cost UAV-system for forestry.** Hagner, O. (*Swedish University of Agricultural Sciences, Sweden; Olle.Hagner@resgeom.slu.se*).

A rugged, low-cost unmanned aerial vehicle (UAV)-system specifically designed for forestry has been developed at the Remote Sensing Lab, Swedish University of Agricultural Sciences in close cooperation with the Regional Forest Board in Västra Götaland. The system was designed to address the specific needs of local foresters. Some of the applications considered were: rapid detection and documentation of wind-throw, monitoring of regenerating forest, mapping in support of logging operations, and detection of areas that are important for biodiversity. The main requirements dictated by the applications are: colour video or high resolution digital camera plus GPS, portable and operated by a single person, ability to operate from small clearings in forest terrain in adverse weather conditions, low-cost and simple maintenance and safe operation. The use of unconventional materials and building techniques has resulted in a very rugged airframe that can be flown in strong winds, rain and snow. Low cost has been achieved by electric propulsion and off-the-shelf-components for radio-controlled model airplanes. Safety is provided by close-range and low-altitude operation combined with low weight and speed.



**Forest inventory by means of sample based 3d-measurements of laser scanning data and digital aerial photographs.** Holopainen, M., Talvitie, M. (*University of Helsinki, Finland; markus.holopainen@helsinki.fi; mervi.talvitie@helsinki.fi*).

Two of the most promising new remote sensing technologies for increasing accuracy and efficiency of forest inventory are tree-wise 3D measurements of airborne laser scanner data or digital aerial photographs. The present state of the art in tree-wise 3D measurements indicates high potential in assessing various parameters of single trees, and to adapt this information for plot and stand level. Since 3D data (laser scanning data or data derived by digital photogrammetry) is expensive for large areas, it is worth examining as a sampling device. Large-area forest inventory using permanent or non-permanent sample plots are perhaps the most feasible operational applications for 3D methods at the single tree level. Laser-scanned samples or 3D measurements of digital aerial photographs can be utilized in compartment-wise forest inventory, if some cheaper remote sensing material is available for generalizing 3D measurement result to the whole forest area. In this paper, method based on 3D forest measurements and two-phase sampling with stratification is presented.

**Radiometric correction methods of digital aerial photographs in forest inventory.** Holopainen, M. (*University of Helsinki, Finland; markus.holopainen@helsinki.fi*), Tuominen, S., Pekkarinen, A. (*Metla, Finland; sakari.tuominen@metla.fi; anssi.pekkarinen@metla.fi*), Wang, G. (*University of Illinois, USA; wang12@uiuc.edu*).

Numerical interpretation of aerial photographs has been hindered, especially, by radiometric irregularities in the imagery. Issues related to the atmosphere, central projection, viewing angles, sun angle, topography, film properties and camera optics cause bi-directional reflectance. These effects make similar objects in different parts of the image differ greatly with respect to their features. This phenomenon causes difficulties in visual interpretation and is especially problematic in numerical interpretation that is commonly based on the stratification of image features into homogenic classes or strata. The effects of bi-directional reflectance can be analytically corrected with so-called BRDF models that take into account the physical, structural and physiological conditions of the imaging environment and illumination geometry. These models, however, have not been widely used in operative applications due to their complexity. Instead, empirical and semi-empirical correction methods of varying viewing angles and BRDF have been applied quite successfully with digital aerial photos, video imagery and spectrometer imagery. Correction methods developed at the University of Helsinki, department of Forest Resource Management and Forest Research Institute (Metla) are evaluated in this paper.

**The evolution of forest health assessment.** Ramsden, M., Hemmens, T.J., Francis, L.P., De Baar, M., Spolc, D.J., Kennedy, J.F. (*Department of Primary Industries and Fisheries, Queensland, Australia; Michael.Ramsden@dpi.qld.gov.au*).

Since 1996, the Department of Primary Industries and Fisheries (Queensland, Australia) has carried out formal forest health surveys throughout Queensland. The forest health surveillance system has adapted methods similar to those used in British Columbia and New Zealand. An important component of these surveys is the detection and identification of exotic organisms before they become established within plantations. The Government of Queensland has been committed to providing best practice surveillance and this was achieved by harnessing, enhancing and implementing new technologies. Detection of potentially damaging insects has been enhanced by establishing static insect trapping stations throughout key plantations; the traps can target specific insects or populations. Random ground surveys have been supplemented by systematic low-level aerial surveys utilizing palmtop computers with Global Positioning System (GPS) capability. During aerial surveys the palmtops are linked via customized software to laser rangefinders. Using a Geographical Information System (GIS), data is then layered onto complex map and flight transects information for analysis and selection of scientifically based sub-samples for follow-up ground team surveys. The further development of airborne and space-borne remote sensing capabilities is now a high priority and, in conjunction with GIS, is set to revolutionize forest health surveillance.

**Laser technology enhances aerial assessment of plantation health.** Ramsden, M., Hemmens, T.J., Kennedy, J.F. (*Department of Primary Industries and Fisheries, Queensland, Australia; Michael.Ramsden@dpi.qld.gov.au*).

Aerial surveys are an integral part of forest health monitoring programs that use a system based on 1000 m-wide transects. Digitized maps of the area to be surveyed are downloaded into the Pilots GPS (Global Positioning System) followed by a transect layer enabling accurate aerial tracking. Two trained observers monitor a 500 m-wide strip on opposite sides of each transect. Surveys are undertaken using a Cessna flying at 100–135 m above canopy at 70 knots airspeed. Observers accurately log the position of forest disorders using palmtop computers containing integrated differential GPS units linked via customized software to laser rangefinders. Using basic trigonometry the lasers measure the horizontal distance from the aircraft to the observed disorder, adjusting the GPS position taken within the plane. This positional data is combined with descriptive data selected from the palmtop for downloading into a GIS (Geographical Information System), which in turn is linked to plantation register data. Data analysis enables

scientifically based sub-samples to be selected for ground team follow-up action. This LaserPos™ system allows highly accurate positional data to be combined with descriptive data for instant GIS interpretation. There is no other rapid interpretable aerial surveillance system such as this currently in place

**The potential of sensor networks for the atomization of remote sensing analysis in forestry: Using an object based internet analysis server and client (RISC).** Stoecker, M. (*University of Muenster, Germany; mstoeck@uni-muenster.de*).

An important factor for the management of complex forest ecosystems is the availability of actual information about the forests. However, remote sensing technologies are capable of supporting an effective collection system, and providing actual, near real time information about the situation of the forest stands for potential users. At the moment, one main obstacle of remote sensing is that a potential user needs special knowledge and special software to analyze the data. During this presentation, a new object-based remote sensing internet analysis server and client (RISC) is shown; it can analyze user-defined remote sensing data over the internet. The user does not need special remote sensing software. He can use the easy-to-operate client to solve his questions based on the selected remote sensing data and pre-defined classification analysis libraries. The remote sensing data are processed by the server which sends back the vector geometries of the different classes. The user can now integrate these classification results in the local GIS environment. RISC is demonstrated by showing different classification libraries for identifying forested areas and clearcuts.

**Integration of wood utilization with intensive forest management**

Organizer: S.Y. (Tony) Zhang *Forintek Canada Corp., Canada; Tony.Zhang@qc.forintek.ca*

**Enhancing the performance of plantation timbers.** Hann, J., Torgovnikov, G., Shaginov, A., Vinden, P. (*University of Melbourne, Australia; jhann@unimelb.edu.au; grigori@unimelb.edu.au; shaginov@unimelb.edu.au; pvinden@unimelb.edu.au*).

The early processing of plantation timbers selected for growth characteristics can result in the production of a product deficient in strength, dimensional stability and natural durability. Innovative processing of these timbers utilizing microwave technology followed by the production of a solid wood composite can enhance the strength (MOE and MOR) and stability of these timbers. Selection of processing parameters can result in increases in MOE of 20% and 14% in MOR. Processing parameters influencing the outcome included the type of microwave applicator utilized, the choice of binder used for production of the composite, and the pressing schedule applied. Dimensional stability and natural durability enhancement whilst identified by previous workers, is being validated for the process.

**Sound absorption properties of wood from five eucalypt species.** Jiang, Z.H., Zhao, R.J., Fei, B.H. (*Chinese Academy of Forestry, P.R. China; fbh@wood.forestry.ac.cn*).

The sound absorption coefficients of wood and wood boards for five eucalypt species (*Eucalyptus urophylla*, *E. urophylla* × *E. grandis*, *E. urophylla* × *E. tereticornis*, *E. urophylla* × *E. camaldulensis* and *E. cloeziana*) collected from a plantation at the Dongmen Forestry Center of Guangxi Province, China, were tested with the standing wave method and their sound absorption properties compared. The results showed that the sound absorption coefficients of the five eucalypt species did not change below 1000 Hz, but above 1000 Hz their sound absorption coefficients increased with increasing frequency. The difference in sound absorption coefficient among the five species was not evident in the tested frequency range (200–2000 Hz), but the sound absorption property of *E. urophylla* was superior at low frequency. The sound absorption coefficient of tangential-sawn boards is higher than that of radial-sawn boards. The sound absorption properties of eucalypt wood 0.5 cm in thickness is much better than that of 1.0 cm. It is concluded that within the frequency testing range, wood sound absorption properties of eucalypts are affected by their board thickness and the type of sawn timber, but the variance of wood sound absorption properties among the five tested species is not significant.

**Forest biomass supply for energy production: under what conditions can it be efficient in central Europe?**

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In Germany, energy from renewable biomass sources has intense political and social support. Hence, numerous biomass co-generation plants have been installed or are planned. Today, biomass from sustainable forest management is only small

proportion of the utilized biofuels because of its relatively high costs, while mostly cheap waste wood and industrial wood is utilized. In contrast to the intensive forestry in Scandinavia or plantation forestry in the tropics, forestry in central Europe often has to cope with small units and environmental restrictions. To overcome these problems, two approaches were followed to increase the energy wood output per hectare. Thinning intensity was increased by harvesting the intermediate trees usually left in the stand. Crosscutting and sorting of logs was modified so that no industrial roundwood, only high quality saw logs and energy wood were produced. This led to an increased output of energy wood from 30 to 120 m<sup>3</sup>/ha. To reduce the generally high costs for chipping, the raw material was concentrated in central locations or at biomass plants. To transfer the brush-wood from the stands to the chipping terminals, it was either compacted with mobile compactors into containers or processed into bundles with slash bundlers.

**Fundamental properties of com-ply made of small diameter fast growing species and mersawa veneer.** Massijaya, M.Y., Nuryawan, A., Assyh, N. (*IPB, Indonesia; yusram@indo.net.id*).

The main objective of this research was to determine the fundamental properties of com-ply made of small diameter fast growing species and mersawa veneer. The type of particle is wafer, made from *Eucalyptus deglupta* Blume, *Acacia mangium* Willd. and *Paraserianthes falcataria* L. Nielsen, and the face and back layers are mersawa veneers, which have an average thickness of 0.57 mm. The board was bonded by phenol formaldehyde and melamine formaldehyde at 10 % based on oven dry wafer and veneer weight. We found that water content, density and internal bond fulfill the JIS A 5908 standard. However, thickness swelling failed to meet the standard. The dimensional stability of com-ply made of *A. mangium* is better than *E. deglupta* and *P. falcataria*. The bending properties all of the boards met the JIS A 5908 standard.

**Quantifying the impact of commercial thinning on product recovery and economics in jack pine.** Schneider, R. (*Université Laval, Canada; robert.schneider.1@ulaval.ca*), Zhang, S.Y. (*Forintek Canada Corp., Canada; tony.zhang@qc.forintek.ca*), Bégin, J. (*Université Laval, Canada; jean.begin@sbfulaval.ca*), Swift, E. (*Natural Resources Canada, Canada*).

Past studies have focused on the effects of thinning on growth and yield at tree and stand levels. Yet, very few of these studies have evaluated the impact of thinning on product recovery and economics. Using data from five jack pine stands across eastern Canada that were thinned between 15–25 years ago, the impact of commercial thinning on wood quality, product recovery and financial return was quantified. The first step was to model the impact of thinning on stem form to allow a sawmill simulation using the Optitek software. Thinning slightly increases stem taper, thus reducing the lumber conversion factor. At the stand level, results show that the financial value of a commercially thinned stand is increased by decreasing harvesting and lumber conversion costs. However, the smaller stems that are harvested in the thinning play a role in the way the stand value evolves through time. Although the value of the control stands marginally reach the levels of the moderately thinned stands, the value increment is higher for the control stands. Heavy thinning exhibits the least financial return. The lumber volume is, on the other hand, only slightly influenced by thinning intensity.

**The covariance between mechanical and chemical properties of longleaf pine.** Via, B.K., Stine, M. (*Louisiana State University, USA*), Shupe, T.F., Groom, L.H. (*USDA Forest Service, USA*).

The covariance between traits of longleaf pine, *Pinus palustris*, was examined for lignin, extractives, density, modulus of rupture (strength), modulus of elasticity (stiffness) and microfibril angle. The modulus of elasticity and modulus of rupture were found to highly correlated ( $R^2 = 0.85$ ). Near-infrared spectroscopy found these two traits to share five of six significant near-infrared wavelengths for prediction, perhaps attributing the covariance between the two to chemical similarity. Lignin and microfibril angle held a moderate relationship ( $R^2 = 0.40$ ). Density was significant in predicting strength and stiffness for most of the tree except for the juvenile wood zone where microfibril angle appeared more important. The relation of extractives to density suggests that extraction of increment cores may improve covariance analysis.

**Strandboards made of hybrid poplar clones from different locations: quality and wood chemical characterization.** Wan, H., Wang, X.M. (*Forintek Canada Corp, Canada; hui.wan@qc.forintek.ca*), Liu, Z.-M. (*Northeast Forestry University, China*), Zhang, S.Y. (*Forintek Canada Corp, Canada*).

In this experiment, 10-year-old logs from different hybrid poplar clones (*Populus deltoides* x *P. nigra*, *P. trichocarpa* x *P. deltoides*, *P. maximowiczii* x *P. balsamifera* and *P. deltoides*) grown in two different locations in Canada were flaked into strands with a commercial flaker. The strands were used to make strandboard under the same hot press conditions. Different sections and portions of the trees were also used to make strandboard. The chemical properties of these clones were characterized. It was found that the strands from different clones at the same flaking parameters had similar strand size distribution. Under the hot press conditions selected, the performance of the strandboard made of

hybrid poplar clones from St-Ours, Quebec, normally met the requirements of CSA 0437 1999 for R-1 grade panel, while panels from the same clone grown in Windsor, Ontario, were subject to panel delamination. We also determined that different tree sections within a clone react differently, with the bottom section successfully producing panels but the top section resulting in panel delamination. The pH and acid and base buffer capacities of these clones were different, which may be explained by clone type and location. The chemical differences in these hybrid poplar clones may also help explain differences in panel performance.

**Development of an integrated decision-support system for stand density management.** Zhang, S.Y., Liu, C.M., Sharma, M., Tong, T. (*Forintek Canada Corp., Canada; Tony.Zhang@QC.forintek.ca*).

An integrated decision-support model was developed for jack pine to assist forest managers in making stand density management and harvest decisions based on stand product recovery parameters instead of the conventional stand yield approach. The model includes four integrated components: 1) a refined stand-level growth and yield model, 2) a model for estimating jack pine diameter distributions using commonly measured stand characteristics, 3) a model describing the relationship between stem quality characteristics and stand density, tree and stand characteristics, and 4) a model describing the relationship between major product recovery parameters and tree/stand characteristics. Product recoveries of individual trees were linked with diameter distribution models to develop the stand-level model for jack pine stand management in eastern Canada. The model developed in this study estimates product recoveries of individual trees and forest stands prior to harvesting. It is evident that the product parameter-based decision-support model would be a valuable management tool for forest resource managers.

## **Optimal matching of species to sites: impacts on growth and wood quality**

Organizer: David Lee *Department of Primary Industries, Queensland, Australia; David.Lee@dpi.qld.gov.au*

### **Potential gains in wood quality from matching taxa to sites: The Queensland pine plantation experience.**

Harding, K.J., Copley, T.R., Toon, P.G. (*Department of Primary Industries and Fisheries, Queensland, Australia; Kevin.Harding@dpi.qld.gov.au*), Dieters, M.J., (*University of Queensland, Australia*), Peters, R.F. (*Department of Primary Industries and Fisheries, Queensland, Australia*).

Site impacts on plantation pine wood properties are reviewed considering results from routine plantations, genetic family trials and clonal tests. Variation among pure species and hybrid taxa in some wood properties are important and are accentuated by site quality, and latitudinal and elevational trends. The implications for timber processors and the opportunities to influence product quality by utilizing this variation are considerable. Families and clones deployed across diverse sites can display relative uniformity to highly reactive trait expression. There is scope to select stable genotypes for broad-scale deployment or for specific site matching to produce wood with particular qualities. Managers need to consider the practicality and economic merits of each approach. The latter requires detailed knowledge of edaphic factors for each planting site and broad-scale testing to reliably predict genotype performance on a particular site. Producing a deployment population of stable genotypes requires selection emphasis, adding to both assessment and selection costs. Matching genotypes that express superior traits on specific site types requires intensive knowledge to strategically deploy genotypes to maximize gains. The potential gains available from both approaches require quantification so that returns on investment can be accurately compared. Queensland results relevant to such an appraisal will be evaluated.

### **The feasibility of clone-site matching considering wood stress end-splitting: A case study of *Eucalyptus grandis* sawtimber in South Africa.** Verryn, S.D., Eatwell, K.A. (*Environmentek, CSIR, South Africa; SVerryn@CSIR.co.za*).

Plantation grown *Eucalyptus grandis* in South Africa can express a significant amount of wood end splitting, which is traditionally attributed to 'growth stresses'. The expression of end splitting and tree growth have been shown to be subject to both environmental and genetic factors, and the interaction between these factors. The economic implications of alternative strategies to address this genotype-environment interaction can have far-reaching impacts. An equation is derived predicting the recovery rate of sawn timber from trees grown on a site, regarded as medium-high for both splitting and growth, using a sawmill study of 260 trees. The heritability of DBH was 0.41 (standard error = 0.12) and that for regressed splitting score was 0.37 (standard error = 0.1). The mean score of wood end splitting can double, when comparing the splitting of four-year-old clones on high- and low-splitting sites. When comparing the highest and lowest splitting clones over 25 sites, the mean score of splitting varied by as much as 50%. Given the above information and equation, the feasibility of matching low splitting clones to high splitting sites, is investigated as a case study. This is compared to the feasibility of simply selecting for growth for deployment.

## Understanding and managing wood quality to improve product value

Organizer: Simon Potter, CSIRO, Australia; Simon.Potter@csiro.au

### Failure mode and microscopic failure of round bamboo (*Dendrocalamus asper* (buloh betong)) loaded in compression and shear. Ahmad, M., Zakaria, M.N., Nordin, K. (*Universiti Teknologi MARA, Malaysia; mansur628@salam.uitm.edu.my*).

Mode of failure of the round bamboo in relation to strength properties of *Dendrocalamus asper* (Bamboo: Buluh Betong) loaded in compression and shear parallel to grain were investigated. Comparison of the mode of failure at different culm portion and between internodes and nodes were carried-out. The modes of failure were identified through visual examination of the tested sample and were further examine under microscope. The failure modes in compression were observed to exhibit three types: splitting and compression (mode 1), multiple failure (mode 2) and compression and end rolling (mode 3). The failure mode in shear exhibited only splitting failure for internodes and nodes. There are some significant differences in the strength properties related to the modes in compression and shear between the portion (bottom, middle and top). The failure modes between the nodes and internodes were found to be significantly different. When observed for microscopic failure at the internodes, the failures occurred primarily at parenchyma region especially at radial direction. However, failure at nodes occurred in both vascular bundles and parenchyma region.

### Using modeling and simulated sawing to value the resource of *Pinus caribaea* var. *hondurensis*. Catchpoole, K., Nester, M. (*Department of Primary Industries and Fisheries, Queensland, Australia; Kerrie.Catchpoole@dpi.qld.gov.au; Marks.Nester@dpi.qld.gov.au*), Leban, J.-M. (*Institut National de la Recherche Agronomique, France; Leban@nancy.inra.fr*), Harding, K.J. (*Department of Primary Industries and Fisheries, Queensland, Australia; Kevin.Harding@dpi.qld.gov.au*).

A decision support system has been developed to link silviculture with wood quality through simulation software. The French-developed Win-EPIFN software has been customized to process simulated stands of *Pinus caribaea* var. *hondurensis* plantation grown in Queensland, Australia. Models of tree growth (height and diameter), branch architecture (height to first green branch, height to first green whorl, height to first dead branch, mean branch diameter per whorl, number of branches per whorl, branch insertion angle and whorl height) and wood density were developed. These models were incorporated in the Win-EPIFN software to perform simulated sawing to specified log lengths and sawing patterns. The machine-graded pine grading rules were used to grade each board produced from Win-EPIFN using separate grading software. This provides a distribution of volume across structural classes to predict the value of the resource. The decision support system allows forest managers to scenario-test different silvicultural scenarios and evaluate the impacts on graded recovery. As an example, these scenarios include the impact of spacing and branch architecture on graded recovery, and the impacts of a change in rotation age on wood quality.

### Kinetics of xylem cell formation in trees and its significance to wood quality. Dünisch, O. (*University of Hamburg, Germany; oliver.duenisch@iangbot.uni-hamburg.de*).

The kinetics of xylem formation of selected high-valued timber trees (gymnosperms and angiosperms) were studied along the shoot circumference and along the shoot axis in a model system. By means of high resolution 3-D laser scans of the shoot, anatomical studies and cellular UV spectroscopy, the phase of radial cell enlargement of individual cambium derivative cells was dated exactly, while the phase of cambial cell division, the phase of secondary wall formation and the lignification of the cell walls were dated in good approximation. It was determined that radial cell enlargement of xylem cells occurs for only several minutes to hours, while secondary wall formation and the lignification of the cell wall occurs over a period of several days to months. The influence of photoperiod, temperature and the water and nutrient supply of the soil on the kinetics of xylem cell formation was investigated under controlled growth chamber conditions. It was determined that wood quality, expressed in terms of anatomical and chemical properties and the formation of growth stresses, are correlated with the kinetics of xylem cell formation.

### Measurement technology and the wood value chain. Evans, R. (*Ensis, Australia*).

Wood is a remarkably versatile raw material. At the heart of this versatility is a complex, organized structure, with sufficient variability to allow trees to adapt to a wide range of conditions as they grow and to withstand the elements, pests and diseases for up to several thousand years. This complexity and variability imposes considerable challenges for characterizing and controlling wood properties. Wood is sufficiently organized to invite detailed investigation at every level, yet sufficiently variable to defy complete characterization. Many analytical tools have been used in an effort to understand and control wood structure for a huge range of end-uses, including electromagnetic radiation, subatomic particles and sound waves. Wood has been broken down for physical and chemical analysis, and even

synthesized in cyberspace in an effort to understand its biogenesis. We have looked at wood variation at scales ranging from nanometres to megametres, and still we struggle to understand and control this most important material. This presentation examines some of the techniques used to analyze wood for the purposes of optimizing its commercial value, emphasizing factors influencing the appropriateness of these techniques to different parts of the wood value chain. Finally, as 'data is not knowledge', I will discuss some common difficulties of interpretation and modeling.

**Variations in wood-water relations in wood with changing weather conditions.** Leal, S., Sousa, V.B., Pereira, H. (*Instituto Superior de Agronomia, Portugal; spleal@yahoo.co.uk; vsousa@isa.utl.pt; hpereira@isa.utl.pt*).

For the last century, cork oak, *Quercus suber* L., stands are oriented towards cork production and the wood used only for fire. However in the 17<sup>th</sup> century it was one of the most important woods for naval construction because of its strength and durability. The wood has also strong aesthetic properties. This work is part of a larger study on the potential of cork oak wood as high quality material. The drying process is a crucial stage for the final quality of wood products. The main wood defects caused by drying can be avoided if the process is performed according to the wood's characteristics and to the conditions it will be exposed to while in use. Our objective was to provide information to sawmills working in the future with cork oak wood about its behaviour with water at different air humidities and temperatures. Three temperatures, representing average conditions inside acclimatized homes, and winter and summer temperatures inside non-acclimated homes, were tested: 22, 15 and 27 °C, respectively. Variations in wood moisture content, density and dimensional stability with decreasing air humidity will be calculated, for each of these temperatures. Equilibrium moisture content and drying curves will be built as well. The research is still on-going.

**Does climate and nutrient optimization affect the wood structure and chemistry of Norway spruce ?** Piispanen, R., Lehto, S. (*Finnish Forest Research Institute (METLA), Finland*), Linder, S. (*Swedish University of Agricultural Sciences, Sweden*), Saranpää, P. (*Finnish Forest Research Institute (METLA), Finland; pekka.saranpaa@metla.fi*).

The effects of fertilization on growth rate and wood structure (fibre dimensions) and wood chemistry of Norway spruce, *Picea abies* (L.) Karst., was studied at a long-term nutrient-optimization experiment in Flakaliden, northern Sweden and in Asa, southern Sweden. The experiment was established in 1987 in a 28-year-old stand in Flakaliden and in a 14-year-old stand in Asa. The amount and composition of nutrient addition was determined annually on the basis of nutrient analysis of foliage, monitoring of nutrients in soil water, and predicted growth response. Altogether, 12 trees and 9 trees from irrigated-fertilized plots and 12 and 9 control trees from untreated plots were selected for analysis of wood properties, after 12 years and after 16 years treatment in Flakaliden and Asa, respectively. Nutrient optimization increased the growth rate three-fold in Flakaliden. The fertilized trees had shorter and thinner-walled fibres than the control trees. Also, latewood proportion was significantly smaller in fertilized trees than in control trees. The concentration of lignin was higher in fertilized trees compared to control trees. However, the effects were different in Flakaliden than in Asa. Fertilization did not affect fibre length in Asa, even though growth rate was doubled compared to control trees. The different responses observed maybe due to differences in vegetation period and genetic differences between the two provenances.

**Properties of fibers for the paper industry from sustainable eucalyptus plantations.** Rezende, G.D.S.P., Demuner, B., da Silva Jr., E.C. (*Aracruz Celulose S.A., Brazil; gdr@aracruz.com.br*).

Eucalyptus is presently the most widely used short-fibered papermaking raw material in the world. Since early 1970s, Aracruz uses *Eucalyptus grandis*, *E. urophylla* and their hybrids for pulp production in Brazil, due to their fast growth, adaptability to different sites and suitability to meet key requirements of different paper grades. By the early 1980s Aracruz developed cloning on a commercial scale. The clonal forests provided significant advances in wood productivity, fiber quality and uniformity, and also gave Aracruz a distinct competitive edge in the worldwide market. A key concept in this practice was the development of a flexible fiber platform. Bleached eucalyptus pulp fiber attributes, such as short fiber length and large number of fibers per gram, translate into a number of desired paper properties for different fine and tissue paper grades (excellent formation, tissue softness, surface smoothness, high opacity, and especially good bulk and dimensional stability). Eucalyptus pulp production and use is still growing. Continuous development of sustainable silvicultural practices and improved clones associating faster growth (harvestable trees in 5–7 years) and better wood quality have been recognized as key elements for producing high added-value pulp at lower costs.

**Maturity effect on basic density, shrinkage and shrinkage anisotropy of Scots pine wood.** Riekkinen, M., Lukkarinen, A., Kärnä, J., Verkasalo, E. (*Finnish Forest Research Institute (Metla), Finland; mika.riekkinen@metla.fi*).

Many wood properties are affected by a variety of genotypic and environmental factors. In addition, the maturation of cambium forming wood cells has a great effect on the properties of formed wood. With increasing maturity the basic

density of Scots pine wood predominantly increases and the shrinkage of wood decreases. The cambium maturity could be expressed in terms of life time (age), or in terms of production (size expressed by the distance from pith). The density and shrinkage variations of wood and the juvenile wood phenomenon should be better known in mechanical wood processing in order to control better the production processes, for instance in sawing, drying, gluing and surface treatments. A sample of approximately 2700 clear wood specimens from different heights was cut from a total of 480 trees growing in 60 mature mineral soil stands in Finland and Sweden. The relationship of basic density and shrinkage to maturity expressed in terms of age or size was studied, answering the question on the primary explanatory variable of these properties. Also the relationship between shrinking anisotropy and maturity was examined. The regional variation and the dependence of relation of maturity and the selected properties on the longitudinal position of the samples were also determined.

**Visual and machining properties of Nordic Scots pine for joinery and furniture industry.** Riekkinen, M., Lukkarinen, A., Kärnä, J., Verkasalo, E. (*Finnish Forest Research Institute (Metla), Finland; mika.riekkinen@metla.fi*).

The specific wood properties of Nordic Scots pine (*Pinus sylvestris* L.) applicable for further processed end-use products, as well as their variation and the affecting factors are not well known, demonstrated, or fully utilized in marketing. Pine wood tends to have large variations in material properties related to silviculture and growth region. Additionally, the level and variation in those properties are most probably different compared to other competing species and non-wood materials. Visual properties can affect customers' choices. In addition, some of these properties, such as grain orientation and knottiness, affect the wood machining properties. Sixty mature Scots pine-dominated stands were selected in three regions in Finland and two regions in Sweden, 12 stands from each region. In each stand, eight Scots pine trees covering the diameter range of conventional saw log and small-diameter log trees (DBH>14 cm) were felled for sampling. The visual and machining properties of wood were examined by studying the heartwood phenomenon and the grain orientation on cut surfaces, in addition to the knottiness properties. Brinell-hardness perpendicular to grain, expressed as the ability of wood to resist the impression of a steel ball under the action of a constant force and the static shear strength parallel to grain were also studied.

**Impact of sustainable harvesting procedures on the wood chain in tropical countries.** Sales, C.G. (*Cirad Forestry Department, France*).

The new procedures in forestry sustainable management are mainly based on an increase of the harvested volume per surface unit to reduce the environmental impact of logging. It is considered that taking into account an ecological point of view, it is less damaging for a forest to cut more trees in a small area than a few trees on a large area. In many tropical rainforests this evolution is changing timber production in terms of species and log quality. The impact on the wood chain in tropical countries is important and strongly related to the type of forest and domestic market demand. For some countries or regions, the adaptation is quite easy. For others, the wood chain should search for new markets, new kinds of manufactured forest products, and will need important investment to adapt its processes of transformation to the new timber resource.

**Internal quality of Scots pine from thinnings.** Stöd, R. (*Finnish Forest Research Institute, Finland; reeta.stod@metla.fi*).

Currently, only a few Finnish sawmills use small-sized timber harvested from commercial thinning as raw material. Several reasons have inhibited its utilization from becoming more common. Firstly, the harvesting costs are high in thinning because of the small average stem size. Secondly, to date there has been an adequate supply of large logs for sawmills. The young and advanced thinning stands' proportion of the cutting potential will, however, increase because the amount of mature stands is diminishing. Moreover, the quality and properties of young trees are not well known. The objective of this study was to investigate the internal quality of young Scots pine trees and to determine the factors—site type, tree properties and silvicultural measures—that affect it. In addition, the relations between internal and external quality were studied. The study produced information regarding the amount and location of knot-free wood material, as well as sound and dead knot sections and other defects. The results enable sawmills to adjust bucking and to direct the raw material to appropriate processes more precisely.

**Consideration of wood quality traits in the prediction of *Eucalyptus grandis* sawtimber recovery and veneer value recovery in South Africa.** Verryn, S.D., Snedden, C. (*Environmentek, CSIR, South Africa; SVerryn@CSIR.co.za*), Wessels, B. (*University of Stellenbosch, South Africa*).

The economic impact of 39 traits of *Eucalyptus grandis* were tested against the sawntimber recovery and veneer value recovery in two mills. Predictive models were derived for the two products. Veneer value was predominantly influenced by the diameter at breast height (DBH), followed by the wood splitting score and interlocking grain. Other properties that play a lesser role in the value are: sapwood/heartwood ratio, minimum density of core, the standard

deviation of radial shrinkage, stress probe values, disease score and stem straightness. The sawmill value was also predominantly influenced by DBH and wood splitting, although brittle heart was also included as a significant factor. Other traits of importance were total radial shrinkage and wood stress. Brittle heart was the cause for 92% of the downgrading. In conclusion, DBH, wood splitting and brittle heart were confirmed to be the major influencers on the value of eucalypt solid wood products. These properties were investigated further.

**Variation of wood properties in relation to felling date (with special emphasis on season of the year and moon phase).** Zuercher, E. (*HSB, Switzerland; ernst.zuercher@hsb.bfh.ch*), Giudici, F. (*Swiss Federal Institute for Forest, Snow and Landscape, Switzerland; Fulvio.Giudici@wsl.ch*).

Traditional knowledge, in form of so-called rural rules, indicate that the date of tree felling has an important influence on wood quality. The main factor, after the season of the year, is said to be the position of the moon. The objective of this project was to study the variability of the user-related properties of 'moon-wood' (Mondholz), by scientifically analyzing measurable factors. The material for this project is from five different Swiss sites and is representative of central European conditions. The study involved 624 trees—European spruce, sweet chestnut and silver fir—felled on 48 dates throughout the fall and spring of 2003–2004 (but always on Mondays or Thursdays). Before the start of the experiment, one sample was taken on the same day from each of the study trees, to serve as reference samples. Wood factors tested are: water-loss, shrinkage under controlled drying, air dry and oven dry density, compression strength, hygroscopicity, leachability and resistance to weathering, decay and fire. The statistically analyzed factors of variation are: weather, astronomic and geodetic type (gravimetry and geomagnetism). The results from this study should bring transparency and objectivity to an unexplored field of traditional knowledge, a field subject to controversial discussions.

## Recent developments in biodegradation and protection of wood materials

Organizers: Andrew H.H. Wong *University Malaysia Sarawak, Malaysia; ahhwong@frst.unimas.my*, and Jack Norton *Department of Primary Industries, Queensland, Australia*

**Development of a non-destructive spectroscopic method for the evaluation of the natural durability.** Baillères, H., Thévenon, M.-F. (*CIRAD, France; henri.bailleres@cirad.fr*), Callot, H., Lanvin, J.D. (*CTBA, France; calixte.blanchard@ctba.fr*).

The objective of this study was to find spectroscopic methods for fast and low cost evaluation of the natural durability (resistance to fungi) of four technically and economically significant species: oak, chestnut, teak and Douglas-fir. Two spectral zones were studied: the visible spectrum and the near infra-red spectrum. Spectro-colorimetry makes it possible to establish statistically relevant models, but is of little or no use in establishing a reliable and robust evaluation of natural durability. The use of the near infra-red spectroscopy makes it possible to obtain useful models, and although reliability and robustness are good, it must be improved for routine use. This implies the use of training samples, covering the total range of variation, are required to analyze and implement more elaborate chemometric methods. In the case of the very durable species, the standard test is not very discriminating, and its improvement for these species should be considered in order to extend the range of variation of the natural durability parameters and to allow the development of more precise models.

**Genetic components of four wood chemical traits assessed by NIRS in *Eucalyptus urophylla* x *E. grandis* full sib families.** Baillères, H., Vigneron, P., Giordanengo, T. (*CIRAD-Forêt, France; henri.bailleres@cirad.fr*), Ognouabi, N. (*UR2PI, Republic of Congo*), Gion, J.M., Chaix, G. (*CIRAD-Forêt, France*).

Wood chemistry properties were assessed by near-infrared diffuse reflectance spectroscopy (NIRS), a rapid prediction measurements technique, on *Eucalyptus urophylla* x *Eucalyptus* hybrids in order to analyse a Congolese progeny test. Calibrations were set for lignin content, syringyl/guaiacyl monolignol ratio, extracts contents and total phenols content. A second aim of this work was to test NIRS efficiency to predict total phenol content, which is correlated with heartwood formation and natural durability. Different spectrum pre-processing and a wavelength selection by genetic algorithm were used to improve calibrations quality. The best calibrations have sufficient predictability to assess wood chemistry traits. Moreover, total phenol content calibration was the most efficient. The four properties were predicted for the samples of the half progeny test. A genetic analysis gave the heritability values, the phenotypic, genetic and environmental correlations and the genetic gain from direct and indirect selection.



**Chemical polymorphism and antifungal activity of essential oils from leaves of different provenances of indigenous cinnamon.**

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The essential oils isolated from nine geographical provenances of indigenous cinnamon (*Cinnamomum osmophloeum* Kaneh.) leaves were examined by GC-MS and their chemical constituents were compared. According to GC-MS and cluster analyses, the leaf essential oils of the nine provenances and their relative contents were classified into six chemotypes: cinnamaldehyde, cinnamaldehyde/cinnamyl acetate, cinnamyl acetate, linalool, camphor and mixed. In addition, the antifungal activities of leaf essential oils and their constituents from six chemotypes of indigenous cinnamon were investigated. Results from the antifungal tests demonstrated that the leaf essential oils of cinnamaldehyde type and cinnamaldehyde/cinnamyl acetate type had excellent inhibitory effects against white-rot fungi, *Trametes versicolor* and *Lenzites betulina* and brown-rot fungus, *Laetiporus sulphureus*. The antifungal indices of leaf essential oils from these two chemotypes at the level of 200 Bg/ml against *T. versicolor*, *L. betulina* and *L. sulphureus* were all 100%. Cinnamaldehyde possessed the strongest antifungal activities in comparison with other constituents of the essential oils from cinnamaldehyde type leaf, and at the level of 100 Bg/ml its antifungal indices were 100%. The IC<sub>50</sub> values of cinnamaldehyde against *T. versicolor*, *L. betulina* and *L. sulphureus* were 73, 74 and 73 Bg/ml, respectively.

**Anti-termite activities of essential oils from coniferous trees against *Coptotermes formosanus* Shiraki.**

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In this study, anti-termite activities of 11 essential oils from three coniferous trees against *Coptotermes formosanus* Shiraki were investigated according to direct contact application. The yields of essential oils from *Calocedrus formosana* heartwood, sapwood, bark and leaf were 5.8, 0.2, 5.5 and 3.4 ml/kg respectively, from *Cryptomeria japonica* heartwood, sapwood, bark and leaf were 3.8, 1.3, 6.3 and 27.4 mL/kg respectively, and from *Chamaecyparis obtusa* var. *formosana* heartwood, bark and leaf were 9.5, 2.6 and 14.1 ml/kg, respectively. Results from anti-termite tests against *C. formosanus* demonstrated that, at the dosage of 10 mg/g, the heartwood and sapwood essential oils of *C. formosana* and *C. japonica* and the leaf essential oil of *C. obtusa* all produced 100% mortality after 5 days. Among tested oils, *C. formosana* heartwood essential oil killed all termites after 1 day, while the LC<sub>50</sub> value was 2.6 mg/g, exhibiting the strongest termiticidal property.

**Effectiveness of some commercial preservative systems against subterranean termites after leaching cycle.**

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This study was conducted to determine the effectiveness of some commercial preservative systems used to treat rubberwood LVL after leaching cycle. Four types of preservative systems were used: Timberlife Exterior™ (brushing method), Protim 235WR™ (double vacuum method), Protecta C (glue-line method) and Protecta C97 (glue-line method). The durability of the treated rubberwood LVL (with and without leaching cycles) against subterranean termites (*Coptotermes curvignathus* Holmgren) was evaluated. Test blocks measuring 20 × 20 × 10 mm were cut from 25 mm-thickness LVL boards (seven ply veneers with 4.0 mm thickness). The test blocks were then exposed to 240 termites with 10% soldiers and 90% workers (1.0 ± 0.05 g) for 28 days according to ASTM D: 3345-74. Twenty-five test blocks measuring 20 × 20 × 10 mm were subjected to leaching cycles test according to JIS A 9201 prior to termite resistant test. The percentages of weight loss and termite mortality were calculated at the end of four weeks. Results showed that Protim 235WR™ gave the best protection against subterranean termites, with mean weight loss of 10.6%, followed by 12.8, 17.8 and 19.3% for Timberlife Exterior™, Protecta C97 and Protecta C respectively. There was no significant relationship between preservative systems and treatment conditions (with and without leaching cycles).

**Fungi causing utility pole decay in South Africa.** de Meyer, E.M., de Beer, Z.W., Wingfield, M.J. (FABI, University of Pretoria, South Africa; elsie.demeyer@fabi.up.ac.za; wilhelm.debeer@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za), Couto, M. (Technology Services International (TSI), South Africa).

Eskom, the largest supplier of electricity in Africa, uses approximately 2.2 million wooden utility poles. Recent investigations found the annual failure rate of poles is approximately 5%, and a major cause is fungal decay. This study was initiated to identify decay fungi, because no information is currently available on the fungal species causing pole decay in South Africa. Samples were collected from six sites throughout South Africa. At each site, two wood cores were removed from 30 poles at soil level with an increment borer. Wood samples were sliced, the disks placed on growth medium and incubated until fungal growth occurred. Cultures were purified and grouped based on culture and spore morphology. Ribosomal DNA (ITS regions) of selected isolates from each group were sequenced for confirmation of identification. More than 470 fungal isolates were obtained and these represented at least 63 species of fungi. The predominant fungal groups were from the genera

*Paecilomyces* and *Sorocybe*. Statistical analyses of the results suggest a strong interaction between pole treatment, age and fungal species present. These results provide a firm base for future evaluations of chemical and biological control strategies.

**The natural durability of timber exposed to the weather, out of ground contact in eastern Australia.** Francis, L.P., Norton, J. (*Department of Primary Industries and Fisheries, Queensland, Australia; jack.norton@dpi.gld.gov.au*).

A comprehensive field research project was established in 1987 to address the absence of research data regarding the performance of timber in above-ground, weather exposed situations in Australia. Prior to the establishment of this research project, above-ground timber durability classifications had been inferred from anecdotal information and from the results of a single in-ground trial. However, there are distinct limitations and inaccuracies arising from extrapolating above-ground classifications from in-ground classifications, due to the different decay and insect hazards for each situation. The aim of the project was to determine above-ground durability ratings for 39 timbers that are commercially significant in Australia and to provide a reference datum for classifying novel wood-based materials. Methods to improve the durability of timber joints have also been examined, along with the effect of painting joinery. Replicate timber specimens were installed at sites throughout the east coast of Australia, onto specially designed racks to represent situations of high decay hazard above-ground. Each specimen consists of two lengths of timber, 35 x 35 mm in cross section, joined to form an L-shape using a mortise and tenon joint. Each specimen (or 'L-Joint') has been assessed periodically to monitor its performance over time. The L-Joints have now been exposed for 16 years, and results to date are discussed.

**Micromorphological and chemical characteristics of cengal heartwood decayed by soft rot fungi.** Kim, Y.S., Singh, A.P. (*Chonnam National University, Republic of Korea; kimys@chonnam.ac.kr*), Wong, A.H.H. (*Universiti Malaysia Sarawak, Malaysia*), Eom, T.-J. (*Kyungpook National University, Republic of Korea*), Lee, K.H. (*Chonnam National University, Republic of Korea*).

This study was undertaken to: 1) characterize degradation of cengal (*Neobalanocarpus heimii*) heartwood using ultrastructure and chemistry, and 2) investigate the correlation between soft rot decay and its micro-distribution in wood tissues. Cengal heartwood revealed a high amount of extractives, with a relatively high amount of condensed lignin and guaiacyl units. Microscopic observations revealed that vessels, fibers and parenchyma cells all contained extractives in their lumina. TEM micrographs showed that cells were impregnated with extractives and that pit membranes connecting parenchyma cells were coated and impregnated with extractives. However, fungal hyphae were present in the extractive masses localized in cell lumina—indicating incompletely inhibition of fungal growth. The extent of cell wall degradation varied with tissue types. Fibers appeared to be more susceptible to decay than vessels and parenchyma. Middle lamella was the only cell wall region remaining intact in all cell types. Microscopic observations suggested a close correlation between extractive micro-distribution and the pattern and extent of cell wall degradation. In addition to the toxicity to fungi, the physical constraint of the extractive material is likely to have a profound effect on the growth and path of invasion of colonizing fungi. The presence of relatively high amount of condensed lignin is also likely to be a factor in the resistance to soft rot decay.

**Implications of findings from a 20-year graveyard test study of 100 Sarawak timbers and eight commercial wood preservatives on the economic utilization of tropical timber.** Ling, W.C. (*Forest Department, Sarawak, Malaysia; wccrling@streamyx.com; wcling@sarawakforestry.com*).

In 1978, a graveyard test site was established in Sibu, Malaysia in a secondary forest with clay soil supporting active termites and fungi. Vegetation was cleared and test samples were planted at 100 x 50 cm spacing. For each species, authenticated samples from 3 trees were processed into 60 pieces of 19 x 19 x 457 mm to represent sapwood, outer heartwood and inner heartwood. Both control and treated samples were planted to a depth of 228 mm and rated at 6 months interval using visual assessment following ASTM D 1758. Data collected over the years were analyzed using SPSS, the failure point for a species was defined as when half the heartwood reached a rating of 7 (moderate degrade). Timber with over 32 kg/m<sup>3</sup> dry CCA dry salt retention performed better than *Eusideroxylon zwageri* (Belian), the most durable timber in Borneo. From statistical analysis, the durability of species tested was classified. It was observed that CCA treated refractory timber had high durability even when the preservative penetration was less than 3 mm, indicating potential for better utilization of refractory timber. The performance of wood preservatives in order of effectiveness were CCA (>25 years), Creosote (10 years), FCAP (5 years) and BFCA (3 years).

**Importance of the wood secondary metabolites on the physical properties and the durability of four tropical wood species from Cameroon.** Mbang, T. (*National Polytechnique School of Yaoundé, Cameroon; mbandtheophile@yahoo.fr*), Thévenon, M.-F., Gérard, J., Thibaut, A. (*CIRAD, France; marie-france.thevenon@cirad.fr; jean.gerard@cirad.fr; anne.thibaut@cirad.fr*), Thibaut, B. (*CNRS, France; bernard.thibaut@guyane.cnrs.fr*).

The role of wood extractives on the physical behaviour and the durability was investigated for four timbers from Cameroon: mansonia, bubinga, moabi and padauk. Physical properties such as density, shrinkage (tangential, radial and

total), fibre saturation point and colour were measured on solid wood samples before and after two successive Soxhlet extractions using ethanol-toluene (1–2 v/v) and boiling water. The influence of extractives on wood natural durability was carried out by testing crude and extracted sawdusts against the activity of termites (*Reticulitermes santonensis*). The extractions were performed as for the solid wood samples, and the sawdust was tested after the first and the second extraction. Extraction rates have been calculated for each set of extractions. In each case, sawdust was compacted into a disc and placed in a petri dish (containing wet sand as a medium) with 50 termite workers, one nymph and one soldier. A daily observation was done, and after five weeks the termite survival rates in the test petri dishes were compared with the controls. The results obtained showed that the wood extractives play an important role in the physical properties (especially in the shrinkage) as well as in the durability against termites.

**Decay resistance of Iranian Poplar wood polymer composite.** Omidvar, A. (*University of Agricultural Sciences and Natural Resources of Gorgan, Iran; asghar1378@yahoo.com*), Zahedi, E. (*Iran*).

The literature identifies that wood polymer composites (WPCs) might resist fungal attack when the polymer loading is very high, but this makes the product economically impractical. In this study, Iranian poplar (*Populus deltoides*) wood specimens were impregnated with styrene monomer at different polymer loadings (40, 80 and 120%) to make WPC. Wood cubes, 19 mm to an edge, of treated specimens as well as controls were decay resistance tested following laboratory soil-block culture in accordance with the AWPA standard (1999 E10-91). *Coriolus versicolor* was the white-rot fungus used to inoculate the specimens. The results showed that there is significant difference between untreated and treated specimens. Weight losses for 120, 80, 40 and 0% polymer loaded WPC were 5, 9, 13 and 66% respectively. Considering economic aspects, poplar WPC made of 80% polymer load is recommended for industrial use since significant difference was not detected between weight losses of 120 and 80% polymer loading.

**Application of bamboo vinegar to evaluate fungi resistance on bamboo materials with soaking treatment.** Shiah, T.-C. (*TFRI, Chinese Taipei; ccshiah@serv.tfri.gov.tw*), Lin, H.C. (*NCYU, Chinese Taipei; alexhlin@mail.ncyu.edu.tw*).

The value of bamboo vinegar, a by-product during bamboo charcoal manufacturing that is composed of over 200 organic compounds, has recently been recognized in Taiwan due to its many uses. The objective of this study was to determine if the original bamboo vinegar obtained from Moso bamboo (*Phyllostachys pubescens*) can be used to increase fungi resistance of bamboo products, and thereby decrease the impact of environmental pollution by fungicides. The specimens used were Moso bamboo after first having been processed with either a carbonized or the steamed treatment. Five strains of fungi were used that are generally present in microbial attacks on bamboo surfaces in Taiwan—*Trichoderma viride*, *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus* sp. and *Mucor* sp. From the experimental results, the fungi resistance of various molds on the surface of Moso bamboo was increased. It is concluded that bamboo vinegar is useful to restrain the molds and can decrease microbiological deterioration of bamboo materials, suggesting that application of bamboo vinegar with a longer soaking time can be used to prevent mildew attack on the surface of bamboo materials.

**Greater resistance of *Pinus radiata* ray tracheids to soft rot as compared to axial tracheids is related to their higher lignin content.** Singh, A.P. (*New Zealand Forest Research Institute Limited, New Zealand; adya.singh@forestresearch.co.nz*), Schmitt, U. (*Federal Research Centre for Forestry and Forest Products, Germany*), Möller, R., Dawson, B.S.W. (*New Zealand Forest Research Institute Limited, New Zealand*).

A visual decay assessment of *Pinus radiata* wood, which was part of the framing timber in a house on the North Island of New Zealand, indicated the presence of surface decay. Microscopic observations provided evidence of decay by cavity-forming soft rot fungi. A comparison of ray tracheids with axial tracheids indicated that ray tracheids were considerably more resistant to soft rot than axial tracheids. In the heavily degraded regions of wood, where axial tracheid walls contained abundant soft rot cavities, the walls of ray tracheids contained only a few or no cavities. An assessment of lignin concentration in the cell walls by a combination of TEM, confocal fluorescence and UV microscopy indicated greater lignin concentration in the secondary wall of ray tracheids as compared to axial tracheids, which may explain the observed greater resistance of ray tracheids to soft rot.

**Ultrastructure of microbial degradation in durable and nondurable tropical timbers: an overview.** Singh, A.P. (*New Zealand Forest Research Institute Limited, New Zealand; adya.singh@forestresearch.co.nz*), Wong, A.H.H. (*Universiti Malaysia Sarawak, Malaysia*), Kim, Y.S. (*Chonnam National University, Republic of Korea*).

Tropical timbers vary in their natural durability. The species that show high natural durability of their heartwood are in great demand because of a rapid decline in the use of traditional preservatives due to their high mammalian toxicity and also environmental concerns. Resistance against basidiomycetes and the presence of high amounts of extractives, particularly the phenolics, are considered to be the main factors for the durability of such woods. Yet another important

property that many of these woods share is the type and high content of lignin in their cell walls. These and other desirable cellular features of the naturally durable and nondurable tropical woods will be discussed, with select examples of commercial Malaysian hardwoods—belian (*Eusideroxylon zwageri*), cengal (*Neobalanocarpus heimii*), Kempas (*Koompassia malaccensis*), Pelai (*Alstonia scholaris*) and Telur Buaya (*Homalium foetidum*)—which are resistant to basidiomycetes although not to soft rot fungi and tunnelling bacteria. Of interest also is a study on a highly prized commercial sapwood species—rubberwood (*Hevea brasiliensis*)—with low lignin and extractive contents, which experiences cell wall degradation by the common tropical sapstain fungus *Botryodiplodia theobromae*.

**Comparative one-year tropical field test exposure of copper-chrome-arsenic treated Malaysian hardwood protection against subterranean termites of Malaysia and Hawaii.** Wong, A.H.H. (*Universiti Malaysia Sarawak, Malaysia; ahhwong@frst.unimas.my*), Grace, J.K. (*University of Hawaii at Manoa, USA; kennethg@hawaii.edu*).

In Malaysia, current protection for decay and termites emphasizes use of preservatives, such as copper-chrome-arsenic (CCA) preservatives for both in-ground and above-ground applications. This study explored whether currently prescribed CCA preservative retentions (5.6 kg/m<sup>3</sup>) were appropriate. Two test sites were established—Hawaii (eucalypt forest in Waimanalo) and Kepong (Malaysia)—where the Formosan subterranean termite *Coptotermes formosanus* and *C. curvignathus* are prevalent on the former and latter localities, respectively. Wood blocks of kempas (*Koompassia malaccensis*) heartwood and rubberwood (*Hevea brasiliensis*) sapwood, vacuum-atmospheric pressure impregnated with CCA salts formulation to target volumetric retentions of 4.0, 4.8 and 5.6 kg/m<sup>3</sup> were installed both above- and below-ground, and inspected after 4 and 12 months using the AWPA termite rating scale. Block mass losses measured wood consumption rates of termite feeding. After 4 months, controls in Hawaii were completely destroyed in the above-ground test. After 12 months, above-ground test in Kepong, a few CCA treated blocks at 4 kg/m<sup>3</sup> retention sustained termite attack. After 4 months of in-ground testing, termites did not attack the controls in Hawaii, while only the controls in Kepong were destroyed. After 12 months in-ground test in Hawaii only slight attack was observed on the lowest CCA treated blocks, while treated blocks at Kepong remained sound.

**Ultrastructure of soft rot decay in moderately durable Malaysian hardwoods of the genus *Koompassia*.** Wong, A.H.H. (*Universiti Malaysia Sarawak, Malaysia; ahhwong@frst.unimas.my*), Schmitt, U. (*Federal Research Centre for Forestry and Forest Products, Germany*).

Bio-deterioration presents a major obstacle in the utilization of timber structures and wood-based composites under Malaysian environments, where many of these wood materials are used either untreated or inadequately treated with proprietary preservatives. While sapwoods of virtually all timbers are perishable to a myriad of wood decay fungi, wood-boring insects, and particularly termites, which are widespread in the tropics, some of the heartwoods of Malaysian timbers are particularly resistant to these structural pests. However the heartwood of other species have varying degrees of natural resistance ranging from low-to-moderate biological resistance. This study used transmission electron microscopy, supplemented with light microscopy, to investigate the disintegration of the heartwood fibre walls of Tualang (*Koompassia excelsa*) and Kempas (*K. malaccensis*) by a common wood decay fungus (*Chaetomium globosum*) which causes typical soft rot decay mainly of wood in ground contact. The polylamellate secondary fibre walls were found to be completely disintegrated. The transition zones dividing the lamellae appeared more resistant. Typical hyphal cavities, called soft rot type 1-mode, were detected within each lamellate of the S2 wall layer, often coalescing to form larger, ovoid-shaped cavities. The relative soft rot resistance of the darker-stained transition zones dividing individual lamellae suggests presence of lignin-enriched zones as barriers to soft rot compared with the lesser-stained lamellae regions of the fibre walls.

## Site specific management and precision forestry

Organizer: Robin Thwaites *Queensland University of Technology, Australia; r.thwaites@qut.edu.au*

**A Southern African perspective on precision forestry.** Ackerman, P. (*Stellenbosch, University, South Africa; packer@sun.ac.za*).

Precision Forestry (PF) in South Africa, stems, firstly, from precision development in viticulture, and hence, the recognition of precision applications in forestry. Secondly, the urgent need to increase yields and productivity in the face of the HIV/Aids pandemic versus extensive manual operations and limited applications of mechanized harvesting systems, severe water conservation policies, reduced forest land and ever increasing environmental pressures. In contrast to these negative factors, South Africa has the benefit of comprehensive, high-resolution resource data, from a history of excellence in plantation forestry practices, highly productive forests and the availability and comprehensive application of GPS/GIS,

GSM, remote sensing satellite technology. A combination of these factors has led to the development of a country-specific definition of PF, addressing integrated approaches between forest operations, site-specific silviculture, forest management and the value chain, using ICT. Current research and development is centred at Stellenbosch University, which serves as an African centre for PF. Current research involves locality and optimization and monitoring systems, particularly in timber harvesting and logistics. Industry concentrates on remote sensing applications in detection of land-cover changes and Lidar. Stellenbosch University has hosted two national symposia on PF during 2003 and 2004.

**Wood flow analysis supporting an efficient wood procurement system in plantation forestry.** Becker, G., de Oliveira, V.C. (*University of Freiburg, Germany; fobawi@fobawi.uni-freiburg.de; valkiria\_co@hotmail.com*).

During the last decade, pulp and paper manufacturing has grown steadily despite some fluctuation. In the near future, companies will face a serious lack of sufficient raw material and are expanding their plantations in remote areas. This means that distances from new plantations to the factory are increasing whereas information concerning roads is either partly missing or non-existent. Longer transport distances lead to higher wood procurement costs for the company. The companies aim at minimizing these costs in order to secure their wood supply and to stay competitive in the future. The optimizations of transport systems are crucial in this context. Calculation of wood flow on a road network is possible with the Software ArcGIS® and its Extension Network Analyst, implemented in a Geographical Information System. This tool calculates the optimal route based on a modified Dijkstra-algorithm according to the transport costs, the distance and/or time. In a case study this method has been developed and applied to a eucalyptus plantation company in the southeast of Brazil. The results show that this approach leads to significant improvements and cost saving for the transport activities of the company.

**Management of precision: A new step aiming at tropical natural forest sustainability.** Braz, E.M. (*Embrapa Florestas, Brazil; evaldo@cnpf.embrapa.br*), Passos, C. (*Forest University of Mato Grosso (UFMT), Brazil; capassos@terra.com.br*), Oliveira, L.C. (*Embrapa Acre, Brazil; lclaudio@cpafac.embrapa.br*), d'Oliveira, M.V.N. (*Embrapa Acre, Brazil; mvno@cpafac.embrapa.br*), Povoá de Mattos, P. (*Embrapa Florestas, Brazil; povoa@cnpf.embrapa.br*).

Knowledge of tropical forest management is fundamental for warranty of the maintenance of forest covering in extensive areas of the world. The methods of tropical forest management have improved over the years; starting with prescriptions for silvicultural treatments, they have developed into studies of forest dynamics under different timber harvesting conditions. The technique of Reduced Impact of Logging (RIL), presented in recent years, has resulted in less soil damage and guarantees greater recovery of soil quality for the next harvesting cycle. In spite of these great efforts, the management of tropical forests is still regarded with distrust by the timber producers. What prevents complete acceptance of the basic approach to natural forest management? First, heterogeneity of the tropical forest would hinder management planning on a global basis. Before adopting any new technology, timber producers want to be assured of the best economic returns. Tools that support adequate planning and analysis in tropical forests should be used more widely; Planning should recognize the heterogeneity of the forest and its species distribution, and optimize their interaction. Optimization will be based on well-known mathematical tools, planning techniques, and operation research. The paper will present this methodology in development and perspectives of this research.

**Application of new tools and technologies to enable precision forestry in space and time.** Carlyle, C., Ryan, P., Culvenor, D., Battaglia, M. (*CSIRO Forestry and Forest Products, Australia; Clive.Carlyle@csiro.au*).

This paper will explore how the above technologies can be integrated to substantially improve the capacity to manage forests in space and time, and deliver a range of benefits. In doing so we will draw on current examples from CSIRO Forestry & Forest Products major project theme 'Precision Plantation Solutions'.

**Introducing precision forestry into the Tropics with RILSIM.** Dykstra, D.P. (*USDA Forest Service, USA; ddykstra@fs.fed.us*).

Tropical forests in developing countries have historically suffered from inadequate management due to remote locations, poor infrastructure, inadequate training and supervision of personnel, and little or no effective governance in the rural areas where they are located. The adoption of reduced-impact logging (RIL) technologies has been proposed as one step that could nudge tropical forest management toward sustainability, but many timber concession holders have resisted because of the perception that RIL technologies would inevitably increase their costs. RILSIM, the Reduced-Impact Logging Simulator, has been developed as a financial-analysis tool to help loggers and concession holders analyze the costs of RIL technologies as compared with conventional logging technologies. In addition to its function as a financial-analysis tool, RILSIM is also designed to help loggers organize and manage their operations to improve efficiency while simultaneously reducing environmental impacts. RILSIM is available free of charge and is designed to run efficiently on computers with modest capabilities. The software is compatible with Microsoft Windows 95 and later operating systems.

**Site classification method based on site quality, logging systems and economics.** Iwaoka, M., Minematsu, H. (Tokyo Noko University, Japan; [iwaoka@fe.rn.tuat.ac.jp](mailto:iwaoka@fe.rn.tuat.ac.jp); [mine@cc.tuat.ac.jp](mailto:mine@cc.tuat.ac.jp)).

The authors think that site classification methods are important for determination of site specific management. A site classification method, a unit of which is a subcompartment, is developed for a purpose of compatibility of logging production with environmental conservation. The method calculates productivity class with soil type, elevation, inclination, slope direction and other elements at first. Then the possibility of setting up cable for yarding is judged from topography. And the cable span is calculated when cable yarding is possible. Then the logging cost of each logging system is calculated with cable span and product volume. At the time the most suitable system is judged by its cost. Though smaller yarders are usually suitable for shorter spans, this is not always true. Larger yarders are sometimes suitable for shorter spans when the product volumes are large. Then the economics is judged by comparing logging cost to proceeds of product logs. Finally, each subcompartment is classified into a logging stand, conservation stand, or road-construction stand, using productivity class and economics. If the compartments are too small, they are merged when their age and species are the same as their neighbours'; many of the merged compartments become logging stand.

**Site-specific N-mineralization: Implications for precision forest nutrient management.** Louw, J.H. (Port Elizabeth Technikon, South Africa; [josua@petech.ac.za](mailto:josua@petech.ac.za)).

The current South African forest resource is managed through intensive silviculture of fast-growing exotic species. Increased intensity in management practices in a diverse forest environment requires reliable decision support tools that facilitate informed decision-making. Substantial resources have been invested in the development of large scale multi-factor forest site classification systems but these spatial databases will only be utilized optimally if linked to scientifically based site evaluation systems. Nutrient budget studies in plantation ecosystems indicated a negative nitrogen balance on many sites. The formulation of site-specific nutrient management policies therefore has been identified as a priority to optimize forest productivity. This study was carried out to investigate the influence of site conditions on N mineralization, as well as the effect of N mineralization on forest productivity. Data were collected from a range of site conditions. N mineralization was monitored using multi-week *in situ* incubations, and compared to a wide spectrum of site factors recorded at each plot. A significant positive correlation was found between  $\text{NH}_4^+$  mineralization during summer and the growth of *Pinus patula*. N mineralization is controlled by a complex interaction of various site factors, and numerous correlations and interactions between  $\text{NH}_4^+$  mineralization and site factors were found.

**Indicators of fine-scale site selection.** Sætersdal, M., Gjerde, I., Blom, H.H. (Norwegian Forest Research Institute, Norway; [magne.setersdal@skogforsk.no](mailto:magne.setersdal@skogforsk.no)).

Basic requirements for the use of indicator species in fine-scale (forest stand) site selection for management of biodiversity are tested. Six forest areas in Norway, of approximately 2 km<sup>2</sup> each, were investigated. The study areas were divided into a 1 ha grid net, and a 0.25 ha study plot within each 1 ha grid was surveyed for vascular plants, bryophytes, macrolichens and wood living polypore fungi. We report results indicating that there are two basic problems with the use of indicator species in a hotspot strategy. First, forest species were found to have weak hotspot patterns. Secondly, potential indicator species associated with the most species-rich plots in one study area were generally not associated with species-rich plots in other study areas. Hence, a list of carefully selected indicator species derived in one study area does not indicate the hotspots in other study areas more successfully than a random list of species. We suggest that the amount of different important habitats for forest species, such as dead wood and old trees, reflecting the well-known species-area relationship, may be more reliable indicators of species richness hotspots than a list of indicator species.

**Precision forestry: Application of advanced technologies to forest resource management.** Schreuder, G.F., Andersen, H.E. (University of Washington, USA; [gsch@u.washington.edu](mailto:gsch@u.washington.edu)).

The recent emergence of several critical advanced technologies has dramatically increased the quantity and quality of the information available to support forest resource management. The development of high-resolution remote sensing systems, including multi-frequency interferometric synthetic aperture radar (IFSAR), and airborne laser scanning (LIDAR), have facilitated direct measurement of critical forest inventory and management variables, including crown height, stand density, crown size, species class, mapping of gaps in the canopy and location of streams. The coincidental increase in computing power has enabled the application of automated computer vision procedures, including individual tree recognition and measurement. The development of highly-precise under-canopy navigation and geopositioning systems, through the application of global positioning systems (GPS) and inertial measurement systems, will also lead to more accurate and precise forest management operations. The application of radio frequency identification (RFID) technology enables the cataloging of virtually every seedling within a plantation, allowing the forest manager to maintain a detailed database that contains the critical attributes of all individual trees within a commercial forest stand. The Precision Forestry Cooperative at the University of Washington is actively involved in

the development of these applications to support a more efficient, sustainable and accountable approach to forest resource management.

**Tactical precision forestry: Site-specific silvicultural operations in the south-east USA.** Taylor, S.E., McDonald, T.P., Fulton, J.P. (*Auburn University, USA; taylost@auburn.edu; mcdontp@eng.auburn.edu; fultojp@auburn.edu*).

Recent trends in the forest products industry have coincided with technological advances to open the door for revolutionary changes in silvicultural operations. Increasing global competition and consolidation among industrial forest landowners have resulted in greatly-reduced workforces and intense efforts to reduce production costs for wood fiber. At the same time, geospatial technologies have undergone many technical advances and cost reductions. These factors have combined to make 'precision forestry' or 'site-specific silvicultural operations' a reality in the south-eastern USA. This paper focuses on tactical approaches to forest management using site-specific silvicultural operations. Precision forestry techniques currently in use and described in the paper include GPS-based tracking and monitoring of variable-rate, banded application of herbicides using ground-based wheeled vehicles; manual herbicide spraying; tree planting operations; and finally mechanized site preparation and road construction operations. These precision operations are resulting in significant reductions in the use of chemicals and other inputs with corresponding reductions in operational cost. The GPS-based tracking and monitoring systems are being used to provide industrial landowners with productivity and quality assurance data that were not previously available. With these types of data, true site-specific forest management is now possible.

**Soil-landscape modeling for site-specific forest management in an upland environment: An Australian view.**

Thwaites, R.N. (*Queensland University of Technology, Australia; r.thwaites@qut.edu.au*).

This paper presents the enhancement of site mapping for forestry by developing quantitative spatial models specifically for an upland geomorphic system. This study was a challenge to devise and test a process in upland, closed forest environments. The approach is based on soil-geomorphological materials, forms and processes. It ultimately provides a prediction of physical site attributes for site-specific forest land management through a quantitative, explicit and repeatable resource assessment process. Soil-geomorphological concepts are used here for forest land management through the use of both conceptual and explicit modeling from field survey, geoinformatic methods, including remote sensing, digital terrain analysis and spatial analysis. The output from the study was of continuous spatial data 'surfaces' of 14 regolith-terrain (physical site) attributes relevant to forest site-specific management, in a fuzzy classification. Five of these attribute surfaces (maps) were close representations of the field attribute status to within 95% confidence. Another five could be represented to within 90% confidence. These are the basis for a site-specific capability map and operations planning decision support system at the site level.

**Czech forest (site) ecosystem classification in the precise forest management.** Viewegh, J., Podrazsky, V. (*Czech University of Agriculture Prague, Czech Republic; viewegh@fle.czu.cz; podrazsky@fle.czu.cz*).

Ecosystem (site) classification of forests in the Czech Republic is among those based on environmental factors. Initially, it was developed on a phytosociological basis, but later, in view of operational applications, the emphasis was placed on the environment of forest ecosystems. Climatic and soil studies helped to characterize environmental conditions and their relationships to forest communities. As the development of a true ecological classification is difficult, existing forest ecosystem classifications are driven either by vegetation or environment. These two different approaches influenced the development of forest classification (commonly referred to as forest typology) in the former Czechoslovakia. This typological system has been applied in Czech forests since 1970. As the composition of most of the original forests was changed to Norway spruce (*Picea abies*) monocultures in last 200 years, two environmental (site) factors were used in organizing the system. These are soil and climatic properties, and the latter are represented by forest vegetation zones which express altitudinal zonation of forest vegetation in Czech Republic. These factors make up a two-dimensional, ecological grid.

**On computer digital elevation modelling of *Cupressus lusitanica* site suitability in Uganda using Geographic Information Systems.** Waiswa, D., Jehopio, P., Gombya-Ssembajwe, W.S. (*Makerere University, Uganda; waiswa@forest.mak.ac.ug; Jehopio@yahoo.com; Gombya@forest.mak.ac.ug*).

This study was conducted to develop a spatially-based computer Digital Elevation Model (DEM) to aid identification and prediction of suitable planting sites for *Cupressus lusitanica* in Uganda. The objectives were to develop a computer DEM for species site suitability assessment and to appraise the effectiveness of computer digital elevation modelling in identifying and predicting suitable plantation sites. The study area encompassed Mbarara, Ntungamo and Kabale Districts in South Western Uganda. The study methods involved creation of a GIS database of soil parameters: texture, depth, drainage and pH; climatic parameters: mean annual rainfall and mean annual temperature; and topographic parameters: elevation and slope, with DEM data included. These datasets were analyzed and integrated using ArcView GIS 3.2a software with its Spatial Analyst,

3D Analyst and Modelbuilder extensions to develop the digital elevation model of *C. lusitanica* site suitability based on pre-determined decision criteria. The results showed that highly suitable sites were associated with the uppermost elevations while suitable and moderately suitable sites were at intermediate and low elevations, respectively. It was concluded that *C. lusitanica* site suitability varies greatly with change in elevation. It is recommended that computer digital elevation modelling approach be adopted as a cost-effective assessment tool for species and site suitability.

**A tele-operation system for forestry machines.** Yamaguchi, H., Mozuna, M., Tanaka, Y., Jinkawa, M. (*Independent Administrative Institution Forestry and Forest Products Research Institute, Japan; hiroy@ffpri.affrc.go.jp*).

Forest machine operators, especially those who are engaged in felling or logging operations, are usually exposed to danger, and they feel very tired from stress caused by machine vibrations. In order to make forest operators free from risks of accidents and offer them comfortable working conditions, we developed a tele-operation system for forest machines. This system consists of a remote-controlled vehicle, remote controller with joystick levers, a monitor which projects an image of the camera equipped within the remote forest machine. When operators control the remote machines, they get information for operation from the monitor vision. At that time, they lose some information, experience a distance feeling of being outside image of a frame, and so on. In this system, we intend to supply useful information, for example, position of the operators in relative coordinates of the machine, routes to road, machine position in forest, places that should be avoided and support operators to control the remote forest machines more efficiently.

**Precise loading for forwarders.** Ziesak, M. (*TU München, Germany; ziesak@forst.tu-muenchen.de*).

Fully laden forwarders belong to those vehicles, which have the highest wheel loads in forestry. Because improperly loaded forwarders can have negative impacts on forest soils, it is important that the technology for precise loading of forwarders developed. In order to accomplish this, a system in which electronic scales are combined with on-board computer software was developed, allowing the loading process to be monitored, automatically. When site specific parameters, determining the ability of a soil to carry the weight, are passed to the software, the loading capacity of the forwarder can be adjusted to the soil tolerable level of the present situation. This will avoid negative impacts on forest soils. Some influential factors will be discussed in order to show the interaction of payload, forwarder-construction principles and site parameters.

## **Detecting, monitoring and modeling deforestation and forest degradation using remote sensing and GIS**

Organizer: Yousif Hussin *The International Institute for Geoinformation Science and Earth Observation (ITC), The Netherlands; hussin@itc.nl*

**GIS application for forest development in drylands of Pakistan.** Ahmad, F., Gulzar, F., Farooq, S. (*University of the Punjab, Pakistan; drylandpk@yahoo.com*).

Pakistan is a tropical country with vast semi-arid and arid tracts of land spread over 68 million ha. Total forest is defined as land with tree crown cover of more than 10% of the ground and area of more than 0.5 ha. In the case of the tropical region, inventory information is supplemented by a remote sensing survey. If only limited or out-dated inventory data are available, combinations of linear projections and expert opinion techniques were applied to fill in data gaps. GIS connects people and their interests; it can be used most efficiently and effectively for the analysis of large-scale spatial data sets. It facilitates cooperative approaches and with the integration of GIS, there will be a whole new framework for organizations and society to work together and make decisions. Adoption of GIS technologies for forest management started at the beginning of the 1990s. This paper summarizes a set of GIS applications for forest management, which were designed and can be implemented in the drylands of Pakistan. The main focus is given to description of application-specific needs and its accomplishment using GIS technologies.

**The GAME model: GIS-based assessment, monitoring and evaluation.** Bantayan, N.C. (*University of the Philippines Los Baños, Philippines; ncb@laguna.net*).

A study of land use necessitates a careful consideration of the factors that determine its appropriateness and sustainability. The key is to identify susceptible areas through the application of a model that estimates the contribution of various factors to land degradation. The analysis of land capability is implemented by comparing an estimate of land degradation with a tolerance limit that prescribes the threshold for agricultural productivity. To operationalize the analytical procedure, a system for geodatabasing the general characteristics of the land for assessment, monitoring and



evaluation was developed. The description of the landscape is carried out using the vector approach – a new method for comprehensively describing all aspects about the landscape. The vector approach enriches the description of the landscape through the various levels of the GAME model – GIS-based assessment, monitoring and evaluation. The geodatabase component of GAME allows a comprehensive description of geographic phenomena. The mapping component, on the other hand, enables visualization of the landscape using GIS. Thus, the status of natural resources (e.g. forest cover) can be readily assessed; the progress of relevant projects (e.g., forest renewal) can be monitored; and the quality of natural resources and the impact of interventions (e.g., forest conversion) can be evaluated.

**Accuracy assessments for spatial forest cover pattern change.** De Clercq, E.M., De Wulf, R.R. (*Ghent University, Belgium; Eva.DeClercq@UGent.be; Robert.DeWulf@UGent.be*).

Long-term forest cover change in Flanders was assessed by a GIS overlay of two land cover classifications. A recent forest mapping was performed in 2000, while historical forestry data is equally available in digital form (dating from 1850 up to 1940). However, these forest maps were conceptualized with a different methodology, resulting in different accuracies. Systematic errors between these thematic maps discourage their use for change detection. Differences in classification systems also hinder a direct comparison of these data sets. Yet, for many users these data are the only national land cover data available. This study presents a methodology that allows comparison of these data sets for change detection in spite of the variation in accuracy. Both the objective that leads to the respective classification and the definition of forest were analyzed. Expert systems as well as fuzzy set analyses were used to address positional accuracy. Fuzzy polygons, i.e. polygons with buffered boundaries, were created to discriminate real areas of change from inconsistency. Spectral confusion was however not addressed.

**Spatial modeling of land use change and deforestation.** de Gier, A., Hussin, Y.A. (*International Institute for Geoinformation Science and Earth Observation (ITC), Netherlands; Degier@itc.nl; Hussin@itc.nl*).

Much concern by policy makers, natural resource managers and civil society at large deals with the consequences of deforestation and forest degradation. To understand the processes and to provide a tool to achieve control over them, a large number of models have been produced. The paper reviews the literature on this subject, especially the quantitative models for use at sub-national level that analyze the effects of people's behaviour on land use change involving deforestation and forest degradation. It was found that spatial models form a minority, despite the fact that spatial factors appear particularly correlated with the location, extent and speed of these processes, knowledge of which is indispensable to manage them. A number of these models contain variables that can be made spatially explicit, and that can be further improved with additional spatial variables obtained from spatial data sources such as satellite imagery. The paper describes one such model, FAO's Area Production Model that simulates long-term land use change. The model was calibrated and validated for a few test areas. The results are shown and accuracy levels given. Its applicability and requirements for use are discussed. Recommendations for further research are made.

**Enhancement of GIS through the integration of forest health surveillance and plantation registrar data.**

Hemmens, T.J., Ramsden, M. (*Department of Primary Industries and Fisheries, Queensland, Australia; Trent.Hemmens@dpi.qld.gov.au*).

Various systems and types of databases have been used for the storage and retrieval of current and historical forest pest and disease records. Some databases are specimen based, therefore do not allow for the inclusion of non-specimen-based records. The resultant proliferation of individual databases inhibits data sharing and client useability. Intellectual property rights have also meant that clients are now demanding ownership of data, which traditionally resided in various research and Government organizations. Linking data into a client's GIS system allows instant access, visual display and the ability to combine this data with other data residing or linked to their system. Currently the Department of Primary Industries and Fisheries, Horticulture and Forestry Science are pinpointing forest health disorders during low-level aerial surveys, using laser technology (LaserPosTM). This positional data is combined with descriptive data selected in-flight from palm computers. This data is then combined to a plantation registrar that includes tree species, plant date, age and area planted. Using electronic field sheets, follow-up ground survey data can be linked in, as can silvicultural regimes, soil attributes, etc. The integration of this data enables forest managers to 'view' and have access to instant GIS interpretation of historical and current forest disorders.

**Detecting and modelling illegal logging using remote sensing and GIS.** Hussin, Y.A., Atmopawiro, V., Zaitunah, A. (*International Institute for Geoinformation Science and Earth Observation (ITC), Netherlands; Hussin@itc.nl; Atmopawiro@itc.nl; Zaitunah@itc.nl*).

Tropical forests are being depleted at a fast rate due to deforestation and degradation. Illegal logging, which was reported to be the cause of 50% of deforestation, is a very pressing issue in Indonesia and is threatening the

sustainability of forest management. The detection of the single felling tree which can be characterized as a specific type of illegal logging can provide information for the assessment of related Criteria and Indicator (C&I) of Sustainable Forest Management (SFM). This study aims to detect single tree felling in the tropical forest using Landsat-7 ETM+ satellite data and two types of classifiers i.e. maximum likelihood classifier and the sub-pixel classifier. Furthermore, it aims to assess the output of the first objective to support SFM through evaluation of specific C&I. field data of new logged points representing single tree felling was collected during fieldwork in East Kalimantan, Indonesia in September 2003. The Landsat image was classified using maximum likelihood and sub-pixel classification. The results showed that the accuracy of the sub-pixel classification was higher than the maximum likelihood classification of the 30-m resolution image. Consequently, more accurate detection of single tree felling can be achieved using the sub-pixel classifier and Landsat-7 ETM+ images.

**Detecting, monitoring and modelling forest fire using remote sensing and GIS.** Hussin, Y.A., Sunuprpto, H., Sharma, N. (*International Institute for Geoinformation Science and Earth Observation (ITC), Netherlands; Hussin@itc.nl*).

Every moment the world is threatened by fires, which could happen as a result of human activity, or any natural event. With increasing world population, the intensity of shifting rotation and cultivation is increasing, resulting in even more burning by the farmers to clear their lands. In addition, especially in tropics, many fires are blamed on logging companies clearing land for plantations. There is a need for active forest fire monitoring and damage assessment. This should be done in order to provide reliable and up-to-date information about the damaged and remaining forest cover area and its quality to support forest management decision, and possibly rehabilitation. To consistently monitor forest fires, remotely sensed data and automated image analysis techniques are the only feasible way. Remote sensing techniques and data can be used for the detection of forest fires and the assessment of their effects. Modelling forest fire can also help us to predict areas of high fire hazard or potential. The objective of this paper is to show how remote sensing and GIS can be used to detect, monitor and model forest fires. The paper shows some of these applications in semi arid, sub tropical and tropics areas.

**Forest cover-type mapping of South Korea using GIS.** Kim, C.M., Rho, D.-K., Lee, S.-H., Kong, G.-S., Kim, K.-M. (*Korea Forest Research Institute, Republic of Korea; helmin@foa.go.kr*).

A regional or nationwide forest map is indispensable as a basic database for forest management and establishing national or regional land use policies. Since the 1970s, nationwide forest inventory programs have been carried out in Korea and forest distribution maps were made as a result. These forest cover-type maps were developed from the manual interpretation of aerial photographs. The decision rules used to delineate the stand units were major tree species, age, dbh classes and crown closure. They were originally made and maintained in 1:25,000 scale 7.5-minute map sheets. During the last several years the late forest cover-type maps were all digitalized with the advancement of GIS, value-adding and granting important roles in natural resources information system implementations. Recently, a nationwide forest map was created joining all the digital forest map files into one coverage using ArcInfo. More than 700 map files were combined for this work, fulfilling the map-joining conditions. The resulting digital forest cover-type map provides many advantages for making additional forest thematic maps such as any specified tree species and age distribution. It also allows opportunities for GIS modeling and spatial analysis all around the nation on the basis of converting the coverage to grid format data.

**Multitemporal detection of burned peat swamp forest in Sabah, Malaysia, using Landsat data.** Phua, M.-H., Lee, J.S., Tsuyuki, S. (*The University of Tokyo, Japan; apmh@mail.ecc.u-tokyo.ac.jp; gandol@fr.a.u-tokyo.ac.jp; tsuyuki@fr.a.u-tokyo.ac.jp*).

Forest fire is recurrent and associated with the recurrent El-Nino event. The largest significant peat swamp ecosystem in Sabah, Malaysia is located at Klias-Binsuluk area and protected by Binsuluk Forest Reserve (12,106 ha) and Klias Forest Reserve (3630 ha). It was severely burned during the 1998 fire. Spatial distribution of the burned area by forest types that can aid fire management has not been available. We examined the usefulness of multitemporal Landsat data for detecting the burned area. It is evident that image-differencing technique with Normalized Burn Ratio (NBR) is superior to the Normalized Difference Vegetation Index because NBR uses middle infrared band that is less sensitive to atmospheric influence. The superior technique was used to detect the burned peat swamp forest of Klias-Binsuluk area. Pre-fire forest types were mapped using an object oriented classification approach. From the spatial distribution of burned areas by forest types, it is evident that fire spread from bushy shrub to secondary forest and dense forest. Half of the dense forest of Klias-Binsuluk area was destroyed. While the dense forest of Binsuluk Forest Reserve was largely burned and fragmented, only a small part of Klias Forest Reserve was burned.

**Forest planning on state level in an environment of Geographic Information Systems. The case of Tamaulipas, Mexico.** Salinas Castillo, W.E. (*University of Tamaulipas, Mexico; wsalinas@uat.edu.mx*), Treviño Garza, E.J. (*Autonomous University of Nuevo León, Mexico; ejtrevin@fcf.uanl.mx*).

Forest inventories in Mexico have always been done on a national level with a working scale of 1:250,000. This does not correspond to the needs of forest resources monitoring on the state level. The SPOT 5 image reception antenna that was put into operation in November 2003 in Xochimilco, Mexico, made it possible to obtain high resolution images showing changes in the dynamics of the use of forest resources at a working scale of 1:20,000 without any costs to the government sector. It is not only possible to study the dynamics of changes but also to precisely record and monitor uses authorized by the government in order to examine if environmental standards applicable to forests are being upheld. The State of Tamaulipas is developing a Geographic Information System by means of an interface developed in Arc-Object 8.2. All official analogue information is converted into digital information and satellite images are integrated into a geobase, which makes the tasks of planning, evaluation and supervision easier.

**Application of remote sensing technologies for the extensive assessment of forest health: opportunities and limitations for operational implementation in Australia.** Stone, C. (*New South Wales Department of Primary Industries, New South Wales, Australia; christines@sf.nsw.gov.au*), Sims, N.C. (*CSIRO Forestry and Forest Products, Australia*).

Recent developments in Australia in the assessment of canopy health of eucalypt forests and plantations using remote sensing technologies will be presented. The overall framework adopted to monitor sustainable forest management in Australia is the Montreal Process. The diverse interests and priorities among stakeholders influence the scale, resolution and accuracy of results sought. This, in turn, influences how assessment data are collected, analyzed and reported. In all cases there is a need for assessment methodologies to be objective, repeatable and cost effective. Remotely sensed digital imagery has the potential to fulfill these requirements. This presentation will illustrate the application of remotely sensed imagery acquired from airborne and satellite sensors to detect and classify damaged forest canopies. Some of the technical difficulties associated with this process will be discussed. We will also demonstrate the multi-functional, quantitative power of remotely sensed spatial data when analyzed in combination with other geo-referenced environmental coverage. This integration of different types of spatial information can be used to identify management options for damaging forest agents and to develop site hazard rating systems for key insect pests and diseases.

**Monitoring successive changes of oil palm plantation area using Landsat data in Sabah, Malaysia.** Tsuyuki, S., Miyake, M., Phua, M.-H. (*University of Tokyo, Japan; tsuyuki@fr.a.u-tokyo.ac.jp; mariem@fr.a.u-tokyo.ac.jp; apmh@mail.ecc.u-tokyo.ac.jp*).

Oil palm (*Elaeis guineensis*, Jacq.) is a major agricultural product in Malaysia and its planted area has been significantly increasing and exceeded 10% of the country's area recently. Environmental problems such as deforestation and pollution are of increasing concerns due to the fast growing area. While statistical information of oil palm plantation by administrative boundary unit is readily available, spatial distribution of age is difficult to obtain for a large area because it is plantation-level information. We used successive Landsat TM and ETM+ data (1991, 1996, 1999, 2002) for retrieving successive annual changes of oil palm area from 1989 to 2002 and for estimating age class distribution in Sandakan Division of Sabah, Malaysia. Land cover classification was done using an object oriented classification approach, which identifies land covers as 'segment-units' rather than pixelwise classification by the conventional approach. Usually, cloud cover is a major problem for remote sensing land cover classification, especially in the tropics. By using the successive analysis approach, the effect of cloud cover was much suppressed compared to independent analysis. Oil palm biomass estimation was also made possible from the age class distribution map obtained.

**Forest damage monitoring: A WebGIS prototype system for geo-location of field survey.** Valentinotti, R., Salvadori, C., Ambrosi, P., Maresi, G., La Porta, N. (*IASMA, Italy; ruggero.valentinotti@iasma.it*).

To improve woodland phytosanitary protection in Trentino (northern Italy), Forest Tree Damages Monitoring (FTDM) has been conducted since 1990 by IASMA in collaboration with the Forest Services of the Autonomous Province of Trento. The adopted methodology included direct field survey by forest personnel; periodic compilation of paper forms and the recording of unknown damages. These new attacks are recognized by diagnostic work carried out both in the forest and laboratory by specialists. In this paper, we present a technology for the accurate and rapid geo-location of field survey and the creation of a central geo-database designed for the development of GIS (Geographical Information System) analysis. The aim of this Internet-based GIS system is to assist in those functions needed to store data and retrieve information from the central geo-database. The method used to implement these functions affect how efficiently the system performs operations with the data. Moreover, if the same data analysis has to be done routinely on a different data subset, the computation may be standardized, implemented on the WebGIS system and made available to the authorized users. The data can be manipulated and analyzed with offline computation to obtain information useful for specific applications.

**Integration of remote sensing and expert knowledge to detect illegal logging in the production forest of East Kalimantan, Indonesia.** Wijaya, A., Sharifi, A., Tolpekin, V. (*International Institute for Geo-information Science and Earth Observation, Netherlands; Alisharifi@itc.nl*).

Deforestation, which is mainly caused by illegal logging, is a serious problem in Indonesia. Illegal logging is closely related to the quality of management; therefore, it can affect forest management. One of the promising techniques for detecting and mapping illegal logging is remote sensing. This paper aims at development and evaluation of a methodology, which can make use of remotely sensed data to identify and map illegal logging in the production forest located in Berau, East Kalimantan, Indonesia. The study makes use of Landsat 7 ETM data of 2003 for the Labanan concession area, and identifies the illegal logging in three main steps. In the first step, the seven bands of Landsat ETM images are used in a maximum likelihood classification. Next, Fuzzy c-means and Neural Network classification methods will be applied to the same datasets. The results of the three classification methods are then compared and combined. Utilization of fuzzy classifiers is based on the assumption that these methods classify better-mixed pixels. This study aims at integrating the results of 3 classification methods in order to improve the identification and mapping of illegal logging using remote sensing techniques.

**Agroforestry: taking stock of recent developments**

Organizers: P.K.R. Nair *University of Florida, USA; pknair@ufl.edu*, and M.R. Mosquera-Losada *University of Santiago de Compostela, Spain; ssm2004@lugo.usc.es*

**Enhancing resource use in fruit-based agroforestry systems of highland Guatemala for increased productivity.**

Bellow, J.G. (*Florida State University, USA; Bellow@coaps.fsu.edu*), Nair, P.K.R. (*University of Florida, USA*).

Worldwide, fruit tree-based agroforestry systems have been only modestly studied in terms of quantification of biophysical interactions. Agroforestry systems based on *Malus*, *Prunus* and *Pyrus* are common in northwest Guatemala. This study evaluates use of photosynthetically active radiation (PAR) and soil moisture by mixed crops of pear trees with maize (*Zea mays*) and fava bean (*Vicia faba*). The two-year, on-station experiment included solecrops and intercrops of maize and fava and a weed free control as understory treatments, and eight-year-old pear trees (*Pyrus* spp.) or tree-like shade structures as overstory treatments. Tree water use, soil water status and radiation capture were assessed daily, and yields of annual and perennial components measured. Increased PAR interception and greater water use were observed in mixed crops and are partially responsible for the higher productivity under mixed cropping. Land and area-time equivalency ratios, economic value and glucose equivalent yields provide estimates of the benefits. The hypothesis that benefits occur through capture of additional resources unexploited in treeless systems is supported, and the results suggest that gains in small farm productivity and fruit quality can be made through careful association of fruit trees and crops.

**Agroforestry homegardens in Sri Lanka: past, present and future.** De Zoysa, M. (*University of Ruhuna, Sri Lanka; mangalaxy@yahoo.com*).

A homegarden represents the interactions between intra-household parameters within a system and its immediate external setting. The tradition of planting and maintaining home-gardens was an expression of culture and represented an intense interaction between humans and plants. Hence the traditional home-garden held promise as an ecologically sound land-management system and as a means of providing for economic, social, aesthetic and cultural benefits. Even now, the agroforestry homegarden is a low-cost production system that contributes significantly to the household economy. However, the area under home-gardens is increasing in certain parts of Sri Lanka while decreasing in others. The yield of homegardens is much lower than their potential due to poor resource management strategies and stiff competition for land, labour and other inputs. The development of future agroforestry homegardens is a multi-disciplinary activity. The maintenance of specific plants in the homegarden should provide a source of stability in the rapidly changing cultural, social and economic environments. Considering its important functions in fulfilling various needs, the real value of agroforestry homegardens should be evaluated.

**Nutritive value of cork oak acorns used as fodder for ruminants in Tunisian forests.** Gasmi-Boubaker, A. (*Institut National Agronomique, Tunis; azizaboubaker@yahoo.com*), Kayouli, C., Buldgen, A.

Cork oak acorns constitute an important fodder resource for ruminant breeding in the Tunisian forest. The annual production of dry matter (DM) is 5 kg/tree on average. The acorns have an energy value comparable to barley (0.9 fodder unit/kg DM) whereas they lack digestible nitrogenous matter (34 g DNM/kg DM), sodium, phosphor and zinc. Therefore, it is necessary to correct these deficits. In addition, fresh acorns are rich in gallic tannins (7 to 10 % of the DM) which may cause intestinal troubles and even death in young animals when they consume great quantities (800 g/day/animal, in the

case of goat). Traditional conservation strategies prefer germination and decay to silo conservation. The use of silage acorns to raise kids (600 to 1230 g/day/animal) allows good daily growth (66 g), especially during the dry season when the nutritive value of shrub vegetation is reduced and kids would lose weight without additional energy supply.

**Nutritive quality of some forest species consumed by ruminants in the Mediterranean zone.** Gasmi-Boubaker, A. (*Institut National Agronomique, Tunis; azizaboubaker@yahoo.com*); Kayouli, C., Buldgen, A.

Leaf analysis of 13 shrub species from the Tunisian forest shows the following: the dry matter content (DM) is 50% in summer and 41.7% in autumn, and the average digestibility varies between 40 and 68%. Total fibre represents half of the DM. Lignin increases by 44% from spring to summer. Most woody species are *Erica arborea*, *Phillyrea angustifolia* and *Pistacia lentiscus*. Contrary to fibre, the total nitrogenous material (TNM) diminishes from spring to summer. With the exception of some leguminous plants (*Calycotum villosa* and *Cytisus triflorus*), other shrub species are poor in TNM (<10% of the DM). Average contents of sodium and phosphorous are 0.06 and 0.12% respectively. Phenol compounds range from 11.2% in spring to 13.1% in summer. Independently of the season, the phenol compounds have a negative impact on cellulytic activity. In order to increase the benefit of forest vegetation to ruminants, it would be necessary to deactivate phenol compounds and increase the supply of energy, nitrogen and mineral substances.

**Agroforestry and international forestry at the University of Laval, Canada.** Khasa, D., Olivier, A., Fankap, R., Margueret, V., Bonneville, J. (*Université Laval, Canada; dkhasa@rsvs.ulaval.ca*).

The Université Laval was founded in 1663. Apart from being the first Canadian university, it was also the first institution in North America to offer higher education in French. It remains the only one in French Canada to offer a complete undergraduate and postgraduate forestry program. Laval University has 17 faculties and over 500 programs at both undergraduate and graduate levels. Of the 38 105 students enrolled in the University, 9 663 (25.35 %) are in graduate level programs. Each year, the University attracts more than 2,500 foreign students. With its mission of research and training of highly qualified personnel, The University of Laval has gained worldwide recognition in many fields including: biomedical and biotechnological research, agri-food, forestry and geomatics, international relations, optical and laser research and cultural-based studies. The agroforestry program was created in 1993, as a joint venture between the Faculty of Forestry and Geomatics and the Faculty of Agricultural and Food Sciences. This paper outlines the various activities of the University of Laval in agroforestry and in international forestry as well as its role on the international arena in these areas.

**Determination of optimum stand density level for forage establishment by thinning in a Japanese larch plantation, Korea.** Kim, J.H., Kang, S.-K. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr; tree@kangwon.ac.kr*).

Thinning of even-aged artificial forests is considered to be a reasonable way to introduce forage or other crops onto the forest floor. This experimental field study was conducted to suggest an optimum level of stand density for forage establishment by degrees of thinning (control, 40 and 60% of trees removed) in a fully stocked 25-year-old Japanese larch (*Larix kaempferi*) plantation of Kangwon Province, Korea. Compared to the control stand, although thinning practice decreased crown coverage to 89 and 80% through thinning by 40 and 60%, respectively, but the practice increased relative light intensity on the forest floor up to 34 and 51%, respectively. However, the leaf area index of the canopy was not changed by the treatments. The amount of forage production and the number incoming understory plant species were significantly increased by thinning treatment, but no difference was detected between cutting levels. The result of experiment indicated that the study forest would be thinned by 40% to 50% of stand density, or to approximately 20 m<sup>2</sup>/ha of residual basal area, so as to enhance radial growth of residual larch trees and improve the microclimatic condition to cultivate forage or other crops on the forest floor.

**Environmental benefits of agroforestry systems: Carbon sequestration.** Montagnini, F. (*Yale University, USA; florencia.montagnini@yale.edu*), Nair, P.K.R. (*University of Florida, USA; pknair@ufl.edu*).

Agroforestry has importance as a carbon (C) sequestration strategy because of carbon storage potential in its multiple plant species and soil, as well as its applicability in agricultural lands and reforestation. Proper design and management of agroforestry practices can make them effective carbon sinks. The extent of C sequestered depends on the amounts of C in standing biomass, recalcitrant C remaining in the soil and C sequestered in wood products. Agroforestry can also have an indirect effect on C sequestration when it helps decrease pressure on natural forests, which are the largest sink of terrestrial C. Another indirect avenue of C sequestration is through the use of agroforestry technologies for soil conservation, which could enhance C storage in trees and soils. Agroforestry systems with perennial crops may be important carbon sinks, while intensively managed agroforestry systems with annual crops are more similar to conventional agriculture. In order to exploit this vastly unrealized potential of C sequestration through agroforestry in

both subsistence and commercial enterprises in the tropics and the temperate region, innovative policies, based on rigorous research results, have to be put in place.

**Economic perspectives on dense stands of *Pinus radiata* silvopastoral system on abandoned agronomic land.**

Mosquera-Losada, M.R., Fernández-Núñez, A., Rigueiro-Rodríguez, E. (*Universidad de Santiago de Compostela, Spain; romos@lugo.usc.es; anriro@lugo.usc.es*).

European Union policy has encouraged important farm changes in Galicia, where most of the dairy farms have changed their main product to meat, as has happened in most European Union countries. The other main change is the emigration and the ageing of the rural population, with dairy farms being replaced by forest plantations. Plantations have caused a reduction in grazing area and increased, in some cases, the need to concentrate the remaining dairy farms. A good solution to this problem can be the use of silvopastoral systems on abandoned agronomic land, which allow the combination of high-quality wood production and pasture for grazing animals. This six-year experiment was carried out in a silvopastoral system with *Pinus radiata* D. Don (2500 trees/ha) developed on a sward mixture of cocksfoot and clover. Two fertilizer treatments were applied: no fertilization (most common in the area) and fertilization with dairy sewage sludge. An economic analysis was undertaken using the seven-year data base, taking into account: exclusive grazing land use, forest land use and the use of a silvopastoral system. Silvopastoral systems enhanced land economic return.

**Mechanical and biological clearing for fire prevention in mature *Pinus radiata* stands.**

Mosquera-Losada, M.R., López-Díaz, M.L., Rigueiro-Rodríguez, A. (*Universidad de Santiago de Compostela, Spain; romos@lugo.usc.es; anriro@lugo.usc.es*).

Clearing is an important practice in mature stands developed in areas where fire risk is important. There are several ways to clear the shrubs developed under the trees: manual clearing, herbicide application, mechanical clearing and grazing. Grazing is the most frequently used method. Mechanical clearing is one of the most expensive silviculture practices in the woodland, and grazing clearance requires a high initial investment for fencing, which is nowadays funded by the autonomous government in Galicia. The objective of this experiment was to compare the efficiency of these two clearance methods using a long-term experiment. The main results indicate that after two years, gorse recovery was much higher following mechanical clearance than under grazing conditions.

**Perspectives on silvopastoral systems in the Mediterranean and Atlantic areas of Europe.** Mosquera-Losada, M.R. (*University of Santiago de Compostela, Spain; romos@lugo.usc.es*), McAdam, J. (*Queens University Belfast, UK; jim.mcadam@dardni.gov.uk*), Papanastasis, V.P. (*Aristotle University, Greece; vpapan@for.auth.gr*), Pardini, A. (*University of Florence, Italy; andrea.pardini@unifi.it*), Rigueiro-Rodríguez, A. (*University of Santiago de Compostela, Spain; anriro@lugo.usc.es*).

Animal grazing in tree stands used to be a common practice throughout Europe, but the integrated tree and animal production (silvopasture) system is now restricted mostly to the Mediterranean region. Pasture production under trees is mainly limited by light availability and it varies according to species, distribution, stand density and age of trees. The main tree species used are indigenous or exotic. The most representative types of silvopastoral systems in Europe are the dehesas (with *Quercus ilex* and *Q. suber*) in western Mediterranean, the dehesa-type landscapes of *Quercus coccifera* and *Q. ithaburensis* in eastern Mediterranean, *Q. cerris* in central Mediterranean, the *Populus* sp. and *Pinus* sp. systems in the southern and southeastern Europe, the *Larix* sp. systems in the mountains of Mediterranean countries and the silvopastoral systems in the Atlantic areas of Europe (with species such as *Q. robur*, *Q. petraea*, *Fraxinus excelsior*, *Betula alba*, *Pinus radiata*, *Eucalyptus* and hybrids of *Populus*). All these systems have desirable social attributes, environmental benefits and economic advantages. These systems are, however, in danger of either being abandoned or converted to intensive monocultures due to the socioeconomic changes that have occurred during the past few decades in both regions, particularly in the Mediterranean. Intensified research and strong policy support are needed to promote these traditional and sustainable systems.

**An overview of recent developments in agroforestry.** Nair, P.K.R. (*University of Florida, USA; pknair@ufl.edu*).

The first part of this decade has witnessed a substantial increase in agroforestry activities around the world, especially in the academic and professional arena. These include major international gatherings, professional publications and new research and development initiatives. Noteworthy among these is the 1<sup>st</sup> World Congress of Agroforestry, held in Orlando, Florida, USA, June–July 2004, attended by delegates from 82 countries, and supported by organizations from four continents (<http://conference.ifas.ufl.edu/wca>). During this period, major research projects on environmental, economic and ecological issues of agroforestry got under way in several industrialized countries including the USA, southern Europe and Australia. Under the leadership of ICRAF (World Agroforestry Centre), agroforestry research and development activities in the deve-

loping nations are pursued in the context of realizing Millennium Development Goals of the United Nations. Thanks to these efforts, agroforestry has acquired a 'new image' as a vehicle for achieving food security and environmental sustainability.

**Phosphorus storage capacity of soils under silvopasture and tree-less pasture in Florida.** Nair, V.D. (*University of Florida, USA; vdna@ifas.ufl.edu*).

The capacity of a manure- or fertilizer-impacted soil to retain phosphorus (P) is of primary importance in avoiding loss of P from sandy soils to adjacent water bodies. Recent studies suggest that the tree component in a silvopasture removes more P from a soil than a tree-less pasture, and therefore silvopastures would contribute to retention of more P in the system, and therefore reduction in non-point source pollution. A new concept to calculate the safe P storage capacity per unit volume of soil, based on the P saturation ratio (available P/Fe+Al) will be used to demonstrate that the 'life' of a soil for additional P loading would be greater for a silvopasture than an adjacent tree-less pasture. Conventional water-soluble P concentration measurements within the soil profile also lead to the same conclusion. Therefore, silvopastures will be able to support animal agriculture for longer periods of time by minimizing P export from a field, as compared to tree-less pastures, given equal P loading as inorganic or organic fertilizers. Although this research was conducted on silvopastoral systems, the results might be true for most agroforestry (and other tree-based) systems.

**Agroforestry characteristics of Iberian trees.** Silva-Pando, F.J. (*CIFA de Lourizán, Spain; jsilva.cifal@siam-cma.org*).

The Iberian Peninsula has a great number of tree species with very different types of growth, products and production. In addition to the autochthonous species, a certain number of species have been introduced for the sake of using their wood or for other uses and products. The use of these trees in agroforestry systems is possible, although their potential is not the same in all cases and depend on their characteristics. Today, some of them are used for agroforestry purposes. This presentation describes 37 tree species, both Iberian and introduced, and gives details on their morphological, autecological and agrosilvicultural characteristics, as well as on their products and uses, with a view to their suitability for Iberian agroforestry systems.

**Negative effect of *Populus deltoides* on growth of wheat under alley cropping system: nature and mechanism of interference.** Singh, H.P., Batish, D.R., Kaur, S., Kohli, R.K. (*Panjab University, India; hpsingh\_01@yahoo.com; daizybatish@yahoo.com; kaur\_shalu@yahoo.com; rkkohli45@yahoo.com*).

*Populus deltoides*, a fast growing exotic, has been widely planted on the northwestern plains of India under various agroforestry programs either along field boundaries or in the alleys. Under alley cropping systems, wheat is the main crop grown during the winter season. The growth and subsequent yield of the wheat crop is significantly reduced under the 4–6-year-old *P. deltoides*. However, not much is known about the underlying mechanism and nature of interference. To elucidate this, laboratory and greenhouse experiments were performed using the fresh and decaying litter of the tree, and its impact on the growth and yield of wheat was determined. Studies were further extended to explore the nature of the inhibitors involved and their interaction with the soil nutrients. The litter of the tree was found to significantly reduce the growth and subsequently yield of the wheat crop. It was observed to contain a significant amount of water-soluble phenolics—the known phytotoxins implicated in allelopathic interactions. There was a significant change in the nutrient status of the soil upon amendment with the litter. Based on the observations recorded in the study, it is concluded that litter of *P. deltoides* releases phytotoxic phenolics that alter the soil nutrients status and bring about reduction in growth of wheat.

**Forest homegardens as an alternative to monocultures for enhancing agroecosystem sustainability in Nikapotte, Sri Lanka.** Wijesekara, V.P.R., Asbjornsen, H. (*Iowa State University, USA; vprenuka@iastate.edu; hasbjorn@iastate.edu*), Kotagama, S.W. (*University of Colombo, Sri Lanka; fogsl@sl.lk*).

Conversion of tropical moist forests to monoculture plantations is a major driver of declining productivity and biodiversity loss throughout the tropics. In Nikapotte, Sri Lanka, land use intensification for sugarcane and rubber plantation establishment has resulted in the conversion of 763 ha (or 61%) of the original forest cover between 1956 and 1999. Traditional forest home-gardens and recent diverse cropping systems that effectively maintain ecological functioning may provide economically viable alternatives to monoculture production. We assessed the productive potential and sustainability of different land use systems occurring along a land use intensity gradient in the Nikapotte region. Key indicators of ecological sustainability measured included: soil quality, primary productivity, structural complexity of the vegetation and functional diversity of the avian and plant communities. Our results indicated a positive relationship between the productive potential of the soils with structural complexity and functional diversity of the agricultural systems, with highest productivity occurring in the home-gardens and mixed cropping systems. Further, sustainability indicators of these complex agrosystems closely mimicked conditions in mature undisturbed forest and riparian systems. These results suggest that forest homegarden and mixed cropping systems provide a promising opportunity for restoring ecological functions and biodiversity in the Nikapotte region of Sri Lanka.

## Sub-theme: Demonstrating Sustainable Forest Management

### Demonstrating sustainable forest management

Organizer: Jerry Vanclay *Southern Cross University, Australia; JVanclay@scu.edu.au*

#### **Empowerment of people for Sustainable Forest Management: India's initiatives.** Biswal, M. (*Hirakud Wildlife Division, Sambalpur, India; meeta\_biswal@rediffmail.com*).

Sustainable Forest Management is the forestry component of sustainable development. It is the process of managing forests to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services, without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment. In other words, sustainably managed forests will maintain their biodiversity and ecological processes, which will ensure the provision of products and services to all stakeholders in an effective, continuous and reliable way. The concepts of sustainable development as well as sustainable forest management both recognize that utilization will change natural ecosystems, and thus conservation of the natural ecosystems becomes important. Both concepts also recognize that management of forest resources is essential for achieving social goals like poverty alleviation and employment generation. India, too, has recognized the importance of involvement of the rural poor in the sustainable management and conservation of its forests, and has tried to raise awareness among rural people through human resource development or through legal empowerment.

#### **Post-Newtonian economics and Sustainable Forest Management.** Kant, S. (*University of Toronto, Canada; Shashi.kant@utoronto.ca*).

Neo-classical economics has remained reluctant to accept 'sustainability' as an economic issue. The main factor to this reluctance is that neo-classical economics is built on the assumption of a representative 'rational economic agent' who is close to being a 'social moron' or a 'mindless individual'; and sustainability cannot be achieved through the choices of 'rational fools'. Natural science has continuously demonstrated the existence of natural processes and phenomena which do not mesh readily with this world vision of the neo-classical economics, an equivalent of a Newtonian world. Quantum theory demonstrated that even sub-atomic particles are entities with a dual aspect – particles and waves, and both aspects are needed to give a full account of the atomic reality. Similarly, according to S-matrix theory, nature cannot be reduced to fundamental entities but has to be understood entirely through self-consistency. Four basic-principles of Post-Newtonian economics – existence, relativity, uncertainty and complementarity – and key differences between Newtonian and Post-Newtonian economics will be discussed. The relevance of Post-Newtonian Economics to sustainable forest management will be highlighted.

#### **Multi-stakeholder assessment of sustainable forestry: Experiences and lessons learned from case studies.**

Mendoza, G.A. (*University of Illinois, USA; gamendoza@uiuc.edu*), Prabhu, R., (*Center for International Forestry Research; r.prabhu@cgiar.org*).

Participatory approaches to natural resource management and development are widely accepted as effective instruments for achieving sustainable resource management particularly in the developing nations. This paper presents an overview of soft system dynamics methods under a participatory modeling framework that is consistent with participatory approaches to assessing sustainable forest management. Three general types of soft system dynamics models are described: cognitive mapping, qualitative system dynamics and fuzzy cognitive mapping. The three models entail different information requirements, knowledge base and varying degrees of complexity. The models can be developed and used as stand-alone resource management tools. Or, depending on the level of complexity and the availability of information about the resource management system in question, they can be integrated to constitute a more robust and flexible planning framework. This paper describes applications of these models in different case studies. Applications of the first two models are reported in detail elsewhere, hence, they are only described briefly. The third model, called fuzzy cognitive mapping, is described in more detail, including an illustrative case study. Experiences and lessons learned from these selected set of applications are also discussed.

#### **Sustainable forest management: Is everything in order but the patient still dying?** Nasi, R. (*CIFOR /CIRAD, France; r.nasi@cgiar.org; robert.nasi@cirad.fr*).

Tropical forests are the most biodiversity-rich terrestrial ecosystems on Earth. Yet they are undergoing unprecedented pressure as demand for agricultural land and forest goods and services increase. Forest management has marginally evolved over the past 50 years, but, during the last decade, an increasing number of tropical forests have been put



under proper management. New, powerful tools (GIS, satellite imagery) are available and used; reduced impact logging guidelines are proposed for the tropics but the basic tenets of European management models that were 'exported' to the tropics in the 1950s, have not really changed. These paradigms are now contested. Existing plans are based on unrealistic prescriptions hindering their adoption or implementation by a large part of the operators or seem viable only for large concessions in untouched forests whereas there is an increasing number of small to medium scale enterprises working in secondary or logged-over forests. The idea of natural forest management as a way to achieve sustainability is strongly criticized and new alternatives like conservation concessions, direct payment for environmental services are promoted. So, is the patient dying? We think not, because new concepts like integrated natural resource management, ecosystem approach and ecosystem management are gaining in strength.

**Steps toward sustainable management of high value tropical timber species.** Ward, S. (*Mahogany for the Future, Inc., USA; seward@caribe.net*).

Although most precious tropical woods are not being sustainably managed overall at present, the focus of this presentation will be on examples of apparent success. Detailed guidelines for sustainable management now exist, but what progress is being made in implementation? Components of sustainability to be considered include: maintenance of biodiversity, ecological services, genetic variation and populations of the target species, sustainability of production and socio-economic effects. Discussion of case studies, including *Swietenia macrophylla* and *Cedrela odorata* in the Yucatan peninsula and *Shorea* spp. and *Tectona grandis* in Asia, will focus on ecological and management issues. Retention of genetic variation may require *ex situ* and *in situ* conservation. One determinant of any management strategy is the regeneration requirements of the species at stake. Complementary use of natural forests and plantations may be required to achieve sustainability for many high value species. Key issues for future consideration will also be presented. There remain many gaps in our critical ecological understanding as well as problems in achieving economic viability for producers of sustainably managed systems. Economic viability requires adjustment of incentives and taking into account the hidden costs of resource utilization.

## **Research: A critical partner in forest certification**

Organizer: William Banzhaff, *Sustainable Forestry Board, USA; banzhafb@sfbnet.org*

**Monitoring Environmental Performance.** Berg, S., Lindholm, E.-L. (*The Forestry Research Institute of Sweden; staffan.berg@skogforsk.se*).

Current fears about a scarcity of resources and energy are influential on investment and development work. Many certification schemes guide investors to enterprises that promise efficient use of resources. The methods used in audits of emissions to air, soil and water often result in laborious monitoring and evaluation procedures for assessing the environmental performance of enterprises. Their precision can also be so low that it is difficult to detect any changes. In close collaboration with some member companies, the Forestry Research Institute (Skogforsk) has developed a practical procedure for monitoring environmental performance, based on the use of a number of simple indicators (ISO 14034) that reflect the criteria a given enterprise has chosen for its environmental evaluation. Using data from forestry operations, the poster will demonstrate how criteria for strategic environmental performance (e.g., reduced emission of fossil CO<sub>2</sub> and emissions of NO<sub>x</sub>) can be monitored using simple indicators that reflect the state of the technology, operations and management, and can easily be interpreted to identify even short-term changes.

**Attitudes of Australian forest growers and primary wood processors toward forest certification.** Bigsby, H.R. (*Lincoln University, New Zealand; bigsbyh@lincoln.ac.nz*), Ozanne, L.K. (*University of Canterbury, New Zealand; lucie.ozanne@canterbury.ac.nz*).

In recent years, the wider social and economic framework that the forest sector operates within has undergone significant change. One of the major challenges facing the industry is a growing trend to market environmental merits of products, particularly through environmental certification. This challenge has led to the research question addressed in this study: What are the attitudes of Australian forest growers and primary wood processors towards forest certification and what factors would facilitate adoption of forest certification among these groups. Data on the Australian forest industry's attitudes towards, and awareness of, forest certification was collected using two mail surveys. Results indicate that interest in forest certification is higher among Australian forest growers than primary processors, with about 30% of forest growers and 18% of primary processors expecting to undertake forest certification. Those who have made the decision to undertake forest certification are more likely to see certification as

important in their markets and to see some benefits in certification. However, many primary processors and forest growers view certification as a defensive reaction to protect markets rather than as a market opportunity.

**Emerging research issues within the Forest Stewardship Council.** Dower, R. (*Forest Stewardship Council USA*).

The ultimate success of any certification program is its ability to protect and enhance the values of sustainable forestry on-the-ground. These values are what create the broad environmental, economic and social stakeholder support for FSC around the world. The almost 50 million hectares of FSC certified forests globally are important indicators of the strength of FSC, but by themselves do not tell us with certainty whether we have, for example, met our obligations to protecting biodiversity or have actually improved water systems dependent on those forest areas. While there have been numerous 'desk top' studies of certification programs, they fall short of being able to identify the improvements that have actually occurred. FSC has a strong interest in better understanding the protocols and procedures for documenting the 'on-the-ground' impacts of certification. Of course, questions abound concerning methodology, baselines, data sets, etc. A rigorous attempt to address these questions and to implement an appropriate assessment would generate important benefits for all certification programs and lead directly to broader stakeholder engagement in certification around the world.

**Forest certification and its effect on forest economics: An Indonesian perspective.** Nirmala Sari, E.N., Kanuma, K. (*Hokkaido University, Japan ; elinns@exfor.agr.hokudai.ac.jp; kanuma@fsc.hokudai.ac.jp*).

Forest Certification was introduced in Indonesia in 1998, and since that time, 14 forest management units (FMU) have undergone certification out of a possible 300. Producers recognize certification as a means of receiving premium prices for certified products and a strategic tool for forest based industry export. The push for certification also comes from NGOs who are encouraging greater environmental and social responsibility from forest managers. To illustrate the current situation, a study was carried out at PT Diamond Raya Timber, a HPH forest concession in Riau province of Sumatera, western Indonesia. A comparison of the socio economical status of the forests with and without the certification is presented. The study also explores consumer willingness to buy certified timber given the price differences between timber with and without certification.

**Emerging research issues within the PEFC.** Parviainen, J. (*Finnish Forest Certification Council, Finland; Jari.Parviainen@metla.fi*).

With more than 120 million ha of certified forests, PEFC (Programme for the Endorsement of Forest Certification Schemes) endorsed certification systems cover the widest areas of forests in the world in implementing sustainable forest management (SFM). The PEFC framework includes 30 member countries representing all continents and 18 endorsed forest certification schemes. PEFC is based on an internationally agreed concept of sustainable forest management and internationally used rules and procedures on certification processes. As a complex market-driven tool, forest certification is a mixture of forest management rules, policy agreements, values, arguments, market expectations and benefits. The scientific approach can mainly be integrated into the forest management standards by setting the threshold values for ecological, economic, social and cultural aspects. While criteria and indicators for SFM provide an essential tool for the certification standards of the PEFC, the newest scientific information and approach can be linked to certification with the worldwide development of indicator processes. The most timely and evident research issues within the PEFC include: 1) Definitions and analysis of the some basic concepts of indicators for SFM such as naturalness, protected forest areas, indigenous peoples rights, social, cultural and spiritual aspects, non-wood forest products indicators and genetic modified organisms (GMO); 2) Harmonizing and clarifying the basic indicators and concepts between the regional processes (MCPFE; Montreal, ITTO, Tarapoto, ATO, African Dry Zone, Near East, Dry Forest Asia, Lepaterique); 3) Clarifying the role of certification in relation to the other tools of SFM such as National Forest Programmes, legislation, financial instruments and/or protected forest programmes, taking into account the implementation possibilities in the countries; 4) The impact of forest certification on the forest management processes and on the forest itself; and 5) The impact of forest certification on the forest product markets, trade, industry and consumer behaviour.

**Effects of forest certification approaches on management strategies of plantation forests in Japan: opportunities or constrains?** Shiba, M. (*Field Science Education and Research Center, Kyoto University, Kyoto, 606-8502, Japan; mshiba@kais.kyoto-u.ac.jp*).

Forest certification, verified by independent third-party assessments, has only been widely accepted a relatively short time, but certification has solidified its place as integral tool for addressing SFM issues in forests around the world. As of July 2004, 18 sites in Japan representing 190,630 ha have been certified by FSC-accredited bodies. The CoC product label is rapidly increasing, with 198 CoC certified private forest landowners and product companies. The primary purpose of this study was to analyze the effects of forest certification schemes on management strategies of Japanese plantation forests. The sample size was relatively small, and the results are not necessarily representative of all completed certifications.

However, each certification examined is of particular relevance to the context of Japanese forest management, particularly given the current period of uncertainty and change. A conclusion of the study is that certification is playing an important role as a 'catalyst' of change in the development of sustainable forest management in Japan.

## **National forest inventories to support sustainable forestry: Research for linking practices to emerging challenges**

Organizers: Piermaria Corona, *University of Tuscia, Italy; piermaria.corona@unitus.it*, and Marco Marchetti *University of Molise, Italy; marchetti@mclink.it*

**Emerging challenges for research supporting national forest inventories on a global scale.** Corona, P. (*University of Tuscia, Italy; piermaria.corona@unitus.it*), Köhl, M. (*University of Hamburg, Germany; m.koehl@holz.uni-hamburg.de*), Marchetti, M. (*University of Molise, Italy; marchetti@mclink.it*).

Sustainable forest management under the current multiple objectives, such as timber production, biodiversity conservation, ecosystem health, carbon sequestration, protective functions against soil degradation and desertification, recreational uses and socio-economic functions, must be based on actual and reliable facts and figures, in order to support objective planning and effective management. Traditionally, forest information has been collected through user-driven national forest inventories (NFIs). Most international programs and initiatives bring them more and more into a context of legally binding information sources. The information needs that have to be satisfied by multi-purpose NFIs require the adoption of new assessment and survey approaches, and the extension of assessments from forests to landscapes. The forest research community has been active in developing NFI methods and tools. This paper presents an overview of current developments and discusses the potential of NFIs, with specific reference to the framework of international reporting obligations. Up-to-date assessment technologies and methods have emerged for practical applications. Distinctively, effective integration of NFIs into natural resources assessments implies wise use of EO, GIS, spatial and ecological modeling techniques, that enables a global view of forests in the light of landscape and ecosystem processes.

**Assessment of trees outside forests: An Indian experience.** Dasgupta, S., Rawat, J.K. (*Forest Survey of India, India; saibaldasgupta@hotmail.com; fsidir@vsnl.com*), Kumar, R. (*National Sample Survey Organization, India; rajsus1@rediffmail.com*).

Trees outside forests (TOF) have gained important status globally due to their economic, social and ecological role. As such, accurate assessment of TOF becomes important for proper planning, management and utilization of these resources. Traditionally, in India, conventional methodology was used for assessment of TOF: complete enumeration of all trees, with diameter of 10 cm and above breast height, in randomly selected villages within randomly selected districts. Data collected in pre-designed formats were analyzed at the district level and aggregated at the national level to obtain tree cover, growing stock, number of trees and species distribution. Although this method provided accurate estimates, it was very time consuming. To overcome this, a recent methodology based on remote sensing data (IRS) using PAN (spatial resolution 5.8 m) and LISS III (spatial resolution 23.5 m, multi-spectral) are used to stratify the TOF area of the randomly selected districts into block, linear and scattered stratum based on geometrical formation of trees. Appropriate numbers of samples are then selected from each stratum and field data on pre-designed formats for each district. The data are then aggregated to give national level estimates as before. This methodology provides more precise estimates, is time effective, and provides spatial distribution of TOF resources on maps.

**The new Italian national forest inventory: A multi-source and multi-resource survey.** De Natale, F., Floris, A., Gasparini, P., Scrinzi, G., Tabacchi, G., Tosi, V. (*Istituto Sperimentale per l'Assessment Forestale e per l'Alpicoltura – ISAFA, Italy; tosi@isafa.it*).

About 20 years after the 1<sup>st</sup> survey, the new NFI has finally started. Significant efforts have been made to build a modern frame, with a sophisticated technological input. The design is based on a three-phase sampling for stratification. A systematic grid of 1 by 1 km cells overlays the whole national territory. In the first phase, a point is randomly selected in each cell (a total of 300,000) and classified by photo-interpreters in relation to a land cover classification system based on Corine Land Cover and FAO FRA 2000 definitions of forest. This phase is carried out by a GIS on digital black and white orthophotos. A sub-sample of the forest photo-points is chosen for the second phase. Point location in the field is carried out through a GPS device that integrates a palm field computer for automatic data collection. In this phase, forest vegetation is classified and qualitative data collected on site, ecosystem, stand, habitats, viability and non-wood forest products. An integration of the second phase information is obtained

from various GIS databases and interviews. A sub-sample of second phase points is chosen for the third phase, where more detailed attributes, dendrometric, silvicultural, ecological data and carbon sink data are collected on ground. In all phases, data are checked on-line by a team of specialists.

**Application of spatial information of forest inventory in estimating carbon sequestration – An example of Taiwan.** Feng, F.-L. (*National Chung-Hsing University, Chinese Taipei; flfeng@dragon.nchu.edu.tw*).

Estimating the country-based carbon sequestration and carbon conservation of forestry and land-use are important for ecosystem management (EM). This paper describes the approach taken to develop this estimate in Taiwan. The first step involved a multi-scale geo-database management system (Geo-DBMS) with individual tree, stand, ecosystem and landscape scales. With the spatial information of status, function and change, empirical and mechanistic models were developed. Spatial interpolation methods were used to estimate the distribution of habitat characteristics from climate stations and soil plots. Taiwan was divided into 3.2 million cells using a 40 x 40 m grid, and compartments of 42 working circles. At the landscape level, the country was classified into seven climate eco-regions using the Holdridge life zone model, and SPOT digital images and aerial photos were interpreted to produce land-cover maps. At the stand level, stand composition, stand structure, growing stock and stand growth were estimated from 4002 sample plots and 2800 permanent sample plots. At the tree level, data, from stem analysis and incremental boring cores from stems in the plots, were used for growth modeling. The models from the different levels were integrated to estimate the stock and flux of tree volume/ biomass. Data from *Cinamomun camphora* were used to develop the carbon estimating system.

**Which density measure to use in stand classification?** Gonçalves, A.C. (*Universidade de Évora, Portugal; acag@uevora.pt*), Oliveira, Â.C., Tomé, M. (*Instituto Superior de Agronomia, Portugal*).

Many forest stands are composed of more than one species. For structure and growth analysis, it is important to know whether stands are pure or mixed. Abundant literature references can be found for different methods to classify these stands (e.g., number of trees per hectare, basal area per hectare, volume per hectare and ground cover). Unfortunately, a large number of methodologies are used in stand classification, making the comparison of stands rather difficult. In addition, these methods do not allow for the analysis of stand dynamics. Two earlier stand classifications were an important improvement for understanding multi-species stand dynamics. A new classification scheme is proposed that builds on those schemes. It uses three criteria: form, type and degree. 'Form' is used to evaluate the spatial distribution of different species, 'type' characterizes their vertical distribution, and 'degree' characterizes their proportions. 'Degree' is presented as an index, and is a function of the number of trees per hectare, basal area per hectare and ground cover. This index enables further detail in stand classification as it allows for the identification of different types of mixed stands.

**Development an application of a GPS navigation program to re-locate forest inventory plots.** Hamberger, J. (*Bavarian State Institute of Forestry, Germany; jhh@lwf.uni-muenchen.de*).

The federal forest inventory has permanent sample plots with a raster of (4 km x 4 km). The interval of data collection is 15 – 20 years. The first inventory was undertaken in 1986, and the second inventory was undertaken in 2002/2003. The centre of every inventory plot is marked with a metal pin that can be relocated with a metal detector. For accurate repetition of data collection, it is necessary to relocate the centre of the sample plot exactly. But in reality it is very difficult to find the plot centres again. To address this problem, GPS navigation software was developed. The program uses tree data (diameter, tree species) and geodetic data collected during the previous measuring, to support the navigation. One challenge was the conversion of geodetic data collected in 1986 and the visualisation of the tree data on the navigation display. With the use of the program we have reduced the time required for relocating plot centres from the 40 minutes required for the old method using a metal detector and map, to 20 minutes using the new method with a navigation program and GPS.

**National forest assessments: Investing in policy guidance for sustainable forest management.** Holmgren, P. (*Food and Agriculture Organization of the UN, Italy; peter.holmgren@fao.org*), Thuresson, T. (*National Board of Forestry, Sweden; tomas.thuresson@svo.se*).

National forest inventories and assessments should be seen as public sector investments that return increased welfare as a result of improved political decisions related to national policies, including forest policies. Current inter-governmental forestry processes have identified seven thematic elements of Sustainable Forest Management that express the various social, environmental and economic benefits expected by society from the forest sector. These elements can be formulated as a goal function, and as such, serve as a framework for forestry monitoring and assessment efforts. As traditional national forest inventories were designed when wood production was the dominating forestry goal, the information obtained in these inventories may not be sufficient to support modern policy processes. Furthermore, the cost and time required for conventional national forest inventories are often considered as limiting factors for improvements. However, it

is suggested in this paper that rapid and economic national forest assessments can be designed, that provide a broader range of relevant and representative information on social, environmental and economic benefits from forest resources at the national level. Results and experiences from such national assessment projects in Latin America, Africa, Near East and Asia are presented, including linkages to, and feedback from, national policy processes.

**Monitoring and reporting the health of native forests: how difficult is it?** Jurskis, V., de Mar, P. (*Forests NSW, Australia; vicj@sf.nsw.gov.au*).

Australia's National Forest Policy requires that native forests be protected from pests, diseases and unnatural fire regimes. Maintenance of ecosystem health and vitality is a criterion of sustainable management, and two indicators are the area affected by damaging agents and the area showing biophysical changes indicative of fundamental ecological problems. These indicators should be implemented immediately, however the 2003 *State of the Forests* report contains no area data. It states that the heterogeneity of data, the variety of different agents of decline and a lack of spatial information make reporting difficult. Further research is underway using remotely sensing to monitor native forest health. However, increasing areas of declining eucalypt forest have been identified across temperate Australia over many decades. A common process of eucalypt forest decline is outlined and a case study is presented of a simple regional assessment of forest health. Regional surveys should be extended, paying less attention to specific agents of decline. Simple assessments, from the ground, of the condition of canopies and structure of a few broad forest types can be used with geographic information systems to estimate the location and extent of declining forests. These estimates can guide adaptive management to address forest decline.

**National system of permanent plots: Proposal for a methodological model.** Malheiros de Oliveira, Y.M., Doetzer Rosot, M.A. (*Embrapa Florestas, Brazil; yeda@cnpf.embrapa.br; augusta@cnpf.embrapa.br*); Batista da Luz, N. (*Embrapa Uva e Vinho, Brazil; naissa@cnpuv.embrapa.br*), Povoá de Mattos, P. (*Embrapa Florestas, Brazil; povoá@cnpf.embrapa.br*).

The new paradigm of human development is the concept of sustainability. Several countries, including Brazil, are signatories of environmental documents and statements from world conferences. The Brazilian Ministry of Environment is committed to the establishment of an effective forest policy, which is primarily aimed at the sustainable development of the country. Since the end of the 1980s – when the national forest inventory was carried out – there has been a lack of information regarding forest resources. The National System for Forest Information, created under the National Forest Program, aims to support internal and external demands related to the process of acquisition, analysis, organization and dissemination of forest data. The Brazilian Agricultural Research Corporation – EMBRAPA, together with the Ministry of Environment and FAO, is now responsible for the development of a proposal to implement a National System of Permanent Plots (SisPP). Technical workshops are being held to discuss aspects related to the structure, organization and functions of the system, as well as the standardization of data collect patterns. Emphasis is placed on the strengthening of local or regional permanent plot networks, as they provide the basis for a continuous forest monitoring system.

**PractiSFM: A multi-resource inventory and decision support system for sustainable forest management in Ireland.** Nieuwenhuis, M., Barrett, F., Somers, M. (*University College Dublin, Ireland; maarten.nieuwenhuis@ucd.ie*).

During the last 20 years, the size of the forest estate in Ireland has increased dramatically. Inventory and management information on the (FSC-certified) publicly-owned forests is widely available, however details on the rapidly expanding private estate, both in terms of inventory data and management objectives, are missing. The PractiSFM Decision Support System comprises customized Microsoft Excel™ based modules that allow forest managers to analyse multi-resource inventory data and to project the development of a forest under a range of management strategies. After each simulation, reports in tabular, graphic and map format are produced on a wide range of variables. Visual tools (i.e. an interactive map interface and a goal analysis module) have been incorporated into the program. It is envisaged that the use of the PractiSFM inventory and decision support system will allow for the reporting of essential information on the state and development of the private forest estate to the State forestry authorities. These standardized data will then form the basis for an forest inventory of the private forests, complementing the already available information on the publicly-owned forests and the results of a low-resolution national inventory that will be carried out during the next three years.

**Deriving unbiased forest statistics for large areas by combining remote sensing data and field data using post-stratification.** Nilsson, M. (*Swedish University of Agricultural Sciences, Sweden; Mats.Nilsson@resgeom.slu.se*).

Remote sensing data can be combined with field data to estimate forest variables over large regions. The accuracy of these estimates depends, for example, on how well the field measurements can be linked to satellite images and on how

well forest areas can be identified. In practice, it is difficult to delineate forest areas from other land cover classes which might result in biased estimates. The Swedish National Forest Inventory (NFI) has therefore decided to use a post-stratification approach to derive unbiased estimates of forest parameters over large regions. In this study, images from Landsat ETM+ were used to post-stratify field plots from the Swedish NFI. The results show that the standard deviation for estimates of stem volume, stem volume for pine, stem volume for spruce and tree biomass were reduced with 15% – 40% on a county level by using post-stratification based on Landsat ETM+ data instead of field data alone. For stem volume of deciduous trees and the amount of dead wood, the reduction in standard deviation was less than 10%. It was also found that at least 3–5 strata should be used.

**MODERNA: a neural network based simulator for forest inventory.** Scrinzi, G., Marzullo, L., Galvagni, D. (*Forest and Range Management Research Institute – ISAFI, Italy; scrinzi@isafa.it, laura.marzullo@isafa.it, galvagni@isafa.it*).

Forest management decisions are made based on information about current resource conditions. Information on wood volumes and related statistics are provided by forest inventories. Traditional methods for collecting data have now become far too expensive, and can easily be affected by bias. Thanks to their flexibility and adaptability, artificial neural networks are an alternative and valid approach for modeling non-linear and complex long-lived dynamic biological ecosystems such as forests. Using the large dataset of the Forest Inventory of the Special Administrator Province of Trento, Italy, a neural network based simulator (MODERNA) has been developed to update the tree diameter-at-breast-height distributions for managed alpine stands. The simulator output is the number of trees in each 5-centimetre diameter class from 20 to 80 cm, on a simulation lapse of time of 10 up to 25 years. MODERNA can be used for updating distribution data of several alpine species: fir (*Picea abies*), silver-fir (*Abies alba*), Scots pine (*Pinus sylvestris*), larch (*Larix decidua*) and beech (*Fagus sylvatica*). MODERNA has been designed as an easy-to-use planning tool, and represents an efficient and reliable alternative to the traditional expensive measurement techniques. MODERNA has been recently adopted by the Forest Management Office of the Province of Trento to integrate standard data acquisition procedures.

**A combined forest inventory concept for Miombo woodland restoration and management in Tanzania.** Schrader, H., Grabitzki, S. (*UNIQUE forestry consultants, Germany; henning.schrader@unique-forst.de, sylvana.grabitzki@unique-forst.de*), Tennigkeit, T. (*Universität Freiburg, Germany; timm.tennigkeit@waldbau.uni-freiburg.de*).

African Miombo woodlands are the largest dry deciduous forest formations in the world. In Tanzania, about 90% of the forests are Miombo woodlands. Most of these forests are degraded, and silvicultural restoration and management are rarely undertaken. In the Kilombero Valley, a satellite-based inventory was conducted to classify Miombo forest types based on high resolution satellite imagery and object-oriented classification. Dense and open Miombo woodland as well as evergreen forests could clearly be identified. Additionally, stand parameters (dimension, stocking volume of valuable tree species) were determined. The study revealed that a combination of terrestrial inventories and satellite remote sensing was suitable to assess the management potential and offered directions for silvicultural treatment and restoration. Considering the current decentralization policy in Tanzania, aiming to empower communities to manage their forest resources autonomously, a procedure for a combined forest inventory is proposed: (1) national-level, satellite-based inventories to detect change and generate maps of management units for community forestry, and (2) community level, simple terrestrial inventories to collect additional information about the stand structure. The combination of these two inventory procedures will allow monitoring of forest management practices and provide guidance to forest communities.

**Assessment of forest non-wood goods and services by national forest inventories.** Ståhl, G. (*Swedish University of Agricultural Sciences, Sweden; Goran.Stahl@resgeom.slu.se*).

Several decades ago, assessment of wood availability and productivity were the main objectives of most national forest inventories (NFIs). However, over the last few decades there has been substantial change and today NFIs are generally designed to support decisions related to a wide range of goods and services from forests. This change has resulted in the need for new indicators of resources, new definitions, new inventory designs, as well as new measurement procedures to acquire the data needed. Regarding appropriate procedures to use within NFIs, we are still in a conversion phase where some of the traditional measurements need to be substituted, or accompanied by, new ones. However, in this development, an interesting observation is that many of the traditional measurements of tree and stand variables are extremely useful for describing the other resources. In this presentation, an overview of resources, indicators and new data requirements will be given based on results from recent EU research projects (MNTFR and DMMD). In addition to this overview, case examples of procedures within the Swedish NFI will be presented.

**Estimation of biomass of the Mt. Makiling Forest Reserve using geographic information system.** Tiburan Jr., C.L., Carandang, M.G., Bantayan, N.C., Cruz, R.V.O. (*University of the Philippines Los Baños, Philippines; cltj\_uplbcfnr@yahoo.com; mgc@laguna.net; rexcruz@laguna.net*).

Important carbon sinks, such as tropical rainforests, are undergoing world-wide degradation. Consequently, the adverse effects of global climate change due to forest degradation are already being experienced. One approach to studying the impact of such degradation is the estimation of forest biomass. A geographic information system (GIS) was used to determine the potential biomass of the Mt. Makiling Forest Reserve (MFR), a vital carbon sink near metropolitan Manila. Five thematic maps were generated: 1) modified Weck's climate index; 2) mean annual precipitation; 3) elevation; 4) slope; and 5) soil texture. The total potential biomass of MFR was estimated at 1.69 Pg. Total actual biomass at three different periods was also estimated using forest inventory data. It was determined that the total actual biomass for 1992, 1997 and 1999 were 1.64 Pg, 1.51 Pg and 1.54 Pg, respectively. This result is significant for the sustainable management of MFR because it provides information that can be used for planning and management operations. Along with this observation, actual biomass and potential biomass of various types of land cover (secondary forest, mossy forest, agroforestry, brushland and non-forest areas) in MFR were also compared.

**Inventorying carbon stock and carbon stock changes by national forest inventories.** Tomppo, E. (*The Finnish Forest Research Institute, Helsinki, Finland; erkki.tomppo@metla.fi*).

National forest inventories have traditionally produced information about forest resources, forest structure, applied and needed cutting and silviculture regimes, as well as cutting possibilities for decision making concerning forestry and forest industrial needs. Monitoring of forest health status, and assessing the status of biodiversity, came into the picture in the 1980s and 1990s. Reporting of greenhouse gas emission under the United Nations Convention on Climate Change and its Kyoto Protocol has set new, very challenging, demands on forest inventory systems. The estimation of state and change in forest carbon pools, as required for the land-use, land-use change and forestry sector in IPCC Good Practice Guidance, involves five pools (above and below ground biomass, dead wood, litter and soil organic matter), in six land use classes (forest land, cropland, grassland, wetland, settlements and other land), and in all possible land use change classes. Three possible approaches and three tier levels are presented in this paper. The Kyoto Protocol presumes further, the estimation of carbon pools in areas related to afforestation, reforestation and deforestation. The possibility to meet the carbon stock reporting requirements in national forest inventories are discussed with some cases from Europe.

**Evaluation of n-tree distance sampling: Bias, reliability and practical applicability to forest inventory.** Trifkovic, S., Yamamoto, H. (*University of Tokyo, Japan; stanko@uf.a.u-tokyo.ac.jp; yama@uf.a.u-tokyo.ac.jp*).

N-tree distance sampling is cost-competitive compared to other statistical methods, but there is a bias against its wide application in forest inventory operations. The objectives of this study were to test the reliability of n-tree distance sampling in estimating tree density and basal area, and to test its applicability in forest inventory. Computer simulations and field measurements were carried out. Computer simulations were conducted using a geographic information system with high-resolution satellite images and aerial photographs. Net grids were established to draw systematic plot sampling points, and distances to simulated n-th trees were measured. Field measurements were conducted in *Cryptomeria japonica* and *Chamaecyparis optusa* forest plantations. Photo-interpretation-based stratification of respective forest stands was undertaken prior to field sampling. Stratification of forest area was carried out, to divide the large population into relatively uniform sub-populations and distinct forest types, so that n-tree distance sampling would not be biased. N-tree distance sampling can be used in uniform-random populations such as forest plantations or even-aged forests. Stratification, which is also necessary if applying other known statistical methods, is the most important, and an unavoidable part, of forest inventory.

## **International research to monitor sustainable forest spatial patterns**

Organizers: Christine Estreguil *European Commission-Joint Research Centre, Italy; christine.estreguil@jrc.it*, and Kurt Riitters *USDA Forest Service, USA; kriitters@fs.fed.us*

**Fragmentation of Australia's forests – the big picture. Nationally consistent data collection, analysis and implications.** Dunn, G., Thackway, R. (*Bureau of Rural Sciences, Australia; geoffrey.dunn@affa.gov.au; richard.thackway@brs.gov.au*).

Forest fragmentation caused by conversion of forest types to other land cover types results in the disruption of ecological processes and reduces the availability of forest habitats for forest dependant species. An analysis of fragmentation at any level requires access to data of a consistent scale, quality and content. Currently, data on Australia's forest extent have not

been collected at a consistent scale and quality, and changes in fragmentation cannot be separated from changes resulting from improved forest mapping. We discuss the need to develop a consistent national forest dataset of scale and quality to aid studies into fragmentation, enabling quantitative assessments for measurement of changes in forest cover and the potential for application of a range of fragmentation metrics to calibrate forest data collected as part of a Continental Monitoring framework. We will also discuss the use of fragmentation studies in informing land management practices.

**Australia's forest and vegetation estate: Inventory and monitoring.** Dunn, G., Thackway, R. (*Bureau of Rural Sciences, Australia; geoffrey.dunn@affa.gov.au; richard.thackway@brs.gov.au*).

There have been recent advances in the inventory and monitoring of Australia's forest and vegetation estate through the integration of existing data, the Continental Forest and Vegetation Monitoring Framework (CVFMF) and Natural Resource Management initiatives.

**Implementation of the MCPFE indicator "Forest Spatial Pattern" to report on European forest biodiversity.** Estreguil, C., Vogt, P., Kozak, J., Hansen, C., Puzzolo, V. (*European Commission-Joint Research Centre, Italy; christine.estreguil@jrc.it*).

The monitoring and reporting on the status and evolution of European forest biodiversity is a key component of the European Union's policy on Environment and Sustainable Development. 'Forest area by forest types', and 'Landscape Level Forest Spatial Pattern' are two indicators of biological diversity that have been identified by government agencies. For a European level application, remote sensing offers the natural way to assess forest spatial pattern. To date, no common monitoring system for forest structure on large areas has been presented, and the availability and comparison of spatial metrics at different time points are lacking. To help fill this knowledge gap, the implementation of these two indicators is one research issue of the Joint Research Centre institutional forest activity, and recent results concerning three European bio-geographic zones—Alpine, Atlantic and Mediterranean—will be presented here. Changes of forest cover and spatial pattern are quantified using Landsat images for 1987 and 2000. Image segmentation and standard supervised classification algorithms, supported by additional data in the classification process (CORINE Land Cover and a digital elevation model), are used to create forest maps. Assessment of spatial forest pattern trends are based on changes in core, patch, edge and perforated forest.

**Montreal Process reporting on forest fragmentation in New Zealand: Current status and research.** Hock, B., Paul, T., Payn, T.W. (*Ensis, New Zealand; Barbara.Hock@ensisjv.co.nz*).

The indicators of forest fragmentation for biological diversity in the Montreal Process depend highly on data quality, the characteristics of the metrics used to describe the fragmentation and the appropriate use of both in the chosen context. For New Zealand's Report on the Montreal Process in 2003, only the size class distribution of indigenous forests was used as a measure for forest fragmentation. Since then, however, significantly more national information has become available that has potential for fragmentation analysis. We present the status of the research on delivering a more accurate picture about the fragmentation of forests in New Zealand. One aspect of the research focuses on the new national scale indigenous and plantation forest datasets. The usability and quality of these datasets in terms of forest fragmentation evaluation is described and issues are highlighted. A second aspect of the research is an evaluation of some of the commonly used indices and metrics as calculated on these datasets. Included in this are the effects of resolution and definitions on the metrics, and their capability of describing forest fragmentation in the highly variable landscapes of New Zealand (the naturally occurring geographic variance). Results, recommendations and further research needs are presented.

**Linking species requirements with landscape information in forest biodiversity management: Some examples of European experiences in habitat suitability modeling.** Mikusifski, G., Edenius, L., Ståhl, G. (*Swedish University of Agricultural Sciences, Sweden; grzegorz.mikusinski@nvb.slu.se; lars.edenius@szoek.slu.se; goran.stahl@resgeom.slu.se*).

Long-term planning in forestry requires tools that assess the outcome of forest management scenarios. We report here on two projects dealing with landscape ecological dimensions of this issue. The project 'Biodiversity Assessment Models' within the Swedish research program 'Heureka' aims at developing spatially-explicit tools to quantify present and future effects of forestry on biodiversity. The species oriented approach has been applied. In particular, the species-specific requirements for the amount and distribution of habitat resources have been linked with landscape data in the process of habitat suitability modeling in a GIS environment. Both real and virtual species with requirements encapsulating a broad range of structural and functional habitat characteristics in different scales were used. The composite indexes quantifying impact of various forest management scenarios on forest biodiversity have been developed. In a project run by the Joint Research Centre of the European Union (the DMMD-project), habitat models for focal species were developed and



applied in four different European sites. The models were based on combining different life requirements (e.g., breeding site quality and forage availability) into an overall index of habitat suitability at the landscape level. Finally, indexes describing landscape structure from the forest biodiversity stand-point have been constructed.

**Analysis of forest structure for sustainability management.** Remes, J., Svoboda, M., Podrazsky, V. (*Czech University of Agriculture, Czech Republic; remes@fle.czu.cz; svoboda@fle.czu.cz; podrazsky@fle.czu.cz*).

Forest structure is the key characteristics of the forest ecosystem. It is determined by characteristics of species, age and dimension; and enables one to predict future dynamics. Analysis of the stand structure is the basic prerequisite of the forest ecosystem studies. The poster documents the use of the technology Field-Map at the Czech University of Agriculture, for the collection and processing of data as well as forest dynamics analysis and prediction in particular natural and planted stands. It was used: (1) in semi-natural forests of the Bohemian Forest National Park, in mountain conditions, (2) in small areas of the Natural Reserves in Central Bohemia, and (3) in natural (primeval) forests of different parts of the Europe (Slovenia, Slovakia, Czech Republic, Poland). The results of particular measurements are presented, showing that the technology is a suitable analytical tool.

**Forest fragmentation research identified by the US 2003 national assessment for the Montréal Process.** Riitters, K. (*USDA Forest Service, USA; kriitters@fs.fed.us*).

'Fragmentation of forest types' is an indicator of biological diversity in the Montréal Process. In the 2003 US National Assessment, the indicator was interpreted as the extent to which forests are distributed as large blocks of habitat. It was assessed by four metrics – patch size, amount of edge, inter-patch distance and patch contrast – that were measured on land-cover maps derived from satellite imagery. According to the contrast metric, forest was the 'background' in 70% of all landscapes containing forest; in other words, the 'patch-based' metrics really applied to only 30% of total forest area. Furthermore, metrics of patch size and edge amount were highly correlated ( $r > 0.85$ ) with the amount of forest present in a landscape, and there was relatively little geographic variation in the inter-patch distance metric. Although the available data permitted a good characterization of the four metrics at continental scale, it is too early to prove the relationships between those metrics and actual biological diversity. Instead, attention should be focused on improving the conceptual model that links forest spatial patterns to biological diversity, and on testing alternate metrics in that framework.

## **The certification of fast-grown plantation forests: Issues, costs and benefits**

Organizer: Chris Goulding, *Forest Research, New Zealand; Chris.goulding@forestresearch.co.nz*

**Can we grow certified eucalypt plantations in sub-tropical Australia?** Carnegie, A.J. (*NSW DPI, Australia; angusc@sf.nsw.gov.au*), Stone, C. (*NSW Department of Primary Industries, Australia; christines@sf.nsw.gov.au*), Lawson, S. (*Department of Primary Industries and Fisheries, Queensland, Australia; simon.lawson@dpi.qld.gov.au*).

In the past few years, several Australian forestry companies have set in place procedures for certification in sustainable forest management (FSC, AFS or ISO 14001). Eucalypt plantation forestry in sub-tropical New South Wales and Queensland is unique in Australia, with the majority of plantations grown for long rotation sawlogs, and a range of tree species different to that planted for pulp in southern Australia. The major insect pests in this region are multivoltine and active for much of the year, due to the warmer climate and short, milder winters. Monitoring is essential for correct timing of insecticide application. However, effective monitoring for insect pests over extended periods of insect activity is difficult due to limited resources of forestry companies in Australia. Chemical control of an important native pest of eucalypt plantations in sub-tropical Australia, *Creiis lituratus*, has proven difficult due to re-infestation and the need for regular spraying over several months. The only insecticide currently registered for this pest, dimethoate, is deemed 'unacceptable' for FSC certification, and some being tested (e.g., imidacloprid) are 'marginally' acceptable. This paper discusses regional issues for cost-effective management of insect pests in relation to certification, including targeted use of slow-release systemic insecticides and insect-based pheromones.

**Integrated approach for the evaluation of SFM indicators at local scales.** Carnus, J.-M. (*INRA, France; carnus@pierroton.inra.fr*), Tomé, M. (*ISA, Portugal; magatome@isa.utl.pt*), Orazio, C. (*European Institute for Cultivated Forests, France; Christophe.ozario@iefc.net*).

In the past decade, sustainability of forests has been assessed through monitoring of widely-accepted criteria and indicators for Sustainable Forest Management (SFM). Evaluation of SFM indicators has been generally conducted at

national levels on the basis of forest inventories data and agreed list of indicators from inter-governmental processes. In parallel, certification processes have been developed and are generally conducted at smaller scales such as regional or management unit levels. Increasingly, SFM indicators will need to be evaluated at those local scales to answer public questions and facilitate societal dialogue on the basis of scientifically sound and pertinent information. To undertake this type of evaluation within homogeneous bio-geographic zones and socio-economic context, an integrated approach is proposed combining (i) use of reference pilot zones, (ii) elaboration of indicators and evaluation of their pertinence through scientific studies for priority domains (carbon sequestration, forest damages, soil disturbances, landscape patterns and biodiversity, global value of products and services), (iii) comparative test of common protocols, and (iv) organisation and sharing of forest information at regional levels with stakeholders and the public. Methods and costs are presented for key indicators corresponding to priority issues for planted forests of European Atlantic regions.

**Certification of fast-grown pine plantations in the U.S. South: Environmental benefits and economic sustainability.** Cabbage, F.W. (North Carolina State University, USA; [fred\\_cabbage@ncsu.edu](mailto:fred_cabbage@ncsu.edu)), Siry, J.P. (University of Georgia, USA; [jsiry@forestry.uga.edu](mailto:jsiry@forestry.uga.edu)).

The U.S. South is the world's leader in fast-grown plantation forest management. With 14 million ha of intensively managed pine plantations, the region contains a large share of the world's fast-grown industrial planted forests. These plantations currently supply about 40% of the region's softwood harvest, and their share is increasing. In recent years, there has been rising interest in certifying these fast-grown plantations, which are owned by both large industrial investors and small nonindustrial private owners. First, information is provided about the current status and trends in the certification of intensively managed pine plantations in the southern USA. Next, certification principles, objectives and performance measures of major certification programs are analyzed to determine their applicability to the region's resources, intensive management techniques and ownership structure. This information helps identify major issues and challenges in the certification of fast-grown plantation forests and evaluates the success of certification programs in resolving them. Finally, the costs and benefits of the certification of fast-grown plantation forests are evaluated, including environmental and social benefits that can be realized through the science-based, environmentally responsible application of intensive management.

**Certification of industrial forest plantations: A view from production forestry in Chile.** Paredes, G. (University Austral of Chile, Chile; [gparedes@uach.cl](mailto:gparedes@uach.cl)).

Certification of environmental standards and practices for the sustainable management of industrial plantations has increased rapidly in the last 5 years in Chile. During this time, the industry association (CORMA), the government forest research institute (INFOR) and a technology transfer organization (Fundación Chile) have spearheaded the development of national standards for certifying sustainable forest management: CERTFOR. This process has succeeded in establishing, in Chile, community-accepted criteria for local natural and plantation forests. With different motivation, the main companies have adopted one or more of the different standards: ISO 14.001, FSC and CERTFOR. In this paper, their motivation and results are described and selected issues are analyzed. The issues include, impact on competitiveness of industrial plantations; the role government agencies in forestry, equity problems faced by small forest owners, and the absence of a comprehensive government policy on sustainable management of native forests.

## **Economics of sustainable forest management**

**Organizers:** Shashi Kant University of Toronto, Canada; [Shashi.kant@utoronto.ca](mailto:Shashi.kant@utoronto.ca), and Sen Wang Natural Resources Canada, Canada; [senwang@pfc.cfs.nrcan.gc.ca](mailto:senwang@pfc.cfs.nrcan.gc.ca)

**Forest owners' species choice for plantation in Japan.** Fujikake, I. (University of Miyazaki, Japan; [fujikake@cc.miyazaki-u.ac.jp](mailto:fujikake@cc.miyazaki-u.ac.jp)).

Forest owners' species choice for plantation is an important factor that shapes the resource dynamics and thereby has an influence on the sustainability of forestry. Sugi (*Cryptomeria japonica*) and Hinoki (*Chamaecyparis obtusa*) are the two main species for plantation in Japan. Although Sugi was once the favorite species in many regions, forest owners have increasingly opted for Hinoki. This study examines the effect of economic factors on the choice between the two species. It models the ratio of Sugi planted in each Japanese prefecture using a generalized estimating equations method. The estimation results suggest that the changes in stumpage prices and forestry wage are the main causes of change in species choice. These findings agree with the theoretical predictions which are derived using a Faustmann type rotation decision model. Japanese forest owners thus seem to choose planting species according to current trends of economic viability.

**Economic impacts of increased forest biodiversity conservation in Europe.** Kallio, M. (*Finnish Forest Research Institute, Finland; maarit.kallio@metla.fi*), Moiseyev, A. (*European Forest Institute, Finland; moiseyev@efi.fi*), Solberg, B. (*Agricultural University of Norway, Norway; birger.solberg@ina.nlh.no*).

The economic impacts of potentially increased forest conservation on the European forest sector are assessed. A baseline case created by a global forest sector model EFI-GTM, was compared with two scenarios where 3% and 5% of the productive forest growing stocks in Western Europe and the EU (WEU) were conserved. The 5% case was further compared to cases where the rest of Europe and North America joined the forest conservation program. The aggregate impacts of conservation seemed relatively low, because international trade counterbalances regional shortages and wood harvests were much below annual forest growth in most European countries. WEU consumption of domestic forest industry products and logs were replaced with imports from Russia and Eastern Europe. With 5% conservation, future WEU log prices increased by 4%, while log harvests were reduced by 3% on the average during 2010–2020. This made the wood sales income of the aggregated WEU forest owners increase slightly. The WEU solidwood industry production decreased by 1% and pulp production by 2%, but the paper industry production was almost unaffected. Forest conservation actions taken simultaneously in Russia and Eastern Europe would further increase the costs of the WEU forest industry.

**Economics of sustainable forest management: From Darmstadt, Germany to Toronto, Canada.** Kant, S. (*University of Toronto, Canada; shashi.kant@utoronto.ca*).

The concept of sustainable forest management (SFM) is an outcome of dynamism in the human value system, and a reflection of social, cultural, economic, and environmental conditions of the late twentieth and early twenty-first century. The concept of SFM incorporates human preferences for timber and non-timber products, preferences for marketed – as well as non-marketed products and services, and the preferences of industrial – as well non-industrial agents, including Aboriginal and other local people. The concept of SFM recognizes diversity of preferences across agents, communities, time and generations. The basic premises of the economics of forest management, which has its roots in Faustmann's formulation, are almost wholly in contradiction to the realities and expectations of SFM. The economic principles, theory and models of SFM need to reflect the realities of the twenty-first century. In this paper, we review the emerging themes and developments in the economics of SFM which were presented at an International Conference on Economics of Sustainable Forest Management, at the University of Toronto in May 2004. The contributions include the relevance of complexity theory, behavioral economics, social choice theory, undiscounted maximization, post-Keynesian economics, theory of multiple equilibria and institutional economics of sustainable forest management.

**Interest and forest growth.** Martins, G. (*Freiburg University, Germany; martinsgilson@hotmail.com*), Rochadelli, R. (*UFPR, Brazil*).

The equation  $PVGI = V(i) * P / (1 + r(i)^2)$  (present value of forest gross income) was derived in order to investigate the relationship between forest growth and interest in conditions of optimality.  $V(i)$  represents the volume per hectare of wood as a dependent variable of the age  $i$ . The price  $P$  of wood is constant (one product) and  $r(i)$  correspond to compatible interest rates per stand age. The compatible rates of interest can be then represented as an exponential function of the relative growth ( $V'/V$ ) of the forest stand, or:  $r(i) = e^{V'/V} - 1$ . This equation was tested using growth functions available in the literature. With this procedure, the interest rate can be directly determined for each age of the forest stand. It transforms the sigmoid growth of the forest into uniform interest rate so that it can be compared with the available interest rate of the market. By choosing an interest rate it is possible to determine at what age of the forest stand it occurs. The further development of this analysis, already initiated by the authors, considers the inclusion of different prices for wood assortments.

**Pecuniary externalities and invisible stakeholders.** Price, C. (*University of Wales, UK; c.price@bangor.ac.uk*).

The agreement of stakeholders is seen as an essential pillar of sustainable forest management. The interconnectedness of economic systems means that not all stakeholders are visible on the ground. Some are affected because present markets transmit signals of scarcity into their sphere of action. The increasing emphasis now given to local participatory decision making tends to under-represent such market effects, rendering them the new economic externalities. Even when commercial considerations enter participatory decision making, participants may not be aware of real trade-offs. Economic cost-benefit analysis traditionally concerned itself only with technological externalities (pollution, biodiversity loss, climate change). Distortions were traditionally treated by using true opportunity costs of resources, and willingness-to-pay measures for products (whether marketed or not). However, pecuniary externalities also trigger influences not matched by direct market transactions. Sustainable local practices may significantly reduce supply and increase prices, thus stimulating supply elsewhere. Such adjustments have their own effects on technological externalities in forests feeding the same timber markets as the focus forest. Thus constraints imposed to make forestry sustainable in one place may, by transferring timber demand elsewhere, decrease sustainability as it affects the other stakeholders.

**Economic effectiveness of sustainable forest management.** Pulkrab, K. (*Czech University of Agriculture Prague, Czech Republic; pulkrab@fle.czu.cz*).

Implementation of sustainable forest management belongs to the priorities of the Czech forestry policy and the whole forestry community. Discussions on principles of nature close management systems grow intensive and the issue is more or less treated by all interested parties. However the implementation of this goal is complicated by continual escalation of two contradictory principles: a decreasing economic profitability of forest production on one hand and a growing stress to provide environmental services by the forestry sector on the other hand. This dilemma can namely be noticed in case of the management of marginal and submarginal forest stands and properties. The article deals with economic aspects of sustainable forest management. The analysis stems from typological system and operation parameters quantification. Several hundreds of variants were calculated for forest silviculture profitability classified by management intensiveness, target management system, share of ameliorating and improving species, share of natural regeneration and set of forest types. The results achieved show a chance to save labour and also show marked differentiation of wood production function effect depending from natural and production conditions and management intensiveness.

**Financial analysis of a tropical forestry enterprise: A case study from Deramakot Reserve, Malaysia.** Schopfer, S. (*University of Hamburg, Germany*), Huth, A. (*UFZ Leipzig, Germany*), Glauner, R. (*Institute for World Forestry, Hamburg; glauner@holz.uni-hamburg.de*).

This study analyzed the financial viability of three management scenarios for the Deramakot Forest Reserve in Sabah, Malaysia: Reduced Impact Logging (RIL), Low Impact Logging (LIL) and Conventional Logging (CL). Three sustainable Annual Allowable Cuts (AAC) were calculated with the process-based model FORMIX 3Q. The study revealed that harvesting is feasible even under the current degraded conditions and an AAC of 10,000 m<sup>3</sup>/year for at least 40 years was suggested. The integration of a costing module allowed the combination of survey cost and revenue-related data of different harvesting scenarios with AAC. Financial indicators were included in order to allow a transparent analysis of different scenarios. The module also provides sensitivity analysis of key features such as timber price and AAC. Apart from the total balance sheet, the module provides information about the internal cost distribution. Sensitivity analysis revealed that the current management scenario, RIL, would be more profitable than CL only if current AAC increased by 18%. A price increase of 14.1% allows the RIL scenario to break even; and the sensitivity analysis concerning the discount rate emphasized the dependence of all results on the chosen discount rate of 7%.

**Economic analysis of sengon (*Paraserianthes falcataria*) community forest plantation, a fast growing species in East Java, Indonesia.** Siregar, U.J. (*Bogor Agricultural University, Indonesia; ulfahjsiregar@yahoo.com*), Rachmi, A. (*Brawijaya University, Indonesia; asminah@yahoo.com*), Massijaya, M.Y. (*Bogor Agricultural University, Indonesia; yusram@indo.net.id*), Ishibashi, N., Ando, K. (*JICA-FORDA Project, Bogor, Indonesia; nobuo-ishibashi@rinya.maff.go.jp; kazuya@indo.net.id*).

Despite strong efforts to rehabilitate degraded forests and lands in Indonesia, successful cases of reforestation are rare. An identified problem was unclear land tenure in certain forest areas, creating conflict between local community and other forestry stakeholders. Although communities seem interested in forestry, as they claim, encouraging them to conduct reforestation or establish forest plantations has proved to be very difficult. In this relation, existence of sustainable community forest plantations in East Java, Indonesia, is uncommon, since they are often regarded as non-profitable. In Kediri community, sengon (*Paraserianthes falcataria*) is mixed mostly with pineapple. As usual, the community invests the minimum in their plantation. Sengon is planted with a density 800 trees/ha. Pineapple is planted only once, and then harvested every two years. Within the 10-year rotation age of sengon, the community can harvest pineapple 3 times before cutting the trees. Using present value of cost and revenue, which adopted a discount rate of 6.83%, calculated B/C ratio was 4.26. Result showed that this plantation is profitable but community decision is influenced by amount of land owned and price of sengon timber.

**Pluralism in the economics of sustainable forest management.** Wang, S., Wilson, B. (*Natural Resources Canada, Canada; senwang@pfc.cfs.nrcan.gc.ca; bwilson@pfc.cfs.nrcan.gc.ca*).

Prevailing societal values have enthroned sustainable forest management (SFM) as a new paradigm governing forest practices. Calling for respecting a range of dynamic conditions instead of a single, static target, SFM differs from conventional forest management on account of its acceptance of plurality in management objectives and approaches. The economics of SFM has evolved accordingly, in response to the need for accommodating pluralism. This paper examines several analytical approaches that attempt to address the issue of pluralism in the economics of SFM, principally: (i) economic trade-offs, (ii) search for compatibility among multiple values, and (iii) the notion of panarchy that accommodates extended rotations. The merits and limitations of each of these approaches are discussed.

The paper ends with some suggestions on handling the issue of pluralism from the perspectives of knowledge and social contract as two additional frameworks of analyses.

**Feasibility study of forestry management using a demand/supply model of timber in Japan.** Yukutake K., Fujikake, I., Fukushima, K. (*University of Miyazaki, Japan; yukutake@cc.miyazaki-u.ac.jp; fujikake@cc.miyazaki-u.ac.jp*).

As a result of imports, the timber self-sufficiency rate in Japan is below 20%. Timber prices are depressed, and planted forests are being abandoned in the middle of the rotation without suitable silvicultural treatments, complicating the application of sustainable forest management. A rise in the supply of home-grown timber could therefore be closely linked to achieving sustainable forest management. We created a timber demand and supply model for the Japanese timber markets for softwood species from four major areas: North American, Russian, New Zealand and domestic timber. Among others, our estimates of the cross-price elasticities of demand for Russian, New Zealand and domestic timber for the price of North American timber, which has the largest share in the market, were 0.619, 2.603 and 0.149, respectively. We also found that a 10% increase in the number of housing starts in the USA raised equilibrium consumption of domestic timber by only 0.9%. Thus, it seems that raising the self-sufficiency rate will be a difficult way to invigorate the sustainable management of plantation forestry in Japan.

### **Long term experiments, inventories and observations in irregular (complex) forests**

Organizer: Andreas Zingg (*Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland; andreas.zingg@wsl.ch*)

**How to design long-term silvicultural experiments in structurally complex forests?** Bauhus, J. (*Freiburg University, Germany; juergen.bauhus@waldbau.uni-freiburg.de*).

Firstly, this review paper will discuss the questions that could and should be addressed with long-term experiments in structurally complex forests from the perspective of silviculture and forest dynamics. Secondly, to discuss the design of silvicultural experiments in these forests, the spatial scale at which the dynamics and variation of different structural elements (canopy tree layer, regeneration, understory vegetation and shrubs, dead wood, litter) can be captured to describe structure, function and composition at the stand/ecosystem level will be considered. Thirdly, questions about a core set of measurements on structural elements and processes will be addressed. This will include aspects of spatial and temporal dynamics, costs and the integration of management and monitoring. Finally, this review will ask what we can learn from past and on-going long-term silvicultural experiments in terms of the context of the experiment, design and research questions, adaptability to new questions, commitment, data management and comparability.

**Reconstruction of stand parameters for the assessment of the predisposition to storm throw of spruce-dominated forests.** Eckmüller, O., Sterba, H. (*BOKU University of Natural Resources and Applied Life Sciences Vienna, Austria; otto.eckmuellner@boku.ac.at; hubert.sterba@boku.ac.at*).

The dynamics of mixed mountain forests are determined by site factors, inter- and intra-specific interactions and diverse disturbing agents. Both the old growth forest 'Rothwald' and the adjacent storm thrown forest area 'Edelwies' belong to the wilderness area 'Dürrenstein', which is a research area of the IUCN-category Ia. This area is unique within Central Europe concerning its size (2400 ha), thus allowing basic research on the succession of interacting disturbing factors and regulating mechanisms. Two different issues are pursued: 1) deduction of the susceptibility of forests to storm throw, and 2) reconstruction (2002/2003) of the features of a wind thrown (1990) forest stand to different simulations runs. These parts are not only important for the dynamics of old growth forest ecosystems, but they are also of interest for managed forests. Forty circular plot samples (radius = 8 m) were surveyed—diameter at breast height and tree height were measured on living trees, as well as the length of the remaining bole, the diameters at the base at the end of the bole, and at several other distances from the base were recorded on the wind thrown lying trees. Based on these measurements tree sizes are iteratively reconstructed using compatible taper curves and bark thickness functions.

**Assessment of fragmented forest mosaics: lessons learned from inventory projects in Latin America.** Kleinn, C., Morales, D. (*Georg-August-Universität Göttingen, Germany; kleinn@gwdg.de*).

For many land owners, particularly in Central America, the tree resource outside the closed forest areas is becoming increasingly important. These trees and fragmented forest mosaics are an important source of raw material and income.

They are not only relevant for economic reasons; they also play a crucial role for biodiversity conservation. There is still much to be done to achieve sustainable management of this resource. Information acquisition to describe the characteristics of the resource is one of the first things to do and it is a challenging issue—among the major reasons are definition problems and the particular spatial structure of the resource. In general terms, fragmented forest mosaics can be assessed by common forest inventories approaches, but specific adjustments have to be made. In this paper, methodological considerations are presented and experiences from inventory projects in fragmented forest mosaics in Colombia and Central America are discussed.

**Long-term stand dynamics at the old-growth Korean pine-broadleaved forests of Ussuriisky Zapovednik in southern Primorsky Krai, Russia.** Kudinov, A.I., Orekhova, T.P., Zhabyko, E.V., Man'ko, Y.I. (*Russian Academy of Sciences, Russian Federation; forest@eastnet.febras.ru; orekhova@ibss.dvo.ru; zhabyko@ibss.dvo.ru; manko@ibss.dvo.ru*), Lee, D.K., Kang, H.-S., Nyam-Osor, B. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr; silvi@chol.com; bnyamosor@yahoo.com*).

Ussuriisky Zapovednik is a nature reserve located in southern Primorsky Krai, Russian Far East. It has high biodiversity and complex stand structure, and no major disturbances for more than 500 hundred years. To understand stand dynamics and development of the old-growth Korean pine-broadleaved forests, two permanent plots were established. Plot 7 (0.35 ha), established in 1964 was re-measured in 1977, 1985, 1991 and 2003. Plot 10 (0.36 ha), established in 1954 was re-measured in 1978, 1985, 1991 and 2003. The major tree species of the two study plots were *Pinus koraiensis*, *Carpinus cordata*, *Tilia* sp., *Abies holophylla*, *Acer pseudosieboldianum* and *Corylus mandshurica*. Species composition of plots 7 and 10 were 13 and 11 tree species in 1964 and 1954, respectively. Stand density was the highest in 1977 (777 trees/ha) and decreased gradually in 2003 (632 trees/ha) at plot 7. However, at plot 10, it was 600 trees/ha in 1978, 520 trees/ha in 1991 and 555 trees/ha in 2003. Monitoring of species composition, stand density, stock volume and natural regeneration characteristics at the study plots indicates that the dominant species, *Pinus koraiensis* and *Abies holophylla* shall decrease due to low regeneration while hardwood species shall rapidly increase to reach the canopy in the near future.

**Measurement and analysis issues for complex stands of British Columbia, Canada.** LeMay, V. (*University of British Columbia, Canada; Valerie.Lemay@ubc.ca*), Smith, N. (*Weyerhaeuser BC Coastal Group, Canada; Nick.smith@weyerhaeuser.com*).

Stands with multiple species and ages and irregular spatial patterns have been termed complex stands by some authors, and irregular stands by others. Because of the high variability in space and time for these complex stands, growth and yield and other measures of stand changes have been difficult to measure and to monitor. In British Columbia (BC), Canada, complex stands occur naturally. Also, the recent trend towards more partial cutting has increased the total area of complex stands in BC and, in some cases, has increased the spatial diversity within stands over that naturally present. Experiments in these stands have been difficult to establish, since very large experimental units are needed to capture variability. Predicting changes in stand development is very challenging given the multitude of possible harvest and silvicultural regimes. In this paper, we discuss some of the measurement and analysis issues for these complex stands of BC, and the sampling, modeling and estimation approaches that are being used to address these issues. The need for continued measurement of long-term research trials is emphasized, along with the use of more robust estimation methods.

**Multi-scale covariates as a tool in improving model validity: a case study of a long-term forest regeneration experiment in northern Finland.** Mäkitalo, K., Alenius, V., Derome, J., Heiskanen, J., Mikkola, K., Pohtila, E. (*Finnish Forest Research Institute, Finland; kari.makitalo@metla.fi*).

In the harsh climate conditions of northern Finland, long-term field experiments are needed for testing various reforestation and site preparation methods. Because of the longevity of the experiments, planting in practical-scale density is needed to avoid seedling competition effects, leading to the use of large experimental plots and blocks. The spatial variability of different environmental variables inside a block may be considerably high. This reduces the validity of the traditional variance analysis models. In this paper, the use of mixed models and multi-scale covariates are presented as a tool to achieve better predictions from a split-plot experiment design with randomized blocks, in which the effect of reforestation (sowing and planting) and site preparation methods (prescribed burning, patch scarification, disk trenching and ploughing) on Scots pine performance was studied over a 25-year period. A total of 72,000 reforestation spots were sown or planted on 288 plots (2500 spots/ha) in 8 experimental areas. The effective temperature sum, topographic index, soil physical (stoniness, texture, bulk density, water-retention characteristics, water content and air-filled porosity) and chemical properties (pH, exchangeable element concentrations both in the soil and soil water) were used as covariates.

**An alternative meta-analytical approach in assessing yield responses of boreal conifers to intensive forest management treatments: Hierarchical linear models.** Newton, P.F. (*Natural Resources Canada, Canada; pnewton@nrcan.gc.ca*).

An essential prerequisite for the development of evidence-based treatment/practice protocols for use in intensive forest management (IFM) is the quantitative synthesis of results derived from multiple long-term experiments, i.e., meta-analysis. Although the historical literature is characterized by un-replicated experiments that hinder the application of traditional meta-analysis procedures (e.g., weighted fixed-effects approaches), the sequential nature of response measurements over time offer analytical opportunities in terms of the application of a linear mixed-effects model approach. The objective of this study was to determine the utility of such an approach in assessing diameter growth responses of black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.) to precommercial thinning (PCT). The analysis consisted of three steps: (1) systematically searching electronic databases and selecting applicable PCT studies based on similarity by species, locality, thinning method, response variables and sequential measurements; (2) deriving paired diameter response measurement sequences and quantifying the relationship via linear regression analysis; and (3) analogous to the computational framework used in mixed-effects meta-analysis, calculating species-specific grand mean intercepts and slope coefficients and associated 95% confidence intervals. Resultant slope coefficients indicated positive relative responses to PCT. Correct model specification was of principal importance when using a linear mixed-effects approach. Results using this approach were contrasted with those based on an unweighted pooled fixed-effects multiple regression approach.

**A long-term study of natural regeneration in mixed broadleaved stand: the influence of canopy structure on seedling development.** Piboule, A., Collet, C. (*INRA, France; alexandre.piboule@onf.fr; collet@nancy.inra.fr*), Epron, E., Guehl, J.-M. (*University Henri Poincaré, France; Daniel.Epron@scbiol.uhp-nancy.fr; guehl@nancy.inra.fr*), Franc, A. (*UMR Biogeco, France; Alain.Franc@pierroton.inra.fr*).

In order to analyze and model the effects of canopy structure on the development of natural regeneration, a series of experiments were established in a beech-dominated mixed broad-leaved forest of north-eastern France. The main experiment was used to analyze the relationships between canopy structure and light availability below the canopy, and between light availability and natural regeneration development. These analyses are based on a detailed description of the structure of the adult trees (location, stem and crown development of the trees), light availability (evaluated by light measurements or by a light transmission model) and the regeneration (seedling inventory in small subplots). In a second experiment, canopy gaps are created and growth, crown architecture, light interception, carbon balance and vulnerability to cavitation of pre-existing seedlings are analyzed in order to study and model seedling development under shaded conditions, and seedling acclimation to canopy gaps.

**Analysis of diameter growth rates for functional groups of tree species in a seasonal forest in Venezuela.**

Ramírez-Angulo, H., Mora, E., Torres-Lezama, A. (*Los Andes University, Venezuela; rharma@ula.ve; emmora@ula.ve; torres@ula.ve*).

The diameter growth per functional group (complete, medium, or no shade intolerance) is analyzed in a seasonal tropical forest with data from 23 annual measurements of trees of diameter at breast height (dbh) >10 cm. A descriptive statistical analysis made in the first year of measurement (1962) was compared with the values of 30 years later (cutting cycle applied in the management plans in Venezuela). The growth rates were calculated by analyzing successive measurements with adjustments of regression models. Both in 1962 and in 1992, the trees with medium shade intolerance showed the highest percentage, but the big shade tolerant trees showed a similar average value in 1962. The model with the best adjustment was linear, with a matrix structure of autoregressive variance and covariance  $S$  of the first order and a homogeneity of variances, however, the correlation decreases in dependence of the time between two measurements. The correlation of 0.95 was highly significant, which shows that the repeated measurements over time are not independent. The species with medium shade intolerance showed the highest growth rates (0.27 cm/yr). All rates were low, because the necessary time to reach cutting diameter is high, at least 108 years.

**Stand dynamics simulation of a Venezuelan seasonal forest with emphasis on tree functional groups.**

Ramírez-Angulo, H., Torres-Lezama, A., Ablan, M. (*Universidad de Los Andes, Venezuela; rharma@ula.ve; torres@ula.ve; mablan@ula.ve*).

Simulation models may be a valuable tool to understand tropical forest dynamics in order to contribute to the conservation and management of these threatened, complex and remarkable ecosystems. Permanent plots data, from a seasonal forest in the Venezuelan western plains, were used to parameterize the FACET gap model. Tree species were grouped according to the maximum height and shade tolerance (shade tolerant, intermediate and intolerant species). Stand forest dynamics were simulated for each physiographical position (levee, transition and depression). After a 500-year simulation period, tolerant species dominated in the levee sites, accumulating a value index (IV) of 54.8 and

followed by the intermediate species with an IV of 34.8, which corresponds to the expected composition for a long-period undisturbed forest. In contrast, in the transition areas, the latter group predominate (IV = 50.0) over the tolerant species (IV = 38.1). In the depressions, the intermediate species reached a higher IV (47.1) than the tolerant species (IV = 32.2). The FACET model showed great potential to predict forest stand dynamics, with the exception of the poorly drained depressions. Therefore, modifications to the water balance routine are required in order to achieve a better representation of forest dynamics in these sites.

**Tree allometric relationships in a Venezuelan tropical seasonal forest.** Ramírez-Angulo, H., Vilanova, E., Barros, R., Torres-Lezama, A. (*Universidad de Los Andes, Venezuela; rharma@ula.ve; vilanova@ula.ve; torres@ula.ve*).

This research focuses on allometric relationships of several tree species from a Venezuelan seasonal tropical forest in logged and unlogged conditions. Allometric coefficients were calculated by nonlinear regression for two representative species of three functional groups (shade tolerant, intermediate and intolerant species) and for each one of those groups. Both in harvested and unharvested sites, for individual species, correlations above 0.5 ( $R^2$ ) were founded in most of the cases, showing a positive relationship between total height and diameter at breast height (dbh). A similar situation is observed for the functional groups, although shade tolerant species show allometric coefficients below 0.5, on the logged sites, which may be explained by low data availability, among other reasons. Intermediate species seems to allocate a greater amount of resources to vertical growth during the first stages of plant development. After tree height reaches 15 m, a significant diameter increment is observed, especially in harvested sites. Tree individuals of tolerant species concentrate on regular diameter intervals which went from 0.3 to 0.5 m dbh. Intolerant species do not seem to respond significantly to the environmental conditions after logging. Although with exceptions, a higher correlation between height and diameter was found in unlogged sites.

**Is there a sound design for studies in complex forest systems?** Sterba, H. (*BOKU University of Natural Resources and Applied Life Sciences in Vienna, Austria; hubert.sterba@boku.ac.at*).

Complex forest systems are characterized by a multitude of species, spatially irregular distribution of trees and multiple layers. Many questions in complex forest systems have to be answered on different scales—the tree, stand and landscape scales. Therefore experimental designs will range from individual tree experiments to large scale experiments where one treatment as a whole may comprise several tens of hectares. Considering the large variation within such a complex system, it seems that the necessary number of replicates may exceed the size of the system itself. More often, data with no predefined treatments (random treatments or ‘experiments without intervention’, i.e. inventory data and observations of individual plots) may be used to find effects and relationships by exploratory statistical methods. Enhanced statistical methods, considering serial and spatial correlations together with random effects are nowadays available, thus reducing the necessary number of replicates in experiments or observations and helping to avoid misinterpretation. From the history of thinning experiments in pure even-aged stands, it has to be committed that even there the ‘sound designs’ referred mainly to the plots within one or a few stands, while inference of the results was made far beyond that limited population—successfully.

**30 years of measurement of old-growth *Cryptomeria japonica* forests on Yakushima Island: the dynamics of a world natural heritage forest.** Takashima, A., Yoshida, S., Murakami, T., Mizoue, N. (*Kyushu University, Japan; atutaka@agr.kyushu-u.ac.jp; syoshida@agr.kyushu-u.ac.jp; muratac@agr.kyushu-u.ac.jp; mizoue@agr.kyushu-u.ac.jp*).

Yakushima Island, which is located at the south end of the main Japanese islands, is a small, steep maritime island containing Mt. Miyanoura (1936 m a.s.l.). The vertical distribution of vegetation is distinctive, and many northern and southern limits of species are represented. Moreover, many endemic species occur on this island. Such an ecosystem was prized, and about 21% of the island was registered as world natural heritage in 1993. *Cryptomeria japonica* forest, which is distributed from 800 m to 1800 m a.s.l., is one of the typical forests of Yakushima Island. We established five permanent plots of 1.0 ha in this forest in 1973–74, and measured each plot three times. The data shows a decrease of old-growth *C. japonica* and poor regeneration. Therefore we undertook additional surveys of *C. japonica* saplings that would play important forest succession roles. The objective of this study is to clarify the regeneration conditions of *C. japonica* in an old-growth forest and propose an appropriate conservation strategy for this forest.

**Time and costs of surveying long-term experimental plots in complex stands.** Zingg, A. (*Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland; andreas.zingg@wsl.ch*).

Long-term experiments in forest research provide good data: long data series of optimal quality which are necessary to build valid growth and yield models suitable for research or practical needs. Research plots in complex stands have to be larger than in stands with more uniform structure. As a consequence the number of trees to survey is greater, and therefore



experiments in complex stands are generally more expensive than in uniform stands. But investments, as long as the experiments are not intensive studies, usually are overestimated. This can be shown on the basis of long-term recorded time studies carried out over more than 10 years of surveys in the long-term growth and yield research network in Switzerland. The survey cost per unit area in complex stands is only slightly more than surveys in uniform stands. The question, how large should a single experimental plot be, depending of stand structural parameters, is one of the questions to be answered in the frame of the IUFRO-Session and the IUFRO activity of the IUFRO Working Group 04.01.03.

## **Sustainable harvest planning and scheduling**

Organizer: Róbert Marušák *TU Zvolen, Slovakia; marusak@vsld.tuzvo.sk*

**Application of spatial information to evaluate habitat suitability. An example of avian in Taiwan.** Feng, F.-L., Wang, G.-L. (*National Chung-Hsing University (NCHU), Chinese Taipei; flfeng@dragon.nchu.edu.tw*).

Species distribution, species abundance and habitat suitable index (HSI) are important spatial information for managing wildlife populations and conserving biodiversity. Therefore, the HSI technique for evaluating wildlife habitat is an important tool for ecosystem management (EM). The spatial data in a geographic information system (GIS) become multi-scale geo-database for a management system (Geo-DBMS) with individual tree, stand, ecosystem and landscape scales. In order to get spatial information of status, function and change, we have to develop and analyze spatial data with the HSI model. Spatial interpolation methods were used to estimate the distribution of habitat characteristics from monitoring stations. The entire Taiwan was the study area. The colored aerial photos were scanned and corrected to the orthogonal images. Then, land cover was interpreted, and land-use, crown closure mapping and digital surface model (DSM) derived with digital photogrammetry and GIS. HSIs of warblers and pheasants were evaluated for biodiversity of landscape and validated with ground-surveyed data with good results. The multiple species model incorporated with forest structure factors enhanced the power of predicting the distribution of a species. The model could be used to simulate forest-thinning scenarios and the impacts of various forest management strategies on an avian community.

**KONTUS: A developed principle of sustainable forest management.** Furuberg, A.M., Stener, S.O., Økseter, P. (*Hedmark University College, Norway; merete.furuberg@hedmark-f.kommune.no*).

The paper presents advantages and disadvantages with KONTUS – a developed principle of sustainable forest management. KONTUS focuses the single tree rather than the forest stand. Thus the market's demand of quality, dimension and multiple use of forests are given priority. The aim is to increase the total income of forest land. Further, the paper presents an ongoing Norwegian research project that compares full scale treatment of forest stands with forest management carried out by the principle of single tree treatment (KONTUS). There are no clear results showing that cutting using mechanized processor, following the principle KONTUS, gives higher cutting costs. The forwarder however has lower productivity and thus the transport costs is approximately \$1 higher per cubic metre. There is much damage on remaining trees when selective cutting, following the principle of KONTUS, is carried out on unfrozen ground. Of remaining trees, 8–26% were damaged. There was no rut damage on dry forest ground with high carrying capacity, but much rut damages on forest ground with low carrying capacity even if the tractor roads were covered by branches. The previous results show that the success of KONTUS is dependent on the growth reaction of remaining trees.

**Sustainable harvest scheduling in nature-oriented forestry.** Marušák, R. (*Technical University in Zvolen, Slovakia; marusak@vsld.tuzvo.sk*).

A long regeneration period, which secures continuous cover in forest stands, is one of the main characteristics of close-to-nature forestry. A shelterwood silvicultural system is a typical system used in Slovakia and was established on these principles. In comparison to clear cutting, harvest scheduling in a shelterwood system is more difficult and it is necessary to use additional constraints. The paper deals with the use of linear programming in harvest scheduling in the shelterwood silvicultural system. Two kinds of constraints are used. The first one secures natural regeneration and the second is fulfilling a specific regeneration period. These constraints are represented by two degrees of cutting. Results were compared to two allowable cut indicators, exploitation percent and empirical cutting percent, which can be used for practical forest management in Slovakia. By using linear programming, more suitable solutions were obtained. Over three decades, harvests calculated with respect to the close-to-nature silvicultural principles were more balanced.

**Damage analysis from timber harvesting in tropical forest under a sustainable management forest system in Western Amazon.** Souza, A.P., Minette, L.J., Souza, A.L., Machado, C.C. (*Federal University of Viçosa, Brazil; amaury Souza@ufv.br; minetti@ufv.br*), Martins Pinto, A.C.

The intensity of damages caused by timber harvesting in the floristic composition and in the structure of two areas of Amazon Forest was evaluated. Samples of old growth forest and of harvested old growth forest were floristically and structurally compared. The experiments were carried out in an area located in Manicoré, Amazon State, Brazil. The inventory was carried out using the randomized sampling method. The floristic composition, the phytosociologic structure, damages to the adult vegetation and the parametric structure (diametric distribution, basal area and volume) were evaluated. The selective timber harvesting did not change the floristic composition of the forest and did not affect the floristic composition. The differences in floristic composition occurred only in relation to number of families. Significant damages did not occur in trees with DBH  $\geq$  5 cm. The changes on the diameter structures, basal area and volume of the harvested forest were most evident in the greater classes of diametric distribution.

**Virtual manufacturing for modeling timber harvesting scenarios in Germany.** Visser, A.-K. (*Virginia Polytechnic Institute and State University, USA; bruchner@vt.edu*), Hemm, M. (*Technical University of Munich, Germany; hemm@wzw.tum.de*).

Virtual manufacturing has been used extensively for the planning and controlling of the production processes in industries. In forestry simulation software of this kind has been rarely used for optimizing production so far. The application of simulation software for modeling timber harvesting operations can be useful in predicting the costs, productivity and ecological impacts of different operations. The key component of this research work focused on creating and testing a model oriented hypothesis in the 3D simulation software AutoModTM. Two implementation projects in which different stands and harvesting operations were simulated showed that there is an enormous range of application of 'virtual manufacturing software' in forestry. The main benefits are: using the software as a decision support tool at the operational level as well as an e-learning instrument for managers to discover the effects of their harvesting decisions. The use of industrial simulation software for managing the wood supply chain and optimizing timber harvesting is a first step on the way to a computer based improvement of forest management with regard to precision forestry.

**Evaluation of carbon sequestration and thinning regimes within the optimization framework for forest stand management.** Yoshimoto, A. (*Tohoku University, Japan; yoshimoo@mail.kankyotohoku.ac.jp*).

While global warming became one of the emerging environmental problems, forest resources have started to be recognized as a source of carbon sequestration from the atmosphere. The objective of this paper is to evaluate carbon sequestration and thinning regimes within the optimization framework for forest stand management. A dynamic programming model is constructed to search for an optimal thinning regime and rotation age in the Kyushu region. This model incorporates the MSPATH (Multi-Stage Projection Alternative Technique) algorithm into a growth simulator derived from a stand density management diagram. The MSPATH algorithm becomes effective where there is a long-term effect of thinning on the objective function, e.g., where there is a price premium by DBH (diameter at breast height). The proposed dynamic programming model with MSPATH is classified as a one-stage and one-state dynamic programming model, where the forest stand age is regarded as the stage and the thinning intensity as the state as well as a control variable. We elaborate how the MSPATH algorithm works and differs from the traditional dynamic programming algorithm, then conduct an experimental analysis for evaluation of carbon sequestration under different settings for optimization of thinning regimes.

**Do we need new management paradigms to achieve sustainability in tropical forests?**

Organizer: Robert Nasi *CIFOR and CIRAD-Forêt, France; r.nasi@cgiar.org*

**Conservation in production forests and production in conservation forests: towards a global approach in tropical forest management.** Billand, A., Nasi, R. (*CIRAD-Forêt, France; r.nasi@cgiar.org*).

The dominant conservation strategy for tropical forests is to expand protected areas, generally in remote areas. Over the next decades, this strategy may cease to be socially, politically and economically acceptable. An alternative model would involve a diversified portfolio of approaches, including a number of elite, nationally and globally significant sites of exceptional value, complemented by a network of protected territories under various land use status including forest production areas. Examples from central Africa demonstrate that production forests have a role in conservation as they move towards sustainable management, with activities such as wildlife inventories, road blocking, poaching control, reduced impact logging and conservation zoning. Protected areas in developing countries remain drastically under-financed.

Revenue generation is currently a compulsory goal for conservation areas managers, and commercial activities such as eco-tourism, NTFPs production, or leisure hunting are actively promoted. This large landscape scale approach with a matrix of areas sustainably managed for multiple uses, balancing production and conservation reconciles the urgent needs of human development with the urgent needs of conservation. While production forests generate profit, few if any sharing schemes between conservation and production have been considered. Greater decentralization and devolution of decision-making to the local level, while still protecting the interests of stakeholders at the national and global levels, is required.

**Tree growth and stand development during a 10-year period after logging with two different selective logging systems in a dipterocarp rainforest in Sabah, Malaysia.** Forshed, O., Karlsson, A., Falck, J. (*Swedish University of Agricultural Sciences, Sweden; Olle.Forshed@ssko.slu.se*).

Pre-marked skid trails, directional felling and climber cutting when logging in natural tropical rainforests might be important ways of reducing damage in the forest and to create a healthier stand for future yields. This study compared the growth of the residual trees after conventional selective logging versus a selective logging system where both pre-marked skid trails and directional felling have been implemented. The pre-marked skid trails were aligned parallel (62 m distance) to one another. Pre-felling of climbers was also carried out combined with the methods mentioned above. A randomized complete block 2 x 2 factorial design consisting of 20 treatment plots was used, which gave eight replicates per logging method and four control plots (virgin forest). The gross plot was 5.76 ha with a net plot of 1 ha in the centre of each gross plot. The results will show the tree growth (divided into species groups) in a commercial secondary rainforest, and compare the stand development during a 10-year period (1993–2003) between the two logging systems and the virgin plots.

**Landscape-scale approaches for INRM: The case of tropical forests.** Frost, P., Campbell, B. (*Centre for International Forestry Research, Indonesia; b\_campbell@site.ntu.edu.au*).

Integrated Natural Resource Management (INRM) is an approach to managing resources sustainably by helping resource users, managers and other stakeholders accomplish their different goals by consciously taking into account and aiming to reconcile and synergize their different interests, attitudes and actions. Whereas the approach is based on the notion that many social and environmental problems, to be resolved successfully, have to be tackled at a range of scales, it has particular significance at the landscape level. This paper explores the potential for sustainable development in tropical forest landscapes through taking a more integrated approach to the management and conservation of natural resources on which the majority of the rural poor in most developing countries depend. We suggest eight cornerstones for applying INRM successfully at the landscape level: 1) focus on multi-scale analysis and intervention, 2) develop partnerships and engage in action research, 3) facilitate change rather than trying to dictating it, 4) promote visioning and the development of scenarios, 5) recognize the importance of local knowledge, 6) foster social learning and adaptive management, 7) concentrate on both people and their natural resources, including biodiversity, and 8) embrace complexity, but wisely.

**Tailor made for forest fashion: Understanding what is unique and common in pursuing management of tropical forest ecosystems.** Hammond, D., Zagt, R. (*Tropenbos International, The Netherlands; rene.boot@tropenbos.org*).

Tropical forests vary considerably in structure and composition, depending on variations in topography and global atmospheric processes. Rock, water and soil support different ecosystems that are in different transitory states. Dynamics in the events shaping tropical forests will fundamentally determine what benefits humankind may achieve, and how best to manage them for present and future benefits. How forests have been affected by (pre)historic human activity can also affect how forests respond to modern uses. Finally, perceptions of forest value and purpose at global, national and local scales are often discordant. Management needs to define trade-offs within an expanded space of decision-making that goes beyond sustained yield requirements. Differences in biophysical and socioeconomic profiles of tropical forests demand a rethink on both conservation priorities and approaches to sustainable use, particularly in association with commodity-based models. This rethink is particularly relevant to Guyana which is subject to socio-cultural, ecological and evolutionary circumstances that can be disjunct from other parts of the Neotropics. A decade of research directed at integrating the results into policy and practice in Guyana has established a forest ecosystem profile that may be useful in identifying practical objectives and scale limits in the pursuit of management paradigms.

**Can we manage tropical forests sustainably?** Hartshorn, G.S. (*World Forestry Center, USA; ghartshorn@worldforestry.org*).

Species-rich tropical forests are a globally important natural resource. Most tropical forests harbor extraordinary biological diversity and provide a broad array of critical environmental services. Though most countries with tropical forests have established national systems of protected areas, the percentage of lands included may be only a small fraction of the remaining forests. Furthermore, many national parks and equivalent reserves as well as unprotected

forests are threatened by development, extraction and climate change, *inter alia*. Sustainable management of complex tropical forests could make major contributions to many forest conservation, environmental and timber production goals. This paper briefly reviews the historical interest in sustainable tropical forest management, the constraints and lessons learned, and the challenges to integrating sustainable tropical forest management into conservation and development planning. The paper focuses on several initiatives in tropical America, such as BOLFOR (Bolivia), Mil Madeiras (Brazil) and PORTICO (Costa Rica). Sustainable management of tropical forests must be ecologically sound, economically viable, socially responsible and politically acceptable. If the tropical forests outside national parks and equivalent reserves are not managed sustainably, they are likely to be converted to other land uses.

**Analysis and monitoring of 17 years of logging in the concessions in Guayana, Venezuela.** Hernández, L. (*Universidad Nacional Experimental de Guayana, Venezuela; lionelher@hotmail.com*).

Seventeen years of logging experience in concessions in Guayana was analyzed on the basis of: 1) location of concessions and sawmills, and 2) volume of extracted and sawnwood. Information was collected from management plans, logging reports and interviews. Logged areas comprise 7% of the regional forest surface, and 20% of the forest reserves are under concession. Over half of the concessions are inactive. The averaged rate of extracted wood (2.5 trees/ha, 5.3 m<sup>3</sup>/ha) is lower than planned, and is related to a few commercial species, low volume of commercial trees and a measurement system that underestimates extracted volume. The most significant impact is more accessibility to intact forest. The high-grading has possibly led to over-harvesting of valuable species and a larger fragmentation area. The outdated technology of sawmills wasted 50% of the wood processed and the installed capacity is twice as high as the sawnwood processed. There is a lack of public information on non-timber forest benefits, ecological and social impact of logging and how the forests are managed. There is not an accurate system to verify volume of wood extracted or to monitor the status of forest resources. Logging contributes marginally to the national economy and provides few benefits to the local population.

**From prediction to decision: Why is applied scientific knowledge not sufficient to find enforceable sustainability criteria in tropical forest management?** Karsenty, A., Gourlet-Fleury, S. (*CIRAD-Forêt, France; alain.karsenty@cirad.fr*).

Knowledge gained on species behaviour and post-logging population dynamics make possible robust and reliable calibration of evolution and prediction models. These models can be used as tools for helping forest managers in decision-making, since they allow the identification of species whose dynamic is compatible with current logging practices and those for which recovery is threatened. Nevertheless, the definition of sustainable management criteria leading to the formulation of harvesting norms and regulations is not really made easier, as it is necessary to decide upon a 'state of the nature' judged as viable within a sustainable development perspective. Therefore, the decision stage mobilizes representations, beliefs and implicit balance between the three articulated components of the sustainable development paradigm—ecology, social and economics—far from the idea of a neutral and 'scientific' assessment of sustainability. As an example, the use of criteria and indicators for forest certification involves disintegrating the whole system into its various components—a process that can induce potential antagonism according to the chosen entry point.

**How should we manage the lowland dipterocarp forest after selective logging?** Nishimura, S. (*Forest Research Institute Malaysia / Japan Wild life Research Center; 1000n@mb.neweb.ne.jp*), Okuda, T. (*National Institute for Environmental Studies, Japan; okuda@nies.go.jp*), Nur Supardi, M.N.. (*Forest Research Institute Malaysia; supardi@frim.gov.my*).

Most of the Asian dipterocarp rain forests have now been disturbed at least once by logging. To evaluate whether selective logging is a sustainable management system, we investigated two questions in Peninsular Malaysia: 1) how was the forest damaged by logging operation, and 2) how does the forest recover in terms of biomass, wood value and biodiversity so that we can or not. We compared the vegetation among three forest stands: un-logged forest, old-logged forest (selectively felled in 44 years ago) and newly-logged forest (3.5 years ago). Our study showed that the wood value of old-logged forest was half of the un-logged forest. However, we found that the above ground biomass of the old-logged forest stand is similar to the un-logged forest. This indicates that if we focus on the wood value, logging is not sustainable, however, in terms of biomass storage, logging is sustainable.

**Assessment and documentation of the "Batangan or Saguday" indigenous forest management system in Mt. Province, Cordillera Administrative Region, Philippines.** Osbucan, P., Costales, A.B., Maddumba, H.A., Martin, F.B., Malecdan, M. (*Department of Environment and Natural Resources – Cordillera Administrative Region, Philippines; erds-car@mozcom.com*).

Even as trend towards forest denudation is evident in many parts of the Cordillera Administrative Region, there are still forests that are managed efficiently and effectively. using indigenous/traditional approaches. One of the indigenous forest management systems is the 'Saguday or Batangan'—practiced in the pine areas of Mt. Province, specifically in

the municipalities of Besao, Sabangan, Sagada, part of Tadian and Southern part of lower Bauko. It is an effective forest conservation and protection system as proven by the existing forests in the area. Customary laws governing the system are big factors in the maintenance and protection of forest—including selective cutting and recognition of elders as final decision-makers, and penalties for those who harvest forest products without permission from the owners, and banning of commercial sale and transport of timber products. Since the system is proven to be sustainable, its adoption to other areas should be promoted. One identified threat is that some forestry laws and policies, especially on utilization, are not in harmony with the system. There is a need to review and evaluate existing policies and identify areas of conflict so as to harmonize these policies with the customary laws of the system.

**Effect of reduced impact logging and conventional logging on soil and water.** Siregar, C.A. (*Forestry Research and Development Agency, Indonesia; siregar@forda.org*), Dharmawan, I.W.S. (*SEAMEO-BIOTROP, Indonesia; wayan@biotrop.org*), Santosa, K.D., Gunarso, P. (*Center for International Forestry Research, Indonesia*).

Reduced Impact Logging (RIL) has been reported as giving more environmental benefits compared to conventional logging (CL), especially on steep slope forested areas. This research was designed to clarify the ecological gains of RIL compared to CL, by evaluating a 22 m x 4 m erosion plot established on RIL and CL areas in the Malinau Research Forest, East Kalimantan, Indonesia. The soil is classified as fine, mixed, isohyperthermic, Typic Kanhapludults. This experiment indicated that there was no significant difference between CL and RIL in terms of runoff, soil erosion rate and infiltration rate. Infiltration rate in both cases was reasonably high (99.5% of rainfall), and the erosion rate was 0.02 ton/ha/year. Average organic litter produced at the RIL and CL plots was 38.31 and 32.59 ton/ha, respectively. Soil bulk density in the RIL plot was somewhat higher across all soil layers from surface to 50 cm soil depth compared to the CL plot. Average water P and K under CL vegetation was consistently slightly higher compared to RIL, due to higher canopy density. Average soil P and K under CL vegetation was higher compared to RIL, due to the fertility nature of the soil.

**Effects of woodfuel consumption on sustainability and biodiversity of forest resources: A case study in Kampong Thom Province, Cambodia.** Top, N. (*Forestry Administration, Cambodia; nethora@hotmail.com*), Mizoue, N. (*Kyushu University, Japan; mizoue@ffp.kyushu-u.ac.jp*), Ito, S., Kai, S., Nakao, T. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp; s.kai@cc.miyazaki-u.ac.jp; a02303u@cc.miyazaki-u.ac.jp*), Ty, S. (*Forestry Administration, Cambodia; fadm20022002@yahoo.com*).

In the 1970s, the ‘woodfuel crisis’ in tropical developing countries drew global attention. Since then, the effects of woodfuel consumption on the sustainability and biodiversity of forest resources have hotly debated. Our research attempted to clarify the arguments, taking Kampong Thom Province as a case study. First, we adopted a GIS-based approach to reveal how the potential supply and demand of woodfuel varies at different spatial scales within the province. A deficiency of woodfuel resources was found in areas of high population density along the main road, due to high woodfuel demand and low woodfuel supply. Second, we examined differences in stand structure and tree species richness and diversity in relation to population density at different distances from forest clusters. Significant negative correlations were found between population density surrounding clusters and stand structure and species richness and diversity. The results indicated that evidence of disturbance was more pronounced at higher population density up to around 5 to 7 km. Our research suggested that intervention is needed to ensure a sustainable woodfuel supply in the long term, especially in areas of high population density. This can be achieved by either increasing woodfuel production or by reducing consumption, or both.

**Are direct payments for environmental services spelling doom for tropical forest management?** Wunder, S. (*CIFOR, Indonesia; s.wunder@cgiar.org*), Karsenty, A. (*CIRAD-Forêt, France*).

Over the past couple of decades, significant funding has been directed to sustainable forest management and integrated conservation and development projects in the tropics, hoping to combine forest conservation with economic gains. To date, results have generally not been encouraging. Direct payments for environmental services have thus been suggested as an alternative, but untested, tool for conservation. Much preoccupation in the debate has been with raising a continuous stream of funds for payments, but it is equally a challenge to design payment schemes that provide the right incentives to actually change behaviour on the ground. It is important to experiment with different direct payment modalities to gain further insights on their different development impacts. In particular, the opportunity costs of a conservationist ‘non-development’ of forests may be distributed on a range of actors. To the extent that these agents are not (fully) compensated, they may oppose payment schemes. Direct payments also need not be in contradiction to forest management, in fact, one can claim that forest certification is a direct market-related payment rewarding sustainable management. Rather than being a once-and-for-all substitute for forest management, direct payments are a promising innovation that are likely to find a complimentary place in the conservation tool box, once its potential has been tested further.

## **Evaluating new modes of governance for sustainable forestry**

**Organizers:** Margaret Shannon *State University of New York, USA*; [mshannon@buffalo.edu](mailto:mshannon@buffalo.edu), Karl Hognl *University of Natural Resources and Applied Life Sciences Vienna (BOKU), Austria*; [karl.hognl@boku.ac.at](mailto:karl.hognl@boku.ac.at), and Heiner Schanz *Freiburg University, Germany*; [heiner.schanz@ifp.uni-freiburg.de](mailto:heiner.schanz@ifp.uni-freiburg.de)

**Participatory forest management as a core of new mode of forest governance in South and Southeast Asia: An overview and comparative analysis of institutional and policy characteristics.** Balooni, K., Inoue, M. (*University of Tokyo, Japan*; [kbalooni@fr.a.u-tokyo.ac.jp](mailto:kbalooni@fr.a.u-tokyo.ac.jp); [mkinoue@fr.a.u-tokyo.ac.jp](mailto:mkinoue@fr.a.u-tokyo.ac.jp)).

Participatory forest management (PFM) though in its evolving phase is now an inevitable part of forest management and conservation policies in developing countries in South and Southeast Asia (SSEA). A review of studies using different research methodologies like case studies, country-specific analysis and comparative analysis of PFM between countries reveals results that have common patterns. By and large, the studies suggest that institutional and policy characteristics of PFM in SSEA countries do not match the ground realities, which affect the performance and sustainability of PFM programs. This study uses a conceptual framework, wherein, the institutional and policy characteristics of PFM program in India (used as a benchmark) are compared with similar programs in select SSEA countries. The objective of this study is to deduce best institutional and policy characteristics of PFM programs in SSEA countries and to suggest their possible applicability in different national environments. The study revealed that the underlying principle of PFM is similar in SSEA countries, but the term has different connotations. While participation of local people in forest management would be the core of the new mode of forest governance, various other stakeholders would also contribute to policy formulation, implementation, monitoring and evaluation.

**Policy issues in the governance of forests: The case of the Philippine natural resources.** Bantayan, N.C. (*University of the Philippines Los Baños, Philippines*; [ncb@laguna.net](mailto:ncb@laguna.net)).

In the Philippines, there has always been a keen interest in policy formulation and how forest and natural resource policies respond to the needs of the sector in terms of assessment and monitoring. Since 1987, more than 70 policy issuances have been drafted in the forestry sector alone. That is why the aggregation of data from the field offices to the next higher levels is so vital in the formulation of responsive policies. A conscious, deliberate and institutionalized link between information generation and policy formulation is important. This study evaluated the link between field offices and policy-making, including the flow of forest and natural resources data and information. The primary objective was to prescribe the most cost-efficient and cost-effective methodology for data transfer and information flow. The study revealed that responsive management must be based on realistic and empirical foundations. This implies well-defined protocols for data generation at the field level. Thus, a framework for management including a user-friendly implementation procedure through a database system is essential. Data characteristics at the lower and more detailed levels should be encoded following a logical recording structure including protocols for data formatting, encoding, elements and fields should be enumerated.

**Forest policy evaluation in Europe.** Buttoud, G. (*The French Institute of Forestry, Agricultural and Environmental Engineering (ENGREF), France*; [buttoud@engref.fr](mailto:buttoud@engref.fr)).

During the last decade, in link with the international dialogue on forests, there was a huge investment in policy research on the formulation of national forest programs and strategies. Now when these new policies are just starting to be implemented, the issues of monitoring, follow-up and evaluation are raised. In 2004, an international symposium highlighted the most recent developments as for the evaluation theories and methods. There are basically 2 groups of researchers. The first school, mainly represented in Central European countries, tends to consolidate a rationalist framework for a causative evaluation of forest policy measures, based on deductive or systematic assessments and on impact analysis. A debate is open on how to better integrate social and environmental aspects into impact assessment. Opposite to these are the approaches that have been recently developed in most of the other countries in Europe and USA; they begin with social considerations and, based on participation and negotiation, address a broader range of policy issues such as conflicts, actors' psychology, institutions, etc. A special emphasis is given in this second school to explain the iterativity of the policy process through various theories, including the spiral theory.

**Emerging modes of forest governance: Bridging scales and knowledge systems in forest policy making and implementation.** Capistrano, D. ([d.capistrano@cgiar.org](mailto:d.capistrano@cgiar.org)).

While policy processes have increasingly incorporated elements of stakeholder participation and greater attention to local level issues, the space for meaningful participation by a broad range of stakeholders and local level input to regional and national policy decisions remain severely constrained. Domination by powerful interest groups and

entrenched modes of thinking in agenda setting and policy implementation processes are among the most common impediments. The paper examines emerging opportunities and continuing policy challenges in effectively and equitably balancing interests of different groups with unequal power and competing priorities for the use and management of forests and forested landscapes, and often with different systems of values and knowledge. Reflecting local scale issues and knowledge systems and responding to them at regional and national scales pose significant challenges, even when enabling policies, such as decentralization are in place. Drawing on insights and findings from a review of experiences in different countries the paper distills lessons and implications for how policy and institutional reform processes may be better designed, facilitated and supported. It examines the role of bridging and facilitating organizations and institutions, and discusses the significance of networks, alliances and multi-stakeholder mechanisms in mediating and framing interactions among stakeholder groups.

**Conceptualizing new modes of governance in Europe. Preliminary results of the “GoFOR-Project” (New modes of governance for sustainable forestry in Europe).** Hogl, K., Pregernig, M. (*University of Natural Resources and Applied Life Sciences, Austria; karl.hogl@boku.ac.at; michael.pregernig@boku.ac.at*).

One of the most significant changes in environmental and natural resource policy-making over the last decade has been the effort to find effective alternatives to command and control regulation. Under the term ‘new modes of governance’ (NMG), policy makers in Europe are striving for less intrusive policy means. As regards forest policy-making, the concept of ‘National Forest Programs’ has been recognized as a promising tool. Thus far however, neither comparative analyses nor systematic evaluations of the effectiveness of these governance practices have been carried out. The main objective of the GoFOR project is to critically evaluate NMG. Based on a sound conceptual framework, it will employ an enlarged set of criteria that illustrate the practice of NMG and its constituent elements such as public participation, inter-sectoral and multi-level co-ordination, adaptive and iterative policy-making, and the use of accountable expertise. The set of criteria draws on the analysis of i) programmatic policy statements, ii) current and evolving practices and iii) assessments of the potential of new governance in the light of theoretical approaches. A comprehensive overview of current and evolving practices of governance will be compared, using case studies across 10 European countries.

**Results-based forest management in action: The British Columbia model.** Nyberg, B., Still, G. (*British Columbia Forest Service, Canada; brian.nyberg@gems6.gov.bc.ca; gerry.still@gems1.gov.bc.ca*).

New results-based forestry legislation was enacted in British Columbia in 2003, initiating a new experiment in public land policy for Canada. This legislation, which guides forest management on the provincial forest area of approximately 60 million ha, is intended to reduce prescriptive government direction to the private forest companies that hold cutting rights on public lands. Instead, the results-based Forest and Range Practices Act sets overall goals and objectives for the land and its many resource values, leaves selection and planning of forest practices up to the private companies (still with government approval of the plans), and depends on compliance and effectiveness monitoring to track outcomes. Two of the key elements that will determine the success or failure of this approach include 1) reliance on the professional conduct of foresters, engineers and biologists who prepare Forest Stewardship Plans for forest companies, and 2) a science-based monitoring and evaluation program complemented by an applied research program. Progress to date on these elements will be described; and examples will be provided of the links between objectives, minimum standards for practices (e.g., in riparian forests), evaluation indicators and the role of research and scientists in guiding adaptive management of forest policy and practices.

**Governance as institution building: Understanding evaluation as dynamic learning.** Shannon, M.A. (*SUNY Buffalo Law School, USA; mshannon@buffalo.edu*).

Governance refers to institutionalized arrangements among all actors engaged in rule making and enforcement in society. As such it is an action, not a set of fixed actors. The kind of action needed for governance is institution building. Thus, the continuous processes of rule making through negotiation, policy formulation, implementation and evaluation are governance. The new modes of governance are responses to the necessity of a dynamic system of relationships. Policy evaluation is generally viewed as either pre-decisional – anticipated effects analysis – or post-decisional – actual outcomes analysis. Both approaches take a static viewpoint regarding the sources of information (either proposals or implemented programs) and the role of the evaluation (informing policy formulation or critiquing policy actions). However, when we understand governance as the continuous process of institution building, then policy evaluation plays a critical role in creating the capacity for dynamic learning. Dynamic learning means that the system of relationships within a governance regime is organized to create information useful to others within the regime, and respond to information received. Instead of viewing governance as largely a stable set of rules and procedures with occasional adjustments, policy learning sees governance as a continuous process of engagement among a dynamic community of actors.

**From evidence to learning, new approaches for practice based policy evaluation.** van der Zouwen, M.W., Turnhout, E., Schanz, H. (*Freiburg University, Germany; heiner.schanz@ifp.uni-freiburg.de*).

In the traditional, more linear view on policy processes, policy evaluation is the phase after policy implementation. Evaluating policy in this traditional perspective suggests that analysts objectively determine the policy's efficacy and efficiency. However, given the shift in governance from hierarchical steering modes to network and civil society modes of steering, this approach no longer suffices. Instead, we feel that policy analysis and policy evaluation should reflect the complexity and context dependency of policy processes. Policy implementation is a case in point. While traditional linear policy analysis would conceptualize implementation as unproblematic application of pre established policies, in our view, policy implementation is better understood as a complex and context dependent process that inevitably involves reinterpretation and renegotiation of policies by the different actors involved. Consequently, the same policy can result in a multitude of different practices, depending on the context. Current forest and nature conservation policies are to a large extent based on an output-oriented steering philosophy, which means that the policy goals, in terms of desired ecological qualities, are central regardless of how these goals are achieved and by whom. The paper discusses conceptual frameworks and how policy evaluation can be developed with a balanced approach.

## **Attempts to measure sustainable forest management**

Organizer: Meeta Biswal *Hirakud Wildlife Division, Sambalpur, India; meeta\_biswal@rediffmail.com*

**Quantification of species diversity: A criterion for sustainable forest management (a case study).** Biswal, D. (*Territorial North Forest Division, India; d.biswal@rediffmail.com*), Biswal, M. (*Hirakud Wildlife Division, Sambalpur, India; meeta\_biswal@rediffmail.com*).

The concepts of sustainable development and sustainable forest management are interlinked. Sustainable forest management can be described as the contribution of forestry to sustainable development. Biodiversity relates to sustainable development and is linked to sustainable forest management through a series of direct and indirect uses. The direct uses include harvest, nature tourism, wild genes used to improve domestic crops, wild species contributing to crop productivity, pest management, sources of medicine and bioremediation (biologically based environmental clean-up). Indirectly, biodiversity relates to sustainable development through services, individual species indicating environmental change or stress, insights into life sciences and wealth generated from rich biodiversity areas. The information generated by quantification of biodiversity can be utilized for organizing efforts leading to sustainable development. Biodiversity, thus, can be used as an indicator of environmental change and is, therefore, related to sustainable development. In the paper, an effort has been made to calculate plant species diversity of a study area. Therefore, species diversity can be used as an indicator to make prescriptions for practicing sustainable forest management in any area.

**Influence of FSC certification on the behaviour of stakeholders: The case study of the Magnifica Comunità di Fiemme (Trento, Italy).** Goio, I. (*IVALSA – CNR, Italy; ilaria.goio@ivalsa.cnr.it; ilaria.goio@libero.it*), Gios, G. (*University of Trento, Italy; geremia.gios@economia.unitn.it*), Pollini, C. (*IVALSA – CNR, Italy; claudio.pollini@ivalsa.cnr.it*).

While the supply of timber is still important for the communities living on the mountain areas of the Southern Alpine multiple use forest, from a strictly economic point of view, other functions expressed by the forest are more interesting. This as a consequence not only because of changes in the socio-economic scenario, but also because of the growing influence of human activity on ecosystems and an increased understanding of the role played by the forests itself. In this context the relationships between the owners (prevalently public) of the forests and the stakeholders are dramatically changing. The role played by forest certification on these relationships is analyzed by the Authors in the Magnifica Comunità di Fiemme, a mountain intercommunity located in Fiemme Valley in the province of Trento (Italy), created more than 1000 years ago. The case study reports changes in behaviour and attitudes of local stakeholders after eight years of implementation of FSC certification and its influence on the forest management adopted.

**Constraints in developing criteria and indicators: India's endeavours.** Singh, A.M. (*Indira Gandhi National Forest Academy, India; arvindmsingh@yahoo.com*).

Many countries, through the sustainable forest management process, have evolved their criteria and indicators. These criteria and indicators will be applied for dealing with other countries in matters of aid and trade related to forests and forest products. The main constraint is the implementation of criteria and indicators at the field level i.e. Forest Management Unit (FMU). The implementing agency is not clear and it will be difficult to develop and conduct field-



testing of the criteria and related indicators. Another constraint is lack of funds to assess and evaluate the criteria and related indicators. The need for increased financial resources to strengthen sustainable forest management has been emphasized by various government agencies. Although the country has been able to revise the policy and legislation, often there are serious constraints in their implementation, primarily because of system-wide problems. Some of the indicators related to criteria developed at the national level are difficult to achieve in the field, for example, those related to the maintenance and enhancement of spiritual benefits. This paper deals with the constraints in developing achievable indicators and the efforts being made in the field.

## Evaluation of sustainable forest management

Organizer: Gordon Hickey *Department of Sustainability and Environment, Victoria, Australia;*  
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**Criteria and indicators for sustainable forest management: The road travelled and the way ahead.** Wijewardana, D. (*Ministry of Agriculture and Forestry, New Zealand; donwije@paradise.net.nz*).

Criteria and indicators (C&I) have emerged as a powerful tool for implementing sustainable forest management. In a relatively short period, around 150 countries have adopted C&I, with some countries using them in forest management and the production of SFM progress reports. The seven thematic areas common to all C&I initiatives are also being used by the FAO as a basis for progress reporting in the 2005 Global Forest Resource Assessment. However, there are a number of significant problems related to the wider application of C&I. A number of countries are not using C&I at all, while in some countries where C&I are being used, they are not being used in an effective manner. Specific areas that need improvement include: strengthening concepts and definitions, rationalizing criteria and indicators, further research on indicators and more effective utilization of C&I in forest policy. The need to maintain a link between research effort and operational needs is a key issue in the future development of C&I. If this is not achieved, it could lead to the waste of resources and effort. Some of the research undertaken recently shows that innovative approaches are being taken to address these issues. This paper identifies areas that need more research and draws from ongoing work to show how current needs are being met.

**The Big Five: harnessing the potential of dryland fruit tree species in east and central Africa.** Jama, B.A., Njui, A.N., Zeila, A.D. (*World Agroforestry Centre (ICRAF), Kenya; b.jama@cgiar.org*), Mohamed, A.M., Mulatya, J. (*Kenya Forestry Research Institute (KEFRI), Kenya; maalimm4@yahoo.com; jackmulatya@yahoo.com*), Njui, A.N. (*World Agroforestry Centre (ICRAF), Kenya; a.njui@cgiar.org*).

There are many fruit trees that could be integrated into dryland farming systems in Sub-Saharan Africa (SSA) to support income and nutritional security. Fruits contain almost all the known vitamins and many essential minerals. Five big ones that are cross-regional include: *Adansonia digitata*, *Tamarindus indica*, *Zizyphus mauritiana*, *Sclerocarya birrea* and *Mangifera indica*. While these species are well integrated in the Sahel region, besides mango, they are generally absent from smallholder farms in east and central Africa. What is utilized is mostly harvested unsustainably from the wild in communal areas. Unlike the situation in the neighbouring southern Africa region, where *Sclerocarya birrea* is utilized extensively in the wine industry, there is virtually no use for the tree in this region, largely because of limited knowledge. *Z. mauritiana* use is also limited because of low quality germplasm—the hard stone clings to the flesh. Given these challenges, a regional framework is presented in this paper that aims at wide scale planting and use of the ‘Big Five’. Key elements of the framework are: improving access to quality germplasm, capacity building on their processing and utilization, and market development—drawing on case studies from the countries in the region and beyond.

**An analysis of Australian research on indicators of sustainable forest management.** Turner, J., Lambert, M. (*Forsci, Pty Ltd, Australia; forsci@fluoroseal.com.au*), Flinn, D. (*David Flinn Consulting Services, Australia; dflinn@bigpond.com*), Mueck, S. (*Biosis Research, Australia; smueck@biosisresearch.com.au*), Kile, G. (*Forest and Wood Products Research and Development Corporation, Australia; glen.kile@fwprdc.org.au*).

The objective of developing indicators of sustainable forest management (SFM) is to provide information on the level of success of forest management in meeting specific objectives. Globally, various systems of criteria and indicators of SFM have been developed, typically with a large number of indicators. Whilst quality and depth of indicators is important, the value of many indicators in measuring or assessing SFM is poorly understood. Australia has adopted the Montreal Process criteria and indicators, and over recent years an extensive program of research has been undertaken to evaluate a subset of

21 of the Montreal indicators. A number of the indicators studied were found to require modification before application was possible in Australian forests, while others were likely to be of limited value in assessing SFM, or could not be implemented cost-effectively. The Australian program of research evaluation of a broad subset of SFM indicators appears unique. An analysis of this substantial body of highly targeted R&D indicates the need for further assessment of many of the proposed indicators before they can be operationalized, and individuals and agencies convinced they are indeed collecting useful information that can result in continuous improvement in forest management.

**Sustainable forest management reporting in Australia.** Howell, C.I. (*Bureau of Rural Sciences, Australia; claire.howell@brs.gov.au*), Wilson, A.D. (*Department of Agriculture, Fisheries and Forestry, Australia; andrew.wilson@affa.gov.au*), Davey, S.M. (*Bureau of Rural Sciences, Australia; stuart.davey@brs.gov.au*), Eddington, M.M. (*Department of Agriculture, Fisheries and Forestry, Australia; margie.eddington@daff.gov.au*).

Criteria and indicators (C&I) are used in a number of sectors to assess progress towards specified goals or targets. The adoption by the Australian Government of the Montréal Process framework of seven criteria and 74 indicators, to report Australia's progress towards sustainable forest management at national and sub-national levels, has improved the ability to report more comprehensively and consistently, on economic, environmental and social values. The establishment of Australia's Montreal Process Implementation Group, with forest conservation, production, public and private forest management representatives from all States and Territories, provides a strong regional ownership and drive of the framework. The adoption of the framework by State government agencies, for both production and conservation forests, to report sustainable forest management demonstrates the framework's relevance at national and sub-national levels. A major development was the implementation, for the first time, of Australia's sustainable forest management reporting framework in Australia's State of the Forest Report 2003. The implementation process revealed issues of relevance to indicators at national and regional levels, data availability, duplication, ambiguity and gaps between some indicators. A national review of the framework is underway to improve the reporting of progress towards sustainable forest management in Australia.

**Scientific review and gap analysis of SFM criteria and indicators initiatives: The case of British Columbia, Canada.** Hickey, G.M., Innes, J.L. (*University of British Columbia, Canada; gordon.hickey@dse.vic.gov.au; john.innes@ubc.ca*).

There are many organizations and individuals working on sustainable forestry criteria and indicator (C&I) research and monitoring initiatives at different scales. In support of Canada's international commitments, the Canadian Council of Forest Ministers recently revised a set of national C&I, based on the Montreal Process. Meanwhile, the Province of British Columbia has implemented a new, results-based, Forest and Range Practices Act, which sets objectives for 11 'Values' that require appropriate C&I for effectiveness evaluation. At the local-level, British Columbia's forest industry requires indicators to achieve third-party certification. Each of these parties seeks an effective, efficient and meaningful mechanism to assess and report on performance and facilitate decision-making. There is, therefore, a recognized desire to define a collaborative approach to C&I research and monitoring frameworks in British Columbia in order to improve communication, reduce duplication, increase efficiency and make more effective use of investment funds. This paper presents the results of a comprehensive scientific review and gap analysis of C&I related to sustainable forest management in British Columbia. Over 80 C&I initiatives from around the world were analyzed using the constant comparison method to produce a matrix of over 2000 potential indicators. These indicators were then analyzed and systematically reduced using a number of methods.

## Sub-theme: Sustaining Forests: A Duty for Forestry and Society?

### Sustaining forests: A duty for forestry and society?

Organizer: Max Krott *Georg-August University Göttingen, Germany; mkrott@gwdg.de*

**Does science have a role in formulating public policy to sustain forests?** Guldin, R.W. (*USDA Forest Service, USDA; rguldin@fs.fed.us*).

Science has two major roles to play in formulating public policy to sustain forests. If credible information on forest conditions and recent trends is not available for the entire country, policy makers lack the scientific foundation necessary to address sustainable forestry issues. How can good policy be made if current forest conditions are now known? Therefore, one of the major roles for federal forest research organizations is managing a national forest inventory and monitoring program to generate current information on the status and trends of forests. Scientists should be involved in both designing the sampling frame and in analyzing the information collected. Secondly, much research is completed each year, yet the results are not reaching policy makers in forms that they can understand and use. The second major role for scientists and their institutions is to develop the ability to work effectively at the forest science-policy interface. Results of a five-year IUFRO task force suggest that by following a few key guidelines, scientists and their institutions can improve the scientific foundation for policy making. Transforming research results into information that policy makers and stakeholders can use is a key role for science in formulating public policy to sustain forests.

**Invasive insects and diseases threaten World forests.** Haack, R.A. (*USDA Forest Service, USA; rhaack@fs.fed.us*), Wingfield, M.J. (*University of Pretoria, South Africa; mwingfield@fabi.up.ac.za*).

The international movement of exotic forest insects and diseases threatens forest sustainability worldwide. International trade is the principal means by which these destructive agents move among countries. Virtually every country in the world has at least a few exotic forest insects or pathogens, while some now face the impact of hundreds of new species. Exotic insects and diseases affect tree growth and survival, biodiversity, ecosystem functioning, local and national economies, and trade. Several case studies from various parts of the world are presented to illustrate the impact of exotic insects and pathogens. We also consider the major pathways by which these invasive agents move. For example, wood packaging material such as pallets, crating and dunnage is a major vector for bark- and wood-infesting pests. New international guidelines for regulating wood packaging material are being formulated and the International Forestry Quarantine Research Group is evaluating other phytosanitary treatment methods and the degree to which reinfestation occurs post-treatment. The paper discusses these new strategies and includes a discussion of future needs such as integrating the concept of invasive pests into the framework of sustainable forestry, improving costs estimates of managing invasive species for decisionmakers, and developing global invasive species databases and identification tools.

**The changing role of the state in attaining sustained forests.** Krott, M. (*Georg-August University Göttingen, Germany; mkrott@gwdg.de*).

Climate change, illegal logging and biodiversity are just a few issues which show the huge challenges that the state faces in guaranteeing sustainable forests. The political response of national and international forest policies has been highly diverse. In world-wide comparisons, the state ownership of forests varies between 5 to 95% within different states without a clear sign whether public or private ownership is superior in guaranteeing sustainability. On the contrary, the most important factor emphasized is how the state activities are organized. Traditional public problem solving formulates binding programs and implements them by partly pledging the means of the state. The limits of this 'forest government' model are the insufficient political power and financial means of the states to handle increasing problems related to sustainability. In the last decade, a new type of problem-solving developed on a national and international level, broadly termed 'forest governance'. This model involves the networking of private and public stakeholders. Mutual cross-sector exchange of information and bargaining should lead the way to innovative solutions.

**Forest management in partnership with civil society: A Russian case.** Teplyakov, V. (*IUCN-The World Conservation Union and Moscow State Forest University, Russian Federation; Victor.Teplyakov@iucn.ru*).

The forests of Russia are of global significance due to their dimensions and influence on global climate change, biodiversity conservation and world timber markets, but they are also an essential source of life for forest-dependent and local people. Since 2000, forest management in Russia has been in a transition period due to administrative and forest legislation reforms. New approaches to forest management are leading to the disintegration of old-fashion management

practices and now viewed as sharing responsibilities between forest governance, forestry operations and oversight (control) of activities in the forest sector. Most of these changes will be introduced in a new Forest Code of the Russian Federation drafted and submitted to the Russian Federal Assembly (Parliament) for consideration. The development of the Russian state towards democracy has led to the involvement of civil society in forest management. Many projects aimed at bringing public opinion to forest management decision makers have been undertaken or are on-going in the Russian forest sector. IUCN-The World Conservation Union, in collaboration with its partners at the Russian Federal Forestry Agency and the Ministry of Natural Resources, and its member organizations have developed a number of approaches to achieve this goal. One of the latest developments is a programme for the training of managers in public participation that will be introduced to the continuous forest education programme. Although democratic traditions in Russia are underdeveloped, the forest sector is trying to incorporate public opinion into decision making. Lessons learned in the forest sector could be transformed into other natural resources for the benefit of both nature and people.

### **Conditions for the transition to sustainable forestry**

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**Inventory of raw materials for the furniture and handicraft industries: Meeting industry's demands through a sustainable supply.** Bantayan, N.C. (*University of the Philippines, The Philippines*; [ncb@laguna.net](mailto:ncb@laguna.net)), Castillo, E. (*Department of Environment and Natural Resources, The Philippines*).

The furniture and handicraft industries are among the Philippines' top export earners contributing \$291 million (furniture) and \$467 million (handicrafts) from 1994–1998. Thus, effective and efficient management of available raw materials must be pursued. Furthermore, up-to-date information on the status of these raw materials that will supply the short-term and long-term requirements of the industries must be available. It is thus imperative to conduct a comprehensive investigation on the major species being utilized in these industries. This assessment identified sites where the raw materials can be used as alternatives to the current sources. Today's furniture and handicraft industries are in dire need of support from advances in data and information handling to provide an overall picture of the current and future state of the industries. Actual sources of production, overall potential areas which can be sustainable sources, market potentials, assessment of other production parameters to indicate the long term sustainability of the industry and vital information to back-up and speed up the industry's production and marketing activities, and global competitiveness were identified.

**Uncovering forest values in New Zealand.** Barnard, T. (*Forest Research, New Zealand*; [tim.barnard@forestresearch.co.nz](mailto:tim.barnard@forestresearch.co.nz)), Spence, H. (*Coastline Consultants, New Zealand*; [harley@coastline.co.nz](mailto:harley@coastline.co.nz)).

This qualitative research sought to provide greater understanding of the way that individuals and communities value forests in New Zealand. Working with selected groups and schoolchildren, researchers sought to identify and categorize forest values using qualitative research and facilitation techniques in three centres including Rotorua, Nelson and the Hunua Ranges. The research revealed some similarities in the general range of values captured between regions and groups. For example, most groups held values relating to wildlife, use, environmental services and landscape. However, there were sometimes subtle differences between case study areas with different emphasis being placed on the way that forests are valued and used. A number of surprising results also emerged that have challenged traditional notions of the way New Zealander's view their forests including the often quoted distinction between plantation and native bush. This work has implications for anyone engaged in forest planning and management, public participation, certification and in the use of criteria and indicators for sustainable forest management.

**Providing the scientific basis for sustainable watershed management, La Mesa Watershed, Philippines: The Akecop-Bantay Kalikasan research connection.** Camacho, L.D., Rebugio, L.L. (*University of the Philippines Los Banos, The Philippines*; [akecop@laguna.net](mailto:akecop@laguna.net); [lucreb@laguna.net](mailto:lucreb@laguna.net)).

This is a case study of regional collaborative research in support of watershed management. Specifically, it focuses on a unique research partnership between the ASEAN-Korea Environmental Cooperation Project (AKECOP), a regional collaborative research on forest restoration and biodiversity conservation financed by the Korean government and Bantay Kalikasan, an environmental NGO managed by the Asia Broadcasting Service–Chronicle Broadcasting Network Foundation. The partnership is aimed at providing the scientific basis for the sustainable management of the

La Mesa watershed, one of the watersheds supplying water to Metro Manila. Under the research partnership, nine integrated studies on the biophysical (eco-physiological, edaphic, hydrological and silvicultural) and socio-economic aspects of watershed management are being undertaken. The results of the biophysical studies could provide the La Mesa watershed resource managers the basic information for deciding on the most appropriate forest restoration strategies to be applied in the watershed, including the correct (site compatible) species and most effective silvicultural techniques. The socio-economic studies are intended to provide resource managers the information base to enable them to plot strategies for effectively dealing with illegal watershed occupants and to devise economic instruments that will help generate the financial resources needed for sustainable watershed management. Lessons from the AKECOP-Bantay Kalikasan research connection could be adapted to other watersheds in the country and in the ASEAN region.

**Assessment of the status of sustainability of forest resources in India.** Dasgupta, S. (*Forest Survey of India, India; saibaldasgupta@hotmail.com*), Rawat, J.K. (*Forest Survey of India, India; fsidir@vsnl.com*), Kumar, R. (*National Sample Survey Organisation, India; rajsus1@rediffmail.com*).

A methodology using an iterative process of 'Group Convergence Method' for assessment of sustainability for forest resources in India was undertaken by utilizing the technical conceptual framework of 'capital and its good and services.' Six internationally accepted and common criteria for sustainable forest management were used: 1) extent of forest resources and contribution to the global carbon cycle; 2) forest ecosystem health and vitality; 3) biological diversity; 4) productive functions; 5) protective functions; and 6) social and economic functions. The appropriate variable under each criterion were assigned weights pertaining to their relative contribution to the sustainability of forest resources. On arriving at a consensus with regards to weight to be assigned for each criterion and variable, compilation of national data and trends for each variable was undertaken. The data was then reviewed by the experts by giving scores between 1–100: 1–25 indicated unsustainable; 26–50 towards unsustainable; 51–75 towards sustainable; and 76–100 sustainable. Thereafter, using the mean scores for the variables and their weights, the contribution of each criterion towards assessment was computed. Overall assessment of sustainability of forest resources in India was assessed as 55.8 which may be classified mildly as 'towards sustainable' with standard error of 1.7.

**A general view on the status of sustainable forest management in Turkish forestry.** Durusoy, I., Türker, M.F. (*Karadeniz Technical University, Turkey; durusoy@ktu.edu.tr, mft@ktu.edu.tr*).

The Bruntland Commission in the 1980s established the definition of sustainable development and the Earth Summit in 1992 produced strategies to attain the goal of sustainable development. The Summit has also established the sustainable development overall policy for all sectors. Sustainable forest management is a crucial goal servicing the sustainable development. Thus, responsibilities of the forestry sector and foresters are increasing. All this process produced a growing consensus on the elements of sustainable forest management and the need for measuring progress. The ecological, economic and social dimensions of forest management are widening. There have been parallel developments in Turkish forestry. International efforts to promote sustainable forest management have influenced the forestry discussion within Turkey. Turkey showed her commitment to sustainable forest management through the Pan-European Process. Turkish forestry is undertaking new changes in forestry management. There are some projects to shift the focus of forestry from maximizing the timber production to long-term ecosystem management. However, there are still some obstacles for sustainability. The organizational, legal, economic, social and planning challenges Turkish forestry face today are perhaps best understood in the international context of sustainable forest management. This paper evaluates Turkish forestry in view of international sustainable forest management criteria, and it identifies the opportunities and threats for Turkish sustainable forest management in a national context.

**Differences in utilization and management of forest resources by local governments in Korea.** Kim, E.-G. (*Gyeongsang National University, Republic of Korea; egkim@nongae.gsnu.ac.kr*), Shon, C.H. (*Korea Rural Economic Institute, Republic of Korea; Shon9@krei.re.kr*).

This study surveyed 149 local governments (city and county) in Korea for information about the distribution, utilization and management of forest resources in order to identify conditions for the transition to sustainable forestry at the level of local governments. The distribution of forest resources showed significant differences depending on local characteristics. The utilization of non-timber forest products in county-based forests is more prevalent than in city forests, with unit products value of \$30.9/ha in cities and \$44.9/ha in counties. Recreation participation is greater in cities compared to counties, with 12,000 and 900 persons per kilometer of forest roads in cities and counties, respectively. In both cities and counties, larger forest areas are associated with higher areas of managed forest per manager or per forestry machine. Therefore, these diverse differences imply the need for local governments to introduce distinctive management strategies based on local characteristics in order to achieve sustainable forest management.

**Conditions for sustainable community forests: Evidence from 17 village groves in Korea.** Kim, I., Youn, Y.-C. (Seoul National University, Republic of Korea; [inae2003@snu.ac.kr](mailto:inae2003@snu.ac.kr); [youn@snu.ac.kr](mailto:youn@snu.ac.kr)).

Historically, many Korean villages had groves that usually formed an important cultural element. However, many of the groves have disappeared. This study identified the factors influencing the conservation or disappearance of groves in 17 villages. Four hypotheses were tested: 1) the likelihood of a grove being maintained is increased with an established management body; 2) the likelihood of a grove being lost is increased when there is a high opportunity cost of conservation; 3) the likelihood of a grove being lost is increased when it is privately owned; and 4) the likelihood of a grove being conserved is increased when there is a cultural value system. Information was collected on the social, economic, cultural and ecological aspects of the villages. The main factors influencing the loss or conservation were identified using Boolean algebra. Important conservation factors were social and cultural institutions. Social institutions governing grove management and religious values are critical for conservation. Most villages that have retained their groves designate and protect them as a cultural heritage. The functions of groves have changed: spiritual values have been replaced by recreational and educational values. In conclusion, the sustainability of community forests in Korea should be understood in a social, cultural and economic context rather than only in ecological terms.

**Preconditions for transition to sustainable forestry: Evidence from a comparative study of six countries.** Lee, Y., Youn, Y.-C. (Seoul National University, Republic of Korea; [johnlee@snu.ac.kr](mailto:johnlee@snu.ac.kr); [youn@snu.ac.kr](mailto:youn@snu.ac.kr); [youn@snu.ac.kr](mailto:youn@snu.ac.kr)), Palo, M. (Finish Forest Research Institute, Finland; [matti.palo@metla.fi](mailto:matti.palo@metla.fi)).

In order to identify the preconditions for transition to sustainable forestry, we first applied John Stuart Mill's direct method of agreement by studying similarities in the underlying causes of transition in Costa Rica, Finland, Germany, Japan and the Republic of Korea as positive cases. Next, Mill's indirect method of difference was applied. Here the method of agreement was first applied to the set of positive cases above and then to a set of negative cases including Indonesia, Philippines, Ghana and Guatemala. The two methods appeared useful, but perhaps are incapable of handling multiple or conjunctural causation. Therefore, we also applied the qualitative comparative analysis (QCA) method of Charles Ragin. The conditions for transition to sustainable forestry were examined by comparing the social, political, economic and cultural institutions and the ecological conditions, which comprised the environment for forest policy in the respective countries. The conditions of each country in country-specific time periods from the *de jure* transition to the *de facto* transition were examined. The results of analysis indicated that the transition could not be possible without a certain balance of policies and markets. Only a sufficient value of forests enables policies to be effective. A sufficient value of forests was created by overcoming transaction costs, and by establishing reasonably clear and strong property rights for forest holdings.

**Transitions into sustainable forestry in Finland.** Lehto, E., Palo, M. (METLA, Kannus, Finland, and CATIE, Turrialba, Costa Rica; [Matti.Palo@metla.fi](mailto:Matti.Palo@metla.fi)).

Only a few developing countries have been able to arrest deforestation and transition into sustainable forestry. Therefore, Finland has been investigated with a single case study method. Deforestation was a threat also in Finland until about 1950. Finland adopted *de jure* sustainable forestry by the forestry law of 1886. The first effective law dates back to 1917, and with the development of some competitive key markets, the deforestation era was finally overcome in three decades. The strong and clear tenure of forest holdings, primarily by farmers, has been one cornerstone for success. Another has been an expanding demand for industrial wood. One consequence of these changes has been a trend of increasing real stumpage prices. A mix of market and policy instruments has been applied over time. Ten subsequent national forest programs since the 1960s have been a distinguishing feature of Finnish forest policy, with increasing public and private investments in forest management intensification. The growing stock of timber in Finland is currently estimated to be at the same level it was two centuries ago. Economic sustainability has thus been achieved, but there are still some efforts ahead towards ecological, social, cultural and spiritual sustainability.

**Forestry revenue policy review in China: A continuous "error testing" process to sustainable forest management.** Liu, J.L., Zhang, S. (The Chinese Academy of Forestry, China; [liujl@forestry.ac.cn](mailto:liujl@forestry.ac.cn), [zhangshougong@caf.ac.cn](mailto:zhangshougong@caf.ac.cn)).

China's forestry taxation and charging system, which has been continuously changing along with macro policy reform from a planned to a market orientated economy, is complex and over burdened, varies greatly, and suffers from high avoidance and low efficiency in collection. These are disincentives for forest management, and both household welfare and the environment suffer because of them. Before 1985, government revenue derived from controlling the price of timber and the market. After implementation of a market economy, farmers were taxed on the market price, and government revenue came from such taxes and additional charges. In the past 7 years, funds from the state fiscal account from forestry development have increased more than 20 times. But, misuse of government funds during collection or transferring from central fiscal accounts is attributed to government over-staffing and poor enforcement. Since 2002, the Chinese government has taking measures to counter these problems. It has eliminated the Special Agriculture Product Taxation, eliminated illegal charges,

decreased the rate of official approval charges, and promised to eliminate the Agriculture Production Tax by 2009. China's case has shown that forestry issues extend beyond the forestry sector, and that governmental institutions were the source of the major constraints for reform to forestry taxes and charges.

**Comparative study on land systems and forests: India and Indonesia.** Masuda, M., Damayanti, E.K., Shiga, K. (*University of Tsukuba, Japan; masuda@sakura.cc.tsukuba.ac.jp*).

Tropical forests as a whole are still in a trend of degradation, but there are some regions that are reversing the tendency. In addition, promotion of tree planting on farm land in China will have a great influence on the statistics of forest covers if the target can be achieved. We focused on such different processes of policy development and the outcomes, and India and Indonesia were selected as cases studies. Even under a federal system, relatively uniformed forest control is found in India, and it succeeded in application of participatory approaches in forest management before other developing countries. Contrary, Indonesia is now under transition from centralized to decentralized administration system but still in turmoil. Based on the difference in the legal aspects relating to the land and resources, effective measures to mitigate ongoing deforestation and fragmentation process in Indonesia are discussed

**A theoretical frame for transitions into sustainable forestry.** Palo, M. (*METLA, Finland and CATIE, Turrialba, Costa Rica; Matti.Palo@metla.fi*).

Research on the causes of tropical deforestation and the transition to sustainable forestry has not yet produced effective instruments for policy implementation. Here we aim uniquely to identify the underlying causes of transitions from deforestation to sustainable forestry on an *ex post-basis*. Our theoretical frame is primarily composed of the theories of Ecological Economics and New Institutional Economics. A typology of pre-industrial, industrial and post-industrial forestry will be applied. The objectives of the three cases are defined as follows: subsistence in pre-industrial forestry, sustained yield of timber in industrial forestry and sustainable forest management (UNCED 1992) in postindustrial forestry. We shall specifically study the transitions from pre-industrial to industrial forestry, and transitions towards post-industrial forestry. Our attention concerns the *de jure* and *de facto* transitions of forest policy objectives, means, institutions and their implementations. Most of the world's forests are state-owned. Socialistic forestry has a tendency to undervalue existing forests and thus increase the opportunity costs of sustainable forestry. Public Choice Theory supports the idea that socialistic forestry also has a tendency to favour corruption. More corruption will lead to more deforestation.

**Market product approach for a better management planning in Madagascar.** Ramamonjisoa, B. (*University of Antananarivo, Madagascar; bs.ramamonjisoa@netclub.mg*).

Since 1997 Madagascar has established new forest policy and forest management plans at national and regional level using a participatory process (including farmers, harvesters, researchers, political decision makers, technicians, donors). The plans have been implemented by the Forest Service at the community level using multilateral funds (World Bank, UNDP) and bilateral donors (German, Swiss, Japanese and French corporations). Unfortunately, the forest degradation process continues with an annual reduction in forest area of 2 to 2.5% due to slash and burn agriculture and traditional forest harvesting. Decision makers are at a loss to explain this result given the participatory policy formulation and implementation process. The hypothesis presented here is oriented on the existing gap between a virtual participatory process and real practices. The Market Product Approach is a method using multidisciplinary tools (micro and macro economy, sociology, anthropology, forest fiscality) for integrating real economical and social aspects in the context of management plan implementation. It is used for accumulating knowledge and information on forest product and resources, identifying stakeholders and their role in market process, and understanding technical and economic production processes and their impact on forest policy or forest management.

**Fire as a tool for sustainable forest management in India.** Schmerbeck, J., (*University of Freiburg, Germany; Joachim.schmerbeck@waldbau.uni-freiburg.de*), Behera, B. (*Technical University of Munich, Germany*).

In India, fire is considered as the major cause for forest degradation and a major impediment for forest regeneration. According to the Government of India, 35 million ha of India's forest (54%) are affected by fire annually, and approximately 90% of the India's forest fires are anthropogenic. Despite its tremendous influence on forests, fire is rarely considered in forest management plans, or as a research topic for sustainable forest management in India. This presentation directly addresses the role of fire in forests under Joint Forest Management programmes in the Indian States Tamil Nadu and Andhra Pradesh. The impact of fire on the forest structure and quality and the role of fire control in the forest management will be discussed. The socioeconomic background will be analysed as a success factor for fire management. The integration of fire into the forest management will be proposed as an alternative to the ban of fire.

**Transitions to industrial and postindustrial forestry in Korea.** Youn, Y.-C. (*Seoul National University, South Korea; youn@snu.ac.kr*).

Korea began reforestation in the 1960s and the growing stock of timber is continuously increasing. Among the underlying factors of the increase in forest resources are strong and clear property rights, prevailing private ownership of forests, stable government, low corruption in forestry, low government and market failures, increasing income per capita, urbanization, decreasing population growth, increasing imports of forest products and effective forest and agricultural policies. These factors have favored Korea from its deforested condition after the Korean War up to the contemporary high forest cover. Korea established four successive National Forestry Programs since 1961 to complement the forestry laws and acts. Korean traditional culture also appreciates trees and forests as identified by the strong mountain spirit heritage and by the burial grounds and temples in the forests. Korean Arbor Day, a paid holiday in April, is intended to mobilize all people to plant trees, and has played a socio-cultural role in promoting forestry. How to make the transition from deforestation and degradation to post-industrial forestry is a hot issue in contemporary global forest politics. Korea is a country that can demonstrate a transition from a pre-industrial forestry to industrial forestry, and the first steps towards post-industrial forestry.

## **The changing roles of stakeholders in sustainable forest management**

Organizer: Meeta Biswal *Hirakud Wildlife Division, India; meeta\_biswal@rediffmail.com*

**Environmental benefits of mangrove forests: Perceptions of local people from the Bhitarkanika Conservation Area, India.** Badola, R., Hussain, S.A. (*Wildlife Institute of India, India; ruchi@wii.gov.in*).

The attitudes of local people towards mangrove forests and their perceptions regarding the services provided by these forests were studied in 35 selected villages in the Bhitarkanika Conservation Area, along the eastern coast of India. The villagers felt that protection from storms and land erosion prevention were the primary functions of this ecosystem, followed by nutrient retention and export and fish production. The farmers in villages situated near mangrove forests felt that mangrove forests help in augmenting production of agricultural crops by enriching the surrounding soils, and this was reflected in the higher price of agricultural land in the vicinity of forests. Around 70% of the local people believed that biodiversity values, ground water recharge and regional climate control were secondary functions. Provision of fuel wood and fodder, non-wood forest products, fish and shellfish were also considered important. Crop degradation and saline water intrusion were the main problems perceived by the residents. Better irrigation facilities (82.6%), restoration of mangroves (77%), maintenance (36.6%) and increase in the height of saline embankments (66%) would help in improving output of the local ecosystem. Most people (92%) were in favour of an integrated conservation and development program.

**Sustaining forests: Changes in roles of various stakeholders in sustainable forest management.** Biswal, M., Biswal, D. (*Hirakud Wildlife Division, India; meeta\_biswal@rediffmail.com*).

Whether it was traditional forest management, where commercial forestry was given importance or whether it is the sustainable forest management, where conservation and preservation have been a focus, a variety of stakeholders have existed and played a pivotal role in the way forests came to be managed across the world. The stakeholders include forest managers and policy makers in the government, indigenous communities, non-governmental organizations and researchers. With increasing awareness on the positive outcomes of sustainable forest management, the stakeholders are now required to play a more responsive role, thereby managing forest resources on a sustainable basis. This envisages a clear demarcation of roles and responsibilities between the stakeholders, while working cooperatively. This paper discusses the changes that are required in the roles of various stakeholders in order to achieve sustainable forest management.

**Paradigm shift of tumpangsari system towards local involvement in Madiun, East Java, Indonesia.** Harada, K. (*Institute for Global Environmental Strategies, Japan; harada@iges.or.jp*), Yokota, Y. (*Japan International Research Center for Agricultural Sciences, Japan; yokotaya@affrc.go.jp*), Oktalina, S.N., Rohman, Putro, W.T. (*Gadjah Mada University, Indonesia; genki\_21@yahoo.com*).

In Madiun, East Java, Indonesia, forest management has mainly been focused on the production of teak timber. However, because of the severe destruction of forests due to current social and economic conditions, Forestry Enterprise (Perum Perhutani) created a management philosophy that included local involvement. The management policy in 2002 declared that production forests are managed in cooperation with farmer groups, and they can share benefits from thinning or final cutting. In Madiun, Gadjah Mada University (UGM) took the initiative to organize farmer groups for forest resource management (MPSDH: Masyarakat Pengelola Sumber Daya Hutan), to facilitate agreement among Forestry Enterprise, local government and local people. The process of selecting groups supported by Gadjah Mada University was democratic



and effectively organized with the involvement of local people. Each group was encouraged to plant food crops or trees in the agricultural strip, to intercrop between planted trees and in the open spaces left after thinning the forest and to share benefits from timber production. This organized local participation in teak forest management is a significant attempt to develop a new paradigm of participatory forest management in Indonesia.

**Role of local communities and some elements of sustainable forest management in Korea.** Kim, J.M., Lee, K.H., Oh, J.S. (*Korea Forest Research Institute, Republic of Korea; KFRI; jmkim99@foa.go.kr; kyeonghlee@foa.go.kr; jsoh@foa.go.kr*).

A local community in northeastern Korea was surveyed to identify some aspects of sustainable forest management, such as forest values, and the necessity for local forest partnership. Based on a 1 – 5 Likert scale, protection of water and soil in forests scored 4.7, highest among 7 suggested values. It seemed that the local community, located in mountainous areas has seen land slides and soil erosion frequently, especially during monsoon seasons. Other forest values, such as conservation of biodiversity, forest protection from fires and diseases, and recreation opportunity provisions scored over 4.0. Surprisingly, production of timber and other short-term cash crops scored lowest at 3.77. A local partnership for forest management is one of the critical factors in implementing sustainable forest management, particularly in developing a set of criteria and indicators based on forest values perceived in the local community. Of the people contacted, 76% believed a local forest partnership was required to enhance forest management practices. In addition, about 71% of respondents showed their willingness to participate directly as members. A majority of them preferred new forms of forest partnership. These survey results indicated how to obtain local community involvement in effective forest management in the future.

**Examination of types and levels of public participation in forest resource management and planning in view of sustainability: Turkey.** Öztürk, A. (*Kafkas University, Turkey; atak08@hotmail.com*), Türker, M.F. (*Karadeniz Technical University, Turkey; mft@ktu.edu.tr*), Durusoy, I. (*Karadeniz Technical University, Turkey; durusoy@ktu.edu.tr*), Pak, M. (*Kahramanmaraş Sütçü İmam University, Turkey; mpak@ksu.edu.tr*).

Forest resources supply many good and services on a sustainable basis but often there are conflicting demands among stakeholders, regarding priorities of resource allocation. It is clearly agreed that in order to achieve sustainable forest management and planning, opinions, demands and interests of different stakeholders should be involved. In Turkey, state ownership of forests is predominant (99.9%) and public participation in forest management and planning is increasingly important. Although public involvement in developing forest management policy and plans is not advanced, there are good examples of participatory approaches at the local and national levels, e.g., National Forestry Program. The paper deals with public participation in forest resource management and planning. Firstly, it explores the participation on a conceptual basis. Then, it examines the types of public participation, possible stakeholder groups, levels of involvement and problems associated with the participatory process in resource management and planning in Turkish forestry.

**Determining demand priorities of various stakeholders regarding forest goods and services in the context of sustainable forestry: A case study from Turkey.** Öztürk, A. (*Kafkas University, Turkey; atak08@hotmail.com*), Türker, M.F. (*Karadeniz Technical University, Turkey; mft@ktu.edu.tr*).

Forests supply many goods and services for individuals and groups. This imposes forest management decisions that are not to be made by foresters alone. The interaction between forestry and society is important and is an integral part of sustainable forest management. In Turkey, State Forest Enterprises are the main forest management units and these institutions manage forests according to timber-oriented goals prepared by foresters. These plans are highly technical and omit the social dimension and direct participation of relevant stakeholders. This is a preliminary study to include the social dimension in forest policies and management strategies. A case study in northeast Turkey involved urban, rural, managerial, industrial and recreational stakeholders as well as non-governmental organizations. Each stakeholder was asked to assign ranks of importance to 15 alternative demands. Based on the findings, guidelines for forestry institutions at local and national levels, and a framework of sustainable forest policies and strategies were developed.

**How effective is community-based forest management as a model for managing former timber concessions: The case of the Lianga Bay Forest, Surigao Del Sur, Philippines.** Rebugio, L.L., (*University of the Philippines Los Banos, The Philippines; lucreb@laguna.net*).

This is a case study on the applicability of community-based forest management (CBFM) as a model for managing large tracts of forests formerly covered by Timber License Agreements (TLA). Lianga Bay Forest is a 59,000 ha cancelled timber concession formerly operated by Lianga Bay Lumber Company, Inc. (LBLCI). When the agreement was cancelled in 1993, the Philippine Government placed the area under CBFM and a federation of peoples'

organizations, called SAMMILIA. Based on the experience of SAMMILIA, CBFM can be adapted to the sustainable management of large tracts of forest lands such as the Lianga Forest, and that the CBFM agreement is a valid instrument for providing security of tenure for CBFM managers and stakeholders. Long term security of tenure provides the motivation to CBFM participants and stakeholders to continue investing their time, energy and resources in sustainable forest management. Further, a federation of primary cooperatives such as SAMMILIA has great potential as a structure for effective CBFM in large areas. However, its effectiveness in managing, sustainably, extensive area of forests, depends on several organizational imperatives that ensure participatory decision-making and equitable benefit distribution within the federation.

**Virtues of exclusive forest user rights for income generation in south-eastern Ethiopia.** Schmitt, J. (*Freiburg University, Germany; Bergulme@web.de*), Grulke, M. (*UNIQUE Forestry Consultants, Germany; markus.grulke@unique-forst.de*).

The low remaining forest cover in Ethiopia of less than 3% and its continuous decline is threatening, because the livelihoods of many rural people rely heavily on this resource. The study challenged the claim that sustainable forest management, combined with properly administered social assets, can bring people out of poverty, while maintaining the forest. In the Adaba-Dodola Forest Priority Area, in southeastern Ethiopia, the regional government granted exclusive forest-user rights to selected forest dweller associations. Five years after project establishment, the participants' household economy and the income potential of forest utilization were investigated in a socio-economic study. The results revealed that forest dwellers did not rely solely on forest production, but combine it with subsistence agriculture and livestock production. Furthermore, wealth inequity among forest dwellers created highly varying strategies of forest utilization. A gross margin analysis, however, proved that local forest products are highly competitive compared to available labour. Additionally, forest utilization had an essential income function during hardships. To increase the potential of sustainable forest management, local knowledge can be augmented with silvicultural management techniques and improved timber processing capacities.

**Engendering forestry: An empirical study on mainstreaming gender in forest conservation and sustainable livelihood.** Singh, M. (*India; monikaxing@yahoo.com*).

Gender mainstreaming in forest conservation, albeit researched and obligated into programs with mandatory women's participation, has remained an area requiring considerable progress. On the other hand, subsistence livelihoods through forests are mostly perceived to be related to women. This stereotyping of gender in forest management and livelihoods has been detrimental to women's involvement in the decision-making processes for forest conservation. The paper focuses on the outcome of 'gendering' management of forests and forestlands, wherein the processes become important for sustainable livelihood and conservation. Three stakeholder sectors, village communities, Non-governmental organizations (NGOs) and the Indian Forest Department (IFD), are examined in a Joint Participatory Forest Management program in Gujarat, India. There is field evidence of proficient use of forests for livelihoods when women are involved in formulating a forest conservation program. On the other hand, analyzing the field realities and impact of women staff in local situations points to the importance of women in implementing agencies such as NGOs and the IFD. This study is based on the empirical findings from intensive work carried out with tribal populations in remote villages. The importance and impact of gender mainstreaming at different levels in forest conservation was established, while providing acceptable systems for local populations.

**Participation and empowerment mechanism of community forestry: An example from Taiwan.** Yeh, M.-C. (*National Chung Hsing University, Chinese Taipei; tfhmcy@ms23.hinet.net*), Lo, S.-L. (*National Chung Hsing University, Chinese Taipei; sllo@dragon.nchu.edu.tw*).

The purpose of this study is to construct a mechanism of participation and empowerment for community forestry in Taiwan. Because of over utilization of the forests for timber, the Taiwan Forestry Bureau established a stewardship program with community residents for conservation and improvement of the economy of forestry-dependent regions. Through community empowerment, local people can receive more opportunity to improve their lives and keep the partnership with the government. Through a three-year study at the Ching-Shui-Kou and Nei-Mou-Pu tracts of the Experimental Forest of National Taiwan University, questionnaires and in-depth interviews were used to investigate the motives, attitudes and routes of participation by community residents. A factorial analysis involving three levels of motive, four levels of attitude and three levels of participation route showed significant positive relationship between motive and attitude. The existing organization (ex. Community Development Organization) will be easy to work with and it can avoid resource abuse. By implementing the concept and enabling the community to make decisions regarding forestry issues that affect the people, the policy of empowerment will be successful.

## What future for community forestry? The case of Nepal

Organizer: Marlene Buchy *Institute of Social Studies, The Hague; buchy@iss.nl*

**Participatory research in community forestry in Nepal.** Acharya, K.P. (*Department of Forest Research and Survey, Kathmandu Nepal; kpacharya1@hotmail.com*).

Community forestry was formally introduced in Nepal in the 1970s to encourage participation of local people in forest management activities as a means to improve their livelihoods. Under the community forestry structure, local people, organized as a Community Forest User Group, make decisions regarding forest management, utilization and distribution of benefits from a forest. Presently more than 1 million ha of forest is under the control of approximately 13,500 forest user groups. The heterogeneous ecological conditions of Nepal, varied needs of people, and demands for site-specific forest management issues, are very difficult to address through conventional research approaches. The paper is based on case studies from the mid hills of Nepal. It presents the methodology and steps for participatory research in community forestry. It argues that participatory research could be an innovative tool for supporting the development and implementation of sustainable forest management by forest user groups. The paper illustrates how participatory research address local forest management issues linking together various knowledge worlds through participatory learning and joint enquiry. The paper argues for the adoption of more participatory approach to forestry research in Nepal to maximize forest productivity while satisfying local needs.

**Towards greater equity among forest users.** Arentz, F. (*Nepal Australia Community Resource Management and Livelihoods Project, Nepal*).

The protection of community forests by forest user groups (FUGs) in Nepal over the last 14 years has resulted in the creation of a resource that can now be mobilized for the benefit of the whole community. The elite male members of the community, who often hold that position as a result of their caste, generally lead decision-making processes within the FUGs. As a consequence, less than 10% of community funds are dedicated to activities that would directly benefit women or the socially disadvantaged members of the community. FUGs also tend to share forest resources on the basis of equality rather than on needs, resulting in hardships for those marginalized groups who have a disproportionate dependence of the forests for their livelihoods. This paper outlines a number of approaches that have been used to empower women and marginalized groups in rural communities. Although these approaches will result in a greater awareness among the target groups of their rights as members of an FUG, this will not guarantee the equitable sharing of the financial and resource benefits that come from the community forest. Therefore an equity sensitization program has to be conducted for the elites, as culturally, they will continue to dominate the decision-making processes. The outcomes of such a program being implemented by NACRMLP are discussed.

**Community Forestry: The unsustainable process?** Buchy, M. (*Institute of Social Studies, The Hague; buchy@iss.nl*)

Community Forestry has been developed and implemented in Nepal for the last 30 years and presents an interesting study case to look at how community forestry policy and field issues have shaped each other. The last 30 years have seen policy changes, as well as changes in approaches and methodology tested and implemented by various actors throughout the mid-hills region and more recently in the Terai. Yet despite considerable resources, numerous programs (including huge efforts in building up the human resource of the forestry sector) and the focus on community participation, the sustainability (social, ecological and economic) of the entire concept is still debatable. Though projects and programs attempt to tackle second generation issues (elite capture, alienation of the poor and marginal groups like women, insecure livelihoods, limited economic benefits for remote areas, corruption) the process at the grass roots levels remains driven by the top. This paper will look at the generic issue of sustainability and institutionalization and contends that Community Forestry in the context of Nepal remains an outsider driven process because the concept was imported and the process not embedded within the local conditions.

**Deliberative governance and public sphere: A reflection on Nepal's Community Forestry 1998–2004.** Khadka, K., Acharya, A.P. (*Nepalese Federation of Forest Resources User's Group (NEFUG), Nepal; kalu56@hotmail.com*).

Forests have been a highly contested domain in many developing countries, and Nepal is considered as a world leader in strengthening policies and institutions to accommodate conflicting claims of the state and local communities over forest resources. We conceptualize that such innovations are themselves a part of 'deliberative

governance' which requires active engagement of citizens in public policy. From this perspective, we analyzed key policy decisions made over the last six years (since the third workshop in 1998) to assess how and to what extent the decisions involved deliberation between government and relevant sections of civil society. Out of the 16 decisions made during this period, we found that only four involved good deliberation. While the deteriorating macro political situation has had some effect, we identified the positive links between innovative characters of different human agencies and the extent of deliberative policy-making. Through this reflection we come to an agenda of reflective practice for enhancement of deliberation and public sphere to better impact livelihoods of the poor and forest sustainability through good governance.

**Contradictions between two aspects of human rights in forest sector: Ownership rights and rights to environment.** MenĀele, L. (*University of Latvia, Latvia; lietaskoks@one.lv*).

The role of the cross-sectoral policies has increased recently in reaching sustainable development. I shall focus on the connection between the human rights concerning forests and the concept of sustainable forest management. Sustainable development requires balance between environmental, economic and social interests. Property rights, as fundamental human rights, can be seen as a basis of economic development. The understanding of the rights to environment can be treated as the rights to claim nature protection. Thus, a connection between both the human rights and the sustainable development concept can be established. The right to environment has not been mentioned directly in the human rights legislation. The protection of the right to environment has been realized through deriving it from the other human rights: rights to life, rights to health, rights to well being. The realization of human rights can be seen as another way towards sustainable development. The protection of the human rights to environment can lead to the protection of forests, as a natural resource, from overexploitation, which is connected with economic development.

**Community forest management school (CFMS) approach in Nepal: A platform at the interface between foresters and communities.** Pokharel, B., Nurse, M. (*Nepal*).

Nepal's community forestry program (CFP) represents the most advanced model worldwide for the participatory management of natural resources. The positive environmental outcomes of the CFP are widely acknowledged. However, the CFP has been challenged, and its success also questioned, due to the protection-oriented forest management system. Some attempts have been made with the establishment of demonstration plots in community forestry, but fail to address the management system issue because formal knowledge still dominates the local knowledge of communities. The Community Forest Management School (CFMS) approach is an innovation to integrate the two knowledge systems, in order to change the current protection-oriented forest management regime to active forest management. This paper summaries the evolution of CFMS and its key principles and features. Comparison is made between the practice of forest demonstration plots and CFMS plots to meet the needs of forest user groups. The authors then present and analyze case study data from Okhaldhunga and Ramechhap Districts of the Middle Hills, where CFMS is being used to understand forest management objectives with forest users (particularly the poor) and then to develop an action research program to enable the users to practice the optimum silvicultural system to meet those objectives, both in the subsistence and commercial realms.

**A cross-cultural perspective on community forestry: Leadership in India and Nepal.** Rishi, P., Gauli, K. (*Indian Institute of Forest Management, India; rishiparul@rediffmail.com*).

Owing to the failure of the earlier system of managing forests without people's participation, Community Forestry, with its behavioral principles of management with people's participation, has come into practice. Its establishment has allowed foresters to re-define their relationship with the people in order to regain their trust and alliance. Both India and Nepal have community-based forest management, but owing to cultural differences, it is likely that preferences for leadership style have differed. A study was conducted to compare and determine preferences for leadership styles in Nepal and India. A Leadership Style Preference Scale was designed to obtain the preference ranking of people and forest officers of both the countries for four possible leadership styles – Charismatic, Authoritative, Nurturing and Participative. Results indicate the preference of participatory style of leadership in Nepal, however, they also preferred the use of nurturing leadership as a back-up style. In India, the nurturing style was more preferred than participatory style, and the authoritarian style was completely rejected. Looking at the collectivist culture of India, results strongly support the hypothesis of culture-led leadership discussed in line with cultural variations in personality, local traditions and the forestry situation. Comparative behavioral models for effective forest management in India and Nepal were also prepared. The study has implications for the sustained efficacy of community forestry programs through effective leadership of forest personnel.

## **Boreal Zone forests in the balance: Regional and global factors in Boreal forest management**

Organizers: Susan Conard, *USDA Forest Service, USA*; [sconard@fs.fed.us](mailto:sconard@fs.fed.us), and Gordon Miller, *Natural Resources Canada, Canada*

**The role of boreal forests in the global carbon cycle: Implications for climate change policy.** Apps, M.J. (*Natural Resources Canada, Canada*; [mapps@nrcan.gc.ca](mailto:mapps@nrcan.gc.ca)).

Earth's climate will change significantly over the coming century, and the ecological and societal impacts that are beginning to appear are expected to increase markedly. The IPCC 2001 Assessment predicted increased global mean temperatures over the next 100 years of +1.4 to 5.8 °C above the 1990s—a decade of record-breaking temperature. These changes will not be simple linear increases in temperature or other climatic variables: the geologic record suggests that abrupt and inherently unpredictable changes are likely. Nor will the changes be evenly distributed: predicted climate change is greatest at mid-to-high latitudes and over continents. Thus, climate change is arguably the most important environmental issue facing boreal forest countries in the twenty-first century. Resource managers will face the dual challenges of mitigation and adaptation: managing natural resources to help reduce emissions of CO<sub>2</sub> and increase ecosystem carbon stocks, while continuing to supply essential products and services; and adapting management to ecosystems that are changing in ways with which they have no experience. Improved scientific understanding of the role of forests in Earth's changing climate system will be at the heart of successful management. What role can management of boreal zone forests have in managing the Earth's climate system?

**Landscape-level disturbances in boreal zone forests: Key agents and interactions.** Conard, S.G. (*USDA Forest Service, USA*; [sconard@fs.fed.us](mailto:sconard@fs.fed.us)), Shvidenko, A. (*International Institute for Applied Systems Analysis, Austria*; [shvidenk@iiasa.ac.at](mailto:shvidenk@iiasa.ac.at)).

Boreal forests and woodlands cover over 1.3 billion ha globally, or about 30% of the world's forested area. They provide an important resource base for wood fiber, water and other forest products, as well as containing about half of the carbon storage of global forest ecosystems. Forests in the boreal zone are subject to extensive disturbances from wildfire, insect and disease, harvesting and other factors. Many boreal zone forests have also experienced significant climatic warming over the past 50 years and this trend is expected to continue. Fire and insect outbreaks currently affect from 20 to 40 million ha of boreal forest annually. Such infestations kill trees over large areas, leading to long-term changes in vegetation composition and affecting the fuel structure and the probability of wildfire. Thawing permafrost leads to cryogenic destruction of sites and can dramatically change hydrological regimes, increasing aridity of environment and accelerating both disturbance regimes and ecosystems' responses. Changes in the types and levels of disturbance in boreal forests or in their management can have a major impact on forest health and on global carbon budgets, atmospheric chemistry and wood supply.

**The challenge of climate change in the boreal forests.** Flannigan, M.D. (*Natural Resources Canada, Canada*; [mike.flannigan@nrcn.gc.ca](mailto:mike.flannigan@nrcn.gc.ca)).

The warming of climate in the northern hemisphere as a result of human activities is expected to have a profound impact on disturbance processes in circumboreal forests. Changing temperature and precipitation patterns will have a direct impact on forest composition and distribution through effects on regeneration and migration. And many of these changes will not happen gradually, but be accelerated by or otherwise impacted by disturbance processes. Recent results from Global Climate Models suggest an increase in frequency and severity of natural disturbances such as fires, pests, diseases and wind storms as a result of climate change, thereby indirectly affecting forest composition and distribution. These changes in disturbance regimes could have a greater short term impact on vegetation distribution and abundance than the direct impact of climate change itself. What then can we do to prepare for climate change in the boreal forests? In managed areas, landscapes can be shaped to minimize disturbance impacts while maintaining stand structures similar enough to those of natural ecosystems to permit the maintenance of biological diversity and key ecological functions. Unmanaged forests may be more susceptible depending on the resilience of the landscape. The future is full of challenges for the boreal forests.

**Sustainable use of forests and forest certification in the Nordic countries.** Karjalainen, T. (*Finnish Forest Research Institute, Finland*), Berg, S. (*SkogForsk, Sweden*), Hoen, H.-F. (*Agricultural University of Norway, Norway*).

Finland, Norway and Sweden have long traditions in forestry and are regarded as forest-rich countries compared to many other countries. The forest sector is an important contributor to national welfare in all countries. The economic use of timber in forest industries is at present the most important use of forest resources, although they also serve other needs with

increasing weight. Most of the forests are owned by private woodlot owners, but an important proportion is owned by companies or the state. Due to intensive use of forest resources, the species composition and age class structure of the forest has changed in recent decades. Use of wood for building purposes is common, in recent years also for apartment housing and public buildings. A substantial part of the timber harvest is used for the creation of bioenergy, mainly for the energy needs of the industry, but any excess is delivered as district heating or electricity. Forest residues are to some extent harvested for energy generation as well. Use of wood for energy is a tradition in these countries, but is now developed thanks to modern technology. Use of wood instead of non-renewable materials and energy also contributes to climate change mitigation. Maintenance of the productive functions of forests is important, but fellings are less than the annual increment. Non-wood forest products and services are becoming more and more important, including berries, game and recreation uses. Relatively large areas have been protected. Most of the forests have been certified.

**Survival and growth of spruce and fir in advance regeneration after harvest cut in Primorsky Krai, Russian Far East.** Man'ko, Y.I., Gladkova, G.A., Butovets, G.N. (*Russian Academy of Sciences, Russia; manko@ibss.dvo.ru, gladkova@ibss.dvo.ru, forest@eastnet.febras.ru*), Lee, D.K., Kang, H.-S. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr, silvi@chol.com*).

Due to the over-exploitation and destruction of habitats for wildlife, commercial timber production in Korean pine-broadleaved mixed forests was prohibited from 1990. Since then, coniferous species such as *Picea jezoensis* and *Abies nephrolepis* have regenerated. To understand the survival and growth of spruce and fir in advance regeneration after harvest cut, 38 permanent plots were established on the cut areas of fir-spruce forests in 1993. The 125 spruce trees (15 trees- less than 50 cm in height, 83 trees – 51~150 cm, 25 trees – over 150 cm) and of 98 fir trees (15, 68 and 15 trees, respectively) were monitored for 10 years. Ages of some fir and spruce trees were more than 100 years at the height of only 2.5~3 m. Annual height increase was related not only with the size of advance regeneration but with its habitat – it is usually better in the gap areas. The 24.2% of spruce and 42.2% of fir died during the last 10 years. From 1993 to 2003, the advance regeneration of fir-spruce was damaged by spring-summer frost in 1994, 1996 and 1998. Most of the trees in advance regeneration showed no height growth after harvest cut.

**Consequences of large-scale windthrow on the regeneration and biodiversity of boreal forests in the Central Urals.** Mochalov, S., Moiseev, P., Zoteeva, E., Mikhailov, Y., Fedorenko, S., Vorobyova, M., Zyusko, A., (*Ural State Forest Engineering University (USFEU), Russian Federation; mochalov@mail.ur.ru*), Lässig, R., Hoffmann, C. (*Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland; christian.hoffmann@wsl.ch*).

Since 1994, in a joint multi-disciplinary project, scientists of the Ural State Forest Engineering University (USFEU Ekaterinburg, Russia) and the Federal Research Institute WSL (Birmensdorf, Switzerland) have been doing research on forest regeneration after windthrow in boreal forests of the Ural mountain range. The effects of four treatments (with and without human intervention) are being examined: 1) without clearance of the fallen trees; 2) clearance and natural regeneration; 3) clearance and planting; 4) looking at the surrounding, unaffected forest. Topics include the evolutionary dynamics of soil properties, of ground vegetation and of natural regeneration of tree species, the process of wood decay and the composition of the xylophile organisms involved in it, and the species diversity of insects, fungi and small mammals. Results will be presented for 11 years of research on the permanent study area 'Shaitanka' (18 ha) to the north of the Sverdlovsk (Ekaterinburg) Region, which was affected by a storm on June 30, 1993. Our main conclusions are that the kind of treatment strongly affects the character and intensity of forest regeneration on windthrow areas. The process of regeneration in boreal forests is characterized by a great biodiversity and is taking a more dynamic course than in managed forests of Central Europe.

**Nitrogen nutrition of boreal forest trees.** Näsholm, T., Erikson, O., Svennerstam, H. (*Swedish University of Agricultural Sciences, Sweden; torgny.nasholm@genfys.slu.se*).

Growth of boreal forests is generally limited by nitrogen supply. Hence, the amount of carbon fixed by these forests is a function of available nitrogen. Recent studies have shown that forest plants may utilize a broad range of different nitrogen sources, including organic nitrogen compounds such as amino acids. There is also data suggesting that such compounds are equally available in the soil solution as inorganic nitrogen. In the studies reported here, we present data suggesting that roots of all plants studied hitherto have a well-developed capacity to absorb all protein amino acids at rates similar to that of inorganic nitrogen compounds. Further, our data suggest that absorbed amino acids are rapidly metabolized within the root and also transported to shoot tissues. We also show that growth of tree seedlings is equal, or even higher, when inorganic nitrogen compounds are exchanged for certain amino acids during cultivation. Plants supplied with organic nitrogen may, however, allocate carbon differently compared to plants supplied with inorganic nitrogen. Thus, our data suggest that rates of absorption, metabolism and transport of organic nitrogen and inorganic nitrogen are similar but that the form of nitrogen may have a profound effect on growth allocation.

**Fertilization of boreal forest reduces both autotrophic and heterotrophic soil respiration.** Olsson, P., Högberg, P., Linder, S. (*Swedish University of Agricultural Sciences, Sweden; per.olsson@sek.slu.se*).

The large extent of the boreal forest, the large amount of carbon contained in the soil and the expected climatic warming, make the boreal forest a key biome to be understood and correctly represented in global carbon models. Separation of soil-surface CO<sub>2</sub> efflux in its component parts is difficult and a girdling experiment was initiated in northern Sweden to quantify the contributions from autotrophic and heterotrophic soil respiration. Forty-year old Norway spruce trees were girdled and fertilized, after which soil respiration, soil moisture and soil temperature were monitored in 1000 m<sup>2</sup> plots. At the time of girdling, standing stem volume in control and fertilized plots was 52 and 172 m<sup>3</sup>/ha, respectively, and mean current annual increment during the previous five-year period was 3.4 and 15.3 m<sup>3</sup>/ha/yr, respectively. In late July, the time of the seasonal maximum in soil surface CO<sub>2</sub> efflux, total soil CO<sub>2</sub> efflux in fertilized plots was 40% lower than in non-fertilized plots. Soil surface CO<sub>2</sub> efflux in girdled control plots was reduced by more than 60%, and in girdled fertilized plots by 50%, as compared with non-girdled plots.

**Water quality changes following harvesting a boreal basin, Montmorency forest, Quebec: A 10-year study.**

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Due to the short term nature of most studies, there is little information on the length of time required for recovery from stream water disturbance in the boreal forest in eastern Canada. Clearcutting 85% of a 122 ha basin, with a 20 m buffer on 66% of the main stream length, significantly increased water temperature, conductivity, pH and the concentration of suspended sediments, NH<sub>4</sub>, N-min, NO<sub>x</sub>, K, Ca, Mg, Na, Mn and Fe. A decrease of P, S and Al was observed. Limited winter data indicated little or no change for the physical characteristics and major ions except for significant increases of NH<sub>4</sub>, NO<sub>x</sub> and N-min. The maximum changes occurred within 2 years after cutting for all parameters except for NH<sub>4</sub> and pH which reached their maximum changes after three and four years, respectively. The timing of the maximum changes for the measured variables was within 1 year of that observed at Hubbard Brook and Coweeta. All values returned to their natural range within 4 years except for NO<sub>x</sub>, N-min, Mn, pH and temperature.

**Creating space for boreal forest aboriginal people in sustainable forest management.** Stevenson, M. (*University of Alberta Sustainable Forest Management Network, Canada; marc.stevenson@ualberta.ca*).

Aboriginal people and their knowledge have thus far made very little impact on, or contribution to, forest management-planning and decision-making in the boreal forest regions of Canada. The main reasons for this are the deficiencies in current systems of provincial forest tenure and policy in which Aboriginal people must participate, and which continue to challenge the exercise of their constitutionally protected rights on their traditional lands. Other reasons include a lack of appropriate institutions to incorporate Aboriginal peoples in forest planning, and an ethnocentric bias in the supremacy of western scientific and economic thought and practice. Both the Aboriginal people as well as forest managers cultured in the western scientific tradition have valuable contributions to make in planning for multiple forest use. Enlightened sustainable forest management (ESFM), is a principle whereby multiple economic, ecological and social values are managed in a manner commensurate with the needs and interests of those possessing rights to forest lands and resources. Its application will provide an opportunity for Aboriginal people to participate, meaningfully, in decision-making and forest management.

**The boreal forests: Fragmented, fragile and fabulous. Key issues and implications for sustainable management and conservation.** Teplyakov, V. (*IUCN-The World Conservation Union, and Moscow State Forest University, Russian Federation; Victor.Teplyakov@iucn.ru*).

Boreal forests occur across northern Asia, Europe and North America – with the largest proportion in Russia and Canada and smaller areas in the USA, Scandinavia, UK, Iceland and Kazakhstan. These unique ecosystems are very fragile because they occur under severe climatic conditions, yet they contain a tremendous base of natural resources. Many boreal forests have been significantly fragmented, especially in developed territories of Scandinavia, the USA, Canada and European Russia. Occurring in often remote areas of Siberia in Russia or North-West Territories in Canada, in Lapland of Finland and Sweden this fabulous ecological region is the home of many fairy tales and epics like Kalevala or Beowulf, fantasy creatures such as Santa Claus or Snow Beauty and lovely animals like Saami reindeer or Russian sable. This paper presents some of the main challenges facing boreal forests, including illegal logging, climate change, peoples' livelihood and low international recognition. Are challenges to their management due to misunderstanding of law, lack of knowledge or management skill, or a need for survival? Why do international fora rarely recognize the global importance of boreal forests? Can changes in tenure and management of boreal zone forestlands improve the sustainability of the rich resources of these regions?

**Decomposition of coarse woody debris in the boreal forest of interior Alaska.** Yarie, J. (*University of Alaska Fairbanks, USA; j.yarie@uaf.edu*).

The importance and dynamics of decomposition of coarse woody debris (logs) in forest ecosystems has been related to soil development, nutrient storage, effects on energy and nutrient availability, seedbed potential, the decomposer and heterotrophic habitat, and forest ecosystem carbon dynamics. The study was started in 1994 and over the next two years six replicate sites were established to observe log decomposition dynamics over the following 100 years. Log decomposition dynamics will be presented for *Alnus crispa*, *Betula papyrifera*, *Populus tremuloides*, *Populus balsamifera*, *Picea glauca* and *Picea mariana* in natural forested ecosystems within interior Alaska. The information to be presented will describe the initial 10-year results of log decomposition within the boreal forest in Interior Alaska. In addition a short-term time sequence will be presented for *Picea glauca* and *P. mariana* in recently burned ecosystems.

**Emerging issues for sustainable forest management**

Session organizer: Robert Deal, *USDA Forest Service, USA; rdeal@fs.fed.us*

**Changes in land use and land values affecting sustainable forest management in different countries.** Alig, R.J. (*USDA Forest Service, USA; ralig@fs.fed.us*).

In contrast forest land values under different geographic, biological, regulatory, economic and social situations, in the policy context of sustainable forest management. Allocation of land by use and cover types is a key determinant in sustainable forest management, with changes in land values providing important signals to land managers. Land valuation varies under market-oriented economies, emerging values in transition economies and administered values in countries with command economies, influenced by interactions between the environment and humans, including land ownership, use and management. Changes in forest land values can result from forest management practices, timber demand and non-market influences, such as forest regulation and forest practices regulation. Emerging issues include management for non-traditional forest-based goods and services, such as forest carbon. A key challenge is maintaining options for forest sustainability and a robust suite of benefits in the face of continuing population growth. The dynamics of forests and society, along with complex economic–environmental–social relationships, complicate efforts to attain sustainability. Potentially, many paths lead to a sustainable future, but each is associated with tradeoffs—such as different economic benefits for consumers, amounts and quality of habitat for wildlife species and living and recreational space that affect the quality of life for people.

**A new and innovative technology for production of broad-leaved forest seedlings to promote sustainable management of European forestry.** Ciccacese, L. (*APAT, Dept. of Nature Conservation, Italy; ciccacese@apat.it*), Mattsson, A. (*Dalarna University, Sweden; amn@du.se*).

The requirement for reforestation and afforestation in Europe is substantial. Almost 1900 million seedlings, mostly conifers, are today produced at European forest nurseries each year. However, the focus on biodiversity and global climatic change has shifted market interest from conifers to broad-leaved seedlings, considerable amounts of which will be required in the future. This change will have a major impact on the production technology of broad-leaved forest seedlings. Today, state of the art is to produce forest broad-leaves as bare-root seedlings sown and grown on open land. If the production should be intensified, to meet the increase in market demand, future broad-leaved production systems have to be based on a cost-efficient container concept. In a project recently concluded and funded by the European Commission, comprising research organizations and enterprises from Denmark, Italy and Sweden, a new and innovative technology was developed for large-scale production of different species of broad-leaved forest seedlings. The technology involves sowing in mini-plug container systems, germination in a closed compact multiple-floor unit not affected by outdoor climate and automatic transplanting to any optional end-container system. The new technology is cost-efficient and environmental friendly and will be introduced at forest nurseries all over Europe.

**Sustainability analysis in the context of emerging regulatory business constraints using large-area inventory, GIS and remote sensing data.** Cieszewski, C.J. (*University of Georgia, USA; biomat@forestry.uga.edu*), Zasada, M. (*Warsaw Agricultural University, Poland*), Lowe, R.C., Liu, S., Borders, B.E., Shiver, B. (*University of Georgia, USA*).

Foresters always have been trying to answer questions related to the impact of forest management on sustainability of natural resources while the notion of sustainability has been anything but definite. The current political environment dictates that according to various constraints the forest industry has to manage its forestland committing certain areas to other resource uses and socio-economic concerns than wood production. The analysis conducted in this project investigates the dynamics of balancing the environmental and economic components in order to achieve sustainability and provides new information on the



dynamics and implications of such balancing. This spatial analysis was based on stand level inventory of approximately 10 million ha of forestland in Georgia, USA, generated by pooling various ground inventory data with GIS and remote sensing data. Considered factors included various harvesting levels, intensive management practices, implementation of riparian zones and road buffers, limited harvesting area, green up and adjacency constraints and shrinking land base due to urban expansion.

**Massachusetts Woodlands Cooperative, LLC: Landowner-driven sustainable forest management and value-added processing.** Damery, D.T. (*University of Massachusetts-Amherst, USA; ddamery@forwild.umass.edu*).

The forests of Massachusetts, the 3rd most densely populated of the USA, are threatened. Decades of high-grading and the threat of conversion to alternative use present challenges for maintaining a forested landscape. Despite being 60% forested, Massachusetts imports approximately 98% of the wood fiber that its citizens consume. The Massachusetts Woodlands Cooperative (MWC) was formed to help private forest landowners manage their land both sustainably and profitably. MWC gained FSC Certification in 2003. More recently, members have benefited from Cooperative management of harvest operations, above market stumpage payments and value added processing and production, including marketing traditionally low value and small diameter material. MWC has developed a novel 'umbrella' certification protocol for FSC green certification for private forest landowners. The process, designed to make certified sustainable forest management affordable for private forest landowners, is described. Several markets have been identified for the sale of MWC products. The history of Cooperative formation is summarized. Management, membership recruitment, financing and operations are also discussed. Case studies of marketing efforts are presented. The combined challenges of promoting sustainable forest management and achieving business success while helping Massachusetts become more self-sufficient in its consumption of forest products are discussed.

**Forest ecosystem services and sustainability.** Davey, S.M. (*Bureau of Rural Sciences, Australia; stuart.davey@brs.gov.au*), Chikumbo, O. (*ENSIS, NZ; Oliver.Chikumbo@ensisjv.com*).

The subject of sustainable use and supply of forest ecosystem services will increasingly become an important science issue over the coming decades, both domestically and internationally. Modelling the environmental sustainability of forest ecosystem services is a challenging task, given complex behaviours and the interactions and different responses of various components of the environment. This paper reviews the evolution in approach to studying the sustainable use and supply of ecosystem services from production forests within one Australian forest region as a case study. Our research shows that the integration of GIS and multi-objective optimization provides a modelling framework that can aid in the balancing of use and supply of ecosystem goods and services in the context of environmental sustainability. The paper discusses the further advances that need to be made in studying ecosystem services from a complex modelling perspective. Such approaches are required to advance sustainable forest management at the regional level and ensure the ecologically sustainable use of forest biodiversity and its associated resources.

**Biological sustainability of European forests.** Freer-Smith, P. (*Forest Research UK; peter.freer-smith@forestry.gsi.gov.uk*).

It is some years now since forest decline was a major public concern in Europe and was addressed in several international research programmes. A number of internationally co-ordinated activities were initiated in the 1980s and 1990s; these delivered valuable data and contributed very significantly to our current understanding of forestry and to the way in which forestry, land-use, conservation and rural development policies have developed. The concept of sustainable development has been developed and is now of immeasurable value in forest policy. The extent to which understanding has advanced is remarkable; much has changed. On the basis of the last 20 years, it is tempting to conclude that we now have highly effective institutional frameworks and have made excellent progress both scientifically and with the science/policy interaction. There have been some clear ecosystem responses to pollutant abatements, but significant pollution problems remain and environmental/climate change represent environmental issues of overwhelming importance to forest sustainability.

**Barriers to sustainable forestry in Central America and promising initiatives to overcome them.** Galloway, G., Stoian, D. (*Tropical Agricultural Research and Higher Education Center, Turrialba, Costa Rica; galloway@catie.ac.cr; stoian@catie.ac.cr*).

In recent decades, Central America has suffered some of the highest deforestation rates worldwide. Vast tracts of forest have been converted to agriculture and pasture, encouraged by ill-designed government policies and perverse incentives. Recently, however, progress has been made towards more sustainable use of forest resources by adjusting forest policies, decentralizing forest administration and providing incentives through environmental service payments and forest certification. Valuable forest management experience has been gained by indigenous and peasant communities. Community forestry in Central America is being increasingly recognized by national governments. Examples include the community

concessions in Petén, Guatemala, and community-based forest operations in Honduras and Nicaragua. Established stakeholder networks have strengthened horizontal and vertical alliances among wood producers and manufacturers, and helped to promote both community development and forest conservation. However, illegal logging, poor law enforcement and lacking economic viability of non-mahogany based forest management still provide disincentives to the sustainable management of tropical broadleaved forests in the region. Future challenges include improved governance through decentralized forest administration, private-sector involvement and third-party certification. It is recommended that integrated supply chains of forest and wood products be developed to improve traceability and value adding.

**Progress towards ecosystem management models in New Zealand.** Griffiths, A. (*Ministry of Agriculture and Forestry, New Zealand; alan.griffiths@maf.govt.nz*).

The management of NZ's indigenous forests has undergone significant change since 1987. Since 2002 there has been no production of timber from indigenous forests owned by the Crown. Of NZ's 6.4 million ha of indigenous forest less than 1 million hectares, privately owned, are available for timber production. Early attempts to manage indigenous forests simply sought to sustain yield. With the introduction of Part IIIA of the Forests Act 1993, private forest owners are constrained in terms of scale and are required to consider amenity and natural values, to regenerate and protect their forests and to harvest sustainably within these constraints. There are knowledge gaps: how to manage podocarps that often display discontinuous replacement patterns; understanding environmental factors influencing *Nothofagus* and broad-leaved hardwood forest regeneration, recruitment, structure; and mixed species interactions. Contemporary management emphasis is towards scales of silvicultural interventions that fall within the 'typical' range of the forest's recorded disturbance history. This requires knowledge of natural disturbance patterns, gap replacement processes, natural mortality and growth. The Ministry is supporting research into projects designed to assist the development of models that recognize entire ecosystems, integrate ecological knowledge, refine quantitative management tools and ultimately modify management approaches towards adaptive ecosystem management.

**Institutions as a key factor for sustainable forest development in the Tropics: The case of Bolivia.** Guzmán Gutiérrez, R.A. (*Centro Amazónico de Desarrollo Forestal, Bolivia; rguzman@cadefor.org*).

The forest sector in the Tropics shows a general weakness of state institutions with regard to supervision, definition of policies and strategies and research. Evidence of institutional weakness is also seen in control and planning structures and in operations. The Bolivian model is based on a legal framework for the management of forests, granting of rights of use and democratic access to these rights and establishment of a regulatory system. The assignment of regulatory and supervisory functions to the Ministry of Sustainable Development, under the responsibility of the Superintendencia Forestal, form the basis for developing constancy for forest stakeholders. The administrative and financial autonomy of the Superintendencia Forestal, its independence and its clear procedures for selecting its principal authority allow for a highly technical and transparent management. The application of principles such as presentation of results, periodic dissemination of information to citizens and use of public hearings as tools of transparency are elements that strengthen the forest administration and offer legal security to forest users. In this context, the Bolivian forest management has changed its image. It has obtained 1,500,000 ha of voluntarily certified forest, allowing the application of responsible management practices, and conducting research to support such management.

**Monitoring sustainable forest management in the Pacific Rim region.** Hickey, G.M., Nitschke, C.R. (*University of British Columbia, Canada; gordon.hickey@dse.vic.gov.au; nitschke@interchange.ubc.ca*).

The Pacific Rim is rich in forest resources. It contains the world's largest contiguous forest areas, high levels of biodiversity, millions of forest dependent people and the world's leading wood product exporting and importing nations. However, due to a range of issues associated with shifting cultivation, industrialization, overpopulation, illegal logging and policy and market failures, the Pacific Rim is also experiencing high rates of deforestation and forest degradation. An important step in addressing these issues and moving towards sustainable forest management, is improved monitoring and information reporting at the local, national and international levels. This paper presents the results of an international comparative analysis designed to identify similarities and differences in sustainable forest management criteria and indicators initiatives in the Pacific Rim region. It considers the environmental, economic and social factors likely to affect sustainable forest management in the region.

**MOTTI: A tool for assessing the effects of multipurpose forest management.** Hynynen, J., Ahtikoski, A. (*Finnish Forest Research Institute, Finland; jari.hynynen@metla.fi*), Valsta, L., Mäkelä, A. (*University of Helsinki, Finland*).

Multipurpose forestry planning requires comprehensive information on the consequences of forest management. MOTTI is a stand-level decision support system for assessing the effects of alternative management regimes on wood production,

forest economics, biodiversity and carbon sequestration. MOTTI predicts stand dynamics with either statistical growth and yield models or process-based models based on the practical forest inventory data. MOTTI predicts the amount and structure of cutting removals by user-defined timber assortments, as well as biomass production by tree compartments. The development of biodiversity indicators obtained by MOTTI include accumulation of deadwood, amount and structure of different tree species and diversity of some species groups (saproxylic beetles, polypore fungi and epiphytic lichens). The financial analyses of MOTTI software operate with values entered by the user, such as silvicultural costs, logging costs and stumpage or delivery prices. Future development of costs and prices can be forecasted by specific time series models. With direct search optimization algorithms MOTTI produces stand-level optimum with regard to various goals such as maximizing net present value, total yield or carbon sequestration. The optimizing feature of MOTTI enables one to evaluate tradeoffs between competing management objectives, providing a powerful decision-support tool for multipurpose forestry.

**ENFORS 1: A European field research network building the future on the legacy of the past.** Mårell, A. (*Cemagref, France; marell@gip-ecofor.org*), Andersson, F. (*Swedish University of Agricultural Sciences, Sweden; folke.andersson@eom.slu.se*).

ENFORS (European Network for long-term Forest Ecosystem and Landscape Research, 2001–2005) is an activity within the 'European Cooperation in Science and Technical Research (COST) and has its background in MCPFE (the Ministerial Conference on the Protection of Forests in Europe) and its resolutions. ENFORS is built on a scientific framework founded on the assumption that future forest resource management needs to consider multiple spatial and temporal scales where ecosystem and landscape approaches are equally important, as well as the long-term perspective. Transdisciplinary efforts need to be developed, but not at the expense of disciplinary advances. Furthermore, ENFORS recognizes that forestry and forest research have a tradition of well-designed long-term field experiments, inventories and monitoring activities. These form an essential base for analyses of present and future problems and their solutions. Further, a closer link between policy and science needs to be developed. ENFORS has developed a European network of approximately 80 field facilities in 26 countries, and built around research infrastructure already existing. These have adopted a new facet by developing a landscape level approach. The network will serve as a baseline and contribute to the assessment of sustainable development and the environmental state of European forests.

**ENFORS 2: A research strategy towards integrated forest resource management in Europe.** Mårell, A. (*Cemagref, France; marell@gip-ecofor.org*), Andersson, F. (*Swedish University of Agricultural Sciences, Sweden; folke.andersson@eom.slu.se*).

Sustainability is today a political will at the regional, national and international level. It is a concept thought to be attainable by political instruments and adequate management. The Ministerial Conference on the Protection of Forests in Europe (MCPFE) is in this perspective the European forum and reference for European Sustainable Forest Management (SFM), which has elaborated criteria and indicators for SFM. However, a qualitative analysis by the European Network for long-term Forest Ecosystem and Landscape Research (ENFORS – COST Action E25) has shown that there are gaps between policy making and research. A research strategy is proposed where the gaps are being identified, and where means for bridging these gaps are suggested. The research strategy emphasizes a holistic approach because of the multiple spatial and temporal scales associated with the three pillars of sustainability – ecological, social-cultural and economic values. Furthermore, it is recognized that resources are scarce, and therefore, new approaches should be developed, taking advantage of existing resources.

**A working definition of sustainable forest management (SFM): Means of achieving and monitoring SFM, and opportunities gained by providing it.** Oliver, C.D. (*Yale University, USA; chad.oliver@yale.edu*), Deal, R.L. (*USDA Forest Service, USA*).

'Sustainable forest management' has evolved from emphasis on 'sustainable timber yield'. Sustainable development, the concept of intergenerational equity – or sharing – emerged to ensure activities did not shift problems to another generation. A broader perspective of 'sustainable forestry' emerged following the Rio Earth Summit of 1992, with concerns over the sustainability of many 'criteria', including timber. Because each ecosystem is unique, 'sustainable forestry' has added the concept of 'spatial equity' to intergenerational equity: that is, each ecosystem should provide its fair share of values. Those naturally small ecosystems will need to be protected; and those ecosystems that contain small intact forests because of human activities will need to be expanded. For most ecosystems, a 'triad' approach can be used, in which part of the ecosystem can be established as 'reserves', part managed for many values through 'integrated management', and – if necessary and appropriate – part managed as intensive plantations. Technologies are allowing the various ecosystems to be delineated; assessed for their 'intact' forests; allocated among reserves, integrated areas and intensive plantations; managed so that they sustain a variety of values; and monitored. When forests are managed so they can be documented as sustainable, investors will have confidence to make them much more financially valuable.

**The European dimension to forest use under the sustainable forestry model.** Paschalis-Jakubowicz, P. (Warsaw Agricultural University, Poland; [paschalis@delta.sggw.waw.pl](mailto:paschalis@delta.sggw.waw.pl)).

The model of sustainable forestry being implemented currently does not take account of existing difficulties in anticipating the expectations of Europe's future generations, when it comes to the state, appearance and diversity of future forests. The evolution of many seemingly timeless views on these matters in Europe is very profound. Economic priorities have given way to protective ones, and there has been an evolution in the direction of individual management of a forest by a given administrative (or ownership) unit. This, to some extent, limits the taking of national- or continental-scale decisions that may be of global significance. Also, there is no way to determine the limit of forest use required by an individual, or to define individual responsibility where resource utilization is concerned. There must thus be a critical assessment of the chances of a forest's fulfilling – over a given time and space – all of the functions possible. Similarly questionable is the idea that the functions in question can be balanced. The proposed new system of land use principles represents a marked widening of the conceptual scope as regards the sustainable development of forests in Europe.

**Criteria and indicators for sustainable forest management: India's role and future strategies.** Singh, A.M. (Indira Gandhi National Forest Academy, India; [arvindmsingh@yahoo.com](mailto:arvindmsingh@yahoo.com)).

At the international level, and through various conventions, treaties and processes, many countries, individually and in groups, are strongly advocating Sustainable Forest Management (SFM). It is becoming almost obligatory due to environmental and ecological reasons. Criteria are being developed across the world for enabling measurement of SFM. In order to monitor the implementation and achievement of the criteria, many indicators are being fixed. Countries not having their own criteria and indicators may be obliged to accept criteria and indicators of others. In this situation, interests of other countries will be automatically thrust on the defaulting country even if its national interests are harmed. India's role in the process of achieving SFM by the developing world is being viewed critically by the other half of the world. This paper discusses various issues related to the development of criteria and indicators, and the problems associated with making the system operational in the field.

**Conserving endangered species and sustaining livelihoods: A case study on cultivation of medicinal plants in mountain regions, India.** Singh, M. (Development consultant, India; [monikaxing@yahoo.com](mailto:monikaxing@yahoo.com)).

Medicinal plants in the Himalayan mountain region have been traditionally collected from forest areas for local use and for sale in local markets. Since the advent of herbal medicines produced by large pharmaceuticals, some of these plants have become endangered due to overexploitation and bad harvesting practices. These market chains, linking up to higher levels, are seldom known to collectors who sell the produce at very low prices, making it necessary for them to collect excess plants from forests to eke out a decent living. In an innovative program, there was an attempt to make markets work for the poor, by increasing their negotiation capacities for bargaining better livelihood and ensuring conservation in forests for three species i.e. *Aconitum*, *Sassurea lappa* and *Phicoriza*. Components of the program include cultivation, conservation, combating pre-cultivation and marketing challenges, and legal aspects. This paper analyzes the above empirically, in light of a sustainable forest management framework, as defined by the XII World Forestry Congress. Different models of marketing medicinal plants are examined and a case is made for sustainable livelihoods and conservation of these plants.

## **Changes in forest ecosystems and their implications on human health**

Organizer: Edmond Dounias *Center for International Forestry Research (CIFOR), Indonesia;* [edounias@cgiar.org](mailto:edounias@cgiar.org)

**Social learning and adaptive collaborative management: Strengthening collective action among African women to solve health, population and biodiversity problems.** Colfer, C.J.P. (*Center for International Forestry Research (CIFOR), Indonesia;* [ccolfer@cgiar.org](mailto:ccolfer@cgiar.org)).

This poster will briefly describe the ACM (adaptive collaborative management) approach that the Center for International Forestry Research (CIFOR) has taken in 30 sites over the past five years. This approach uses participatory action research to strengthen collaboration among stakeholders, build processes of social learning within communities and empower communities in interaction with policymakers. Building on CIFOR experience, Colfer will describe plans to expand the approach to focus on health and population issues in Cameroon and Zimbabwe. The central idea is that working with women is of central concern in health and population issues, for a number of interrelated reasons that impinge both on human and environmental well being. The intention is to build women's capacity for collective action through their existing health and reproductive responsibilities, working toward their broader involvement in environmental monitoring and general management.

**Rain forests and local human health: Assessing the evidence.** Colfer, C.J.P., Kishi, M., Sheil, D. (*Center for International Forestry Research (CIFOR), Indonesia; ccolfer@cgiar.org; mkishi@cgiar.org; dsheil@cgiar.org*).

We surveyed a large literature about the cultural, nutritional, disease and medicinal aspects of rainforest resources scattered across various disciplines. We are, however, dissatisfied with the state of knowledge on this topic, finding the research too often focused on narrow disciplinary concerns and neglecting closely related/linked topics. Although the interactions among people, accessibility, land use, disease, health care and so on, are vital, few studies address this broader picture; and fewer adopt a comparative or analytical approach. Many forest products, their uses and apparent significance are well documented, and forest loss and degradation appear to threaten these values. Existing research implies that people living in and around forests are often badly affected by ongoing changes. But many fundamental issues need further study: the balance, for instance, between the positive and negative effects of 'modernization' (and reduced access to forest) on forest peoples remains uncertain; how to harness traditional forest knowledge with cosmopolitan health care remains elusive; the forest-related health implications of climate change have been little considered; and others. The relationship between health and tropical forests has significant implications for the well being of forest dwelling (and other) peoples. A strongly interdisciplinary approach to research and action is needed/required.

**Medicinal plants trade: Selective demise of the most effective species.** Cunningham, A.B. (*People and Plants International, Australia; tonyc05@bigpond.net.au*).

Based on studies of medicinal plants sold in African marketplaces, this paper provides evidence to show that the trade in commercial medicinal plants poses conservation challenges. Firstly, there is overharvesting of slower growing, habitat-specific species, particularly from forest and grassland systems. Secondly, some of the most effective species are disappearing because of species-selective overharvesting. Re-introduction into small-scale local agroforestry systems can be a viable option, and an example is given in this paper of a species used to treat secondary infections resulting from HIV/AIDS which was re-introduced in SE Zimbabwe after it became extinct in the wild.

**Recapitulation of the key issues of the short presentations and cross-continent overview of potential solutions.** Cunningham, A.B. (*People and Plants International, Australia; tonyc05@bigpond.net.au*).

The goal of this presentation is to provide a synthesis of the key issues that were pointed out by the former eight speakers. The relevance of these issues will be analyzed from a cross-continent perspective and a series of potential solutions will be formulated in order to stimulate the final discussion that will follow this final presentation.

**Diet and health in transition: How the changing lifestyles of former forest hunter-gatherers highlight the consequences of biodiversity loss on human health.** Dounias, E. (*Center for International Forestry Research (CIFOR), Indonesia; edounias@cgiar.org*).

Through history, forests dwellers have had to adapt to permanent changes of forest ecosystems that, in essence, are dynamic. However, the changes that forest peoples face today are much more brutal and radical than those they have faced in the past. As deforestation, drastic modification of resource availability and the invasive influence of cash economy occur more rapidly, social, cultural, economic and political systems become increasingly difficult to accommodate. The choices made by foraging societies are no longer validated by experience, and may be costly in terms of ecological success. Diets and diseases are sensitive indicators of the ecological and cultural costs that former hunter-gatherers – like the African Pygmies and the Punan of Borneo – actually pay to get their share of modernity. In relation to human health, recent hunter-gatherers serve not only as models of how humans lived when their lifestyles and their genetic endowment were more nearly in harmony. Assessing hunting and gathering ways of life is of vital importance to general human health. The cumulative experience of foraging societies can usefully be viewed as a benchmark for present-day efforts to promote health and prevent disease, even in the world's industrialized countries.

**Health and the history of Central African forests: An evolutionary perspective.** Froment, A. (*IRD, France; Alain.Froment@orleans.ird.fr*).

Most of the evolutionary past of Man, as a primate, happened in tropical rainforest but a crucial step was the adaptation to savanna. Since then, archaeological and paleontological research has shown that open environments were more favourable to the expansion and biological success of modern humans. In the meantime, tropical rainforests were continuously inhabited by hunter-gatherers and, later, by farmers who radically modified the forest landscape. Nowadays, forest populations are made mostly of farmers. Various populations of hunter-gatherers, who chose not to shift to agriculture, are currently confronted with demographic expansions that raise the problem of availability of wild edible resources, and force them to become more sedentary. Even more threatening than food insecurity to the survival of forest people is the burden of

transmissible diseases that are particularly diverse in moist and hot ecosystems. The paper will review the health problems that forest people have experienced, and will discuss their biological consequences.

**Integrating ethno and bio-medical health care: Challenges and priorities for improving the health of forest peoples and ecosystems in Kalimantan (Indonesian Borneo) and Madagascar.** Gollin, L.X. (*University of Hawai'i, USA; lxgollin@hawaii.edu*).

If local peoples are to remain the stewards of the environments in which they live, then addressing their economic, social and health needs (well-being) is critical to conserving biodiversity. This paper presents an overview of key health challenges in remote rainforest regions of, primarily Kalimantan (Indonesian Borneo) and, secondarily, Madagascar. Seventy-percent of Kalimantan is rural; it is in these areas that health services are most deficient. Forest dwellers continue to rely on the rich diversity of their natural surroundings for primary health care. The Health Ministry has established a system of village clinics and cadres, and promotes the use of 'traditional medicine', but these efforts do not fully meet the needs of Indonesia's diverse and dispersed populations, nor take advantage of local bio-cultural resources. In Madagascar, the relationship between government and local medicine is more antagonistic. The author will present observations made while conducting ethnobotanical research in East Kalimantan and Madagascar. The talk will focus on the physiological and cultural implications of polypharmacy and women's health. Successful models for conservation health programs and recommendations for improving community health through addressing site-specific concerns and integrating local healers and 'essential' (safe and effective) botanical therapies into government health services and promotion, will conclude the discussion.

**Contribution of indigenous plant biodiversity in African and Latin American forests to food security, nutrition and health.** Johns, T. (*McGill University, Canada; tim.johns@mcgill.ca*).

Plant biodiversity as an essential component of traditional food and medicine systems of African and Latin American forest dwellers has relevance for the ongoing adaptation of people in these ecosystems to changing economic, ecological and social conditions. Fruits, nuts, leaves, roots and other plants in the diets of forest dwellers provide important nutritional complements to animal-source foods in the form of carbohydrates and micronutrients. While diverse dietary elements play other important health functions including as antioxidants or immunostimulants, forest dwellers also use plant species as the basis for medicines and sophisticated healing systems. Ethnobotanical studies have identified many important species, but analyses of plant composition or assays of medicinal functions are more slowly demonstrating the role of inter and intraspecific diversity in traditional adaptations, and the potential present and future benefits plant biodiversity offers both forest dwellers and global society. Integration of forest communities into market economies offers income opportunities including sale of food and medicinal plants to urban populations. Conversely, greater reliance on purchased commodities can adversely affect diet and nutrition of rural populations. In either case participatory research providing empirical evidence and incorporation of traditional knowledge and cultural values are key components of sound ecosystem health management.

**Impact of logging on medicinal plant demography in the Brazilian Amazon.** Shanley, P. (*Center for International Forestry Research (CIFOR), Indonesia; pshanley@cgiar.org*).

Exudates and barks from long-lived tree species are critical components of health care for rural and urban Amazonians. The majority of these medicinals are sourced from the wild. Many of the species used for barks and exudates are also valuable as timber species, being extracted for their wood. Direct extraction, collateral damage resulting from predatory logging practices and the growing incidence of fire in logged over forests, could threaten the habitat of some low density, long-lived tree species. With sufficient market incentive, might farmers invest in managing medicinal tree species? A study of five of the most valuable medicinal tree species sought to assess their vulnerability to logging and fire in frontier regions and to compare this with their potential for management in peri-urban areas. Results differ according to species' characteristics, ecology, locally perceived value, market demand and price. Findings indicate that small numbers of farmers in peri-urban areas have nascent initiatives to manage select species used for exudates such as *Parahancornia fasciculata* and *Himatanthus sucuuba*. Barks from widely used species such as *Tabebuia impetiginosa* and *Hymenaea courbaril* continue to be sourced from saw mills, show few signs of management and a potentially higher degree of vulnerability.

**Forest ecosystem change and human health: Recent knowledge, new needs and urgent risks.** Wilson, M.L. (*University of Michigan, USA; wilsonml@umich.edu*).

During millions of years, forest ecosystems have been evolving, yet the present rate of human-induced evolutionary pressures and ecological changes appears unprecedented. Serious threats to local economic growth, global ecosystem stability and human well-being have resulted. Various human health effects have appeared through diverse pathways,

including food security, air pollution, global and local climate changes, vector-borne diseases, psychological and physical activities and many other domains. Nutritional and medicinal impacts of tropical forest resources on local populations are important examples. This review is intended to consider other direct and indirect health impacts (e.g. infectious diseases, shifts to cash crops, tobacco farming, etc.). The manner in which impacts differ for people who are poor, living in urban vs. rural settings, whose jobs depend on forest resources, and through pathways that go beyond simple SES or power measures will be addressed. Other less obvious pathways that may be equally important will be considered. Such analyses should critically evaluate health implications of forest ecosystem changes by exploring how they have affected the disadvantaged throughout the world. Some forest ecosystem change effects are local, but many others are the result of globalization, and the resulting policy issues must be dealt with.

## Natural and anthropogenic disturbances – rehabilitation of forests

Organizers: Reinhard Hüttel, Werner Gerwin, *Brandenburg University of Technology Cottbus, Germany*; [huettl@tu-cottbus.de](mailto:huettl@tu-cottbus.de); [werner.gerwin@tu-cottbus.de](mailto:werner.gerwin@tu-cottbus.de)

**Returning native ecosystems after mining: An Australian perspective.** Bell, L.C., Nichols, O. (*Australian Centre for Minerals Extension and Research (ACMER), Australia*; [c.bell@acmer.com.au](mailto:c.bell@acmer.com.au); [o.nichols@acmer.com.au](mailto:o.nichols@acmer.com.au)).

Degradation of native ecosystems is recognized as a serious environmental issue throughout most of the world. In Australia, the area of natural vegetation cleared for mining purposes is small compared to some other land uses such as agriculture, but the local impact can be significant. This impact can be greatly reduced by successful post-mining rehabilitation. The Australian minerals industry, which is dominated by coal, gold, bauxite, iron ore, base metals and mineral sand operations, is scattered across a continent with a wide range of climatic zones ranging from moist temperate in the south, through hot deserts in the centre, to moist tropical in the north. Mining takes place in a wide range of forest, woodland and other ecosystems, and most mine sites aim to re-establish the native vegetation after mining. Technologies have had to be produced to ensure successful establishment and stability of these reconstructed ecosystems under often harsh climatic conditions. This paper describes some of the innovative approaches used to re-establish native ecosystems after mining, and the methods developed to assess the success of the rehabilitation.

**Comparison of soil stabilization with three-thorned acacia and iron-wood forest trees in Iran.** Habibi Bibalani, G. (*Azad University of Shabastar, Iran*; [ghhabibi@iaushab.ac.ir](mailto:ghhabibi@iaushab.ac.ir)), Majnonian, B. (*University of Tehran, Iran*; [bmajnoni@ut.ac.ir](mailto:bmajnoni@ut.ac.ir)), Adeli, E. (*Azad University of Tehran, Iran*), Sanii, H. (*Tarbiat Modares University of Tehran, Iran*).

This study was done on ruined forest in northern Iran. Research focused on the stabilization role of two species: three-thorned acacia (*Gleditsia caspica*) and iron-wood (*Parrotia persica*). Landslides occurred in this area because of clear cutting forests and inappropriate land use, including agriculture clearing and practices. The study determined that planting three-thorned acacia and iron-wood can help to control soil erosion in northern Iran. In this study, the Bishop method was used to calculate the factor of safety of slopes. This calculation was applied to two conditions: 1) with vegetation cover of iron-wood and three-thorned acacias, and 2) without a vegetation cover. Iron-wood trees were suitable to stabilize slopes of 45–60% and three-thorned acacias were suitable for slopes of 25–40%.

**Forest regeneration following logging in a community-owned New Zealand forest.** Carswell, F. (*Landcare Research, New Zealand*; [CarswellF@LandcareResearch.co.nz](mailto:CarswellF@LandcareResearch.co.nz)), Doherty, J. (*Tuhoe Tuawhenua Trust, New Zealand*; [jm.doherty@xtra.co.nz](mailto:jm.doherty@xtra.co.nz)), Richardson, S., Allen, R. (*Landcare Research, New Zealand*; [RichardsonS@LandcareResearch.co.nz](mailto:RichardsonS@LandcareResearch.co.nz), [AllenR@LandcareResearch.co.nz](mailto:AllenR@LandcareResearch.co.nz)).

The Tuawhenua Trust administers 9000 ha of hardwood-conifer (Podocarpaceae) forest in the central North Island of New Zealand. Selective logging of large individuals of the podocarp species from half of the forested area has led to an increased canopy dominance of the remaining hardwood species, particularly tawa (*Beilschmiedia tawa*). The concern of the Trust is that the podocarp species, of special cultural significance to Māori, are not regenerating in sufficient quantity to ensure a future forest of these species. One of the project goals is to suggest management options for restoration of the podocarp species as the dominant canopy species. Remaining dead logs of podocarp species are about to be salvaged, and the possibility remains of removing large individuals of tawa to provide revenue for further restoration, if it appears that canopy opening would aid the podocarp regeneration. A survey of seedling distribution in logged forest areas revealed that soil nutrients (nitrogen, carbon, phosphorus and calcium) best predicted seedling presence. Further, a restoration goal was defined through examination of the population structure of unlogged forest plots in the same area. Unlogged forest plots had more individuals in the intermediate size classes (60–150 cm dbh).

**The chemical nature of soil phosphorus in adjacent natural and plantation forests of subtropical Australia.**

Chen, C.R., Xu, Z.H., Boyd, S. (Griffith University, Australia; [c.chen@griffith.edu.au](mailto:c.chen@griffith.edu.au); [zhihong.xu@griffith.edu.au](mailto:zhihong.xu@griffith.edu.au); [sue.boyd@griffith.edu.au](mailto:sue.boyd@griffith.edu.au)), Zhang, S.L. (Northwest Sci-Tech University of Agriculture and Forestry, China).

Improved understanding of soil phosphorus (P) availability and dynamics is critical for sound environmental management of forest ecosystem impacts due to land-use changes. Adjacent natural forest (NF) and first (1R, 51 years old) and second rotation (2R, 2 years old) hoop pine plantations in south-east Queensland, Australia, were selected to investigate the effects of conversion of natural forest to hoop pine plantations and forest management (harvesting and site preparation of plantation) on the size and the nature of P pools in surface (0–10 cm) soils using chemical fractionation and solution 31P NMR analysis. Conversion from natural forest to hoop pine plantations did not substantially affect soil total P (1290, 1289 and 1190 mg P/kg for soils under NF, 1R and 2R, respectively), but significantly reduced the availability of soil P. Soil labile P (sum of solution P and NaHCO<sub>3</sub> extractable P) decreased from 125 mg P/kg under NF to 79 mg P/kg under 1R and 59 mg P/kg under 2R. But recalcitrant P pools (sum of the second NaOH extractable and residual P) increased from 504 mg P/kg under NF to 537 mg P/kg under 1R and 623 mg P/kg under 2R. The 31P NMR analysis structurally confirmed this change.

**Economic returns from environmental problems: breeding salt and stress tolerant eucalypts for salinity abatement and commercial forestry.** Dale, G. (Saltgrow Pty Ltd, Australia; [glenn.dale@saltgrow.com.au](mailto:glenn.dale@saltgrow.com.au)).

Agricultural landscapes affected by salinity typically encompass a progression from non-saline recharge areas, through areas with high water tables at risk of salinity, to saline areas ranging from land with reduced agricultural production through to salt pans and lakes. Remediation of salinity requires, in part, the targeted re-introduction of trees into these landscapes. However, the successful application of forestry on a scale necessary to achieve meaningful salinity impacts dictates that such plantations provide economic returns at least equal to that of the agriculture they are replacing. In the majority of areas affected by salinity, where rainfall is generally less than the 650 mm limit to conventional forestry and where groundwater is often saline, the objective of achieving economically viable forestry production presents a significant challenge. In 1996, Saltgrow commenced a breeding program to combine the salt and stress tolerance of *Eucalyptus camaldulensis*, with the growth rate, stem form and wood properties of *E. grandis* and *E. globulus*. This program aimed to produce trees with the potential for commercial rehabilitation of saline landscapes. Results, covering a range of site conditions from over 100 trials around Australia, are presented. The opportunity for commercial plantations, integrated with agriculture, in low to medium rainfall areas to address salinity and sustainability is discussed.

**Lead transport into Bayou Trepagnier Wetlands in Louisiana, USA.** Devall, M.S. (USDA Forest Service, USA; [mdevall@fs.fed.us](mailto:mdevall@fs.fed.us)), Thien, L.B. (Tulane University, USA), Ellgaard, E. (Deceased, formerly Tulane University, USA), Flowers, G. (Tulane University, USA).

Establishment of a petroleum refinery in 1916 near the headwaters of Bayou Trepagnier in Louisiana, USA with subsequent dredging of the bayou resulted in spoil banks containing high levels of lead (highest value 76,000 ppm). A large cypress-tupelo community (*Taxodium distichum* – *Nyssa aquatica*) abuts the eastern spoil bank of the bayou. Cores were taken from 15 baldcypress trees at various distances along a 610 m transect and a 183 m transect running perpendicular from the spoil bank into the cypress-tupelo community. The cores were cross-dated and annual rings were measured, and five year segments of the cores were prepared and analyzed for heavy metals. Lead in the growth rings of the baldcypress trees averaged 8.5 ppm from 1895–1995 along transect 1 and 7.9 ppm along transect 2. Lead in the soil along transect 1 drops off from an average of 2250 ppm (spoil bank) to about 20 ppm at 610 m. The baldcypress trees growing on the spoil bank averaged 4.5 ppm lead. The greater uptake of lead by trees in the cypress-tupelo community is discussed in terms of soil dynamics and lead isotopes and sources.

**Natural and anthropogenic disturbances.** Hüttel, R.F. (Brandenburg University of Technology Cottbus, Germany; [huettl@tu-cottbus.de](mailto:huettl@tu-cottbus.de)).

External impacts, of natural or anthropogenic origin, affect the composition, structure and function of ecological systems. From the beginning of industrialization, anthropogenic influences have caused extensive modifications of, and disturbances to, the former natural ecosystems. The term ‘disturbance’ has been used by ecologists for a long time to describe more or less severe changes of ecological systems due to external influences. Numerous research projects have been carried out focusing on the mechanisms and effects of various types of disturbances. From these studies more comprehensive definitions for ‘disturbance’ have arisen. Severe disturbance leading to a complete destruction of the original system can be of either natural or anthropogenic origin. Mining activities serve as an example of anthropogenic disturbance of great severity. Particularly, the exploitation of raw materials by way of open cast mining has resulting in extreme alterations of the former landscape. On the other hand, open cast mines ‘produce’ completely new sites (terra nova). This paper deals with a more recent approach of ‘disturbance research’ that uses severely disturbed ecosystems as case studies for understanding ecological development at the ecosystem to landscape scales.



**Wildfire effects on soil chemistry and ecosystem nutrient budgets.** Johnson, D.W. (*University of Nevada, USA; dwj@cabnr.unr.edu*).

Stand-replacing wildfire resets the clock for ecosystem development and has a major effect on the long-term nutrient budgets of forest ecosystems. Wildfire has some immediate effects on nutrient budgets and distribution because of the volatilization of some nutrients (especially nitrogen) and the conversion of other less volatile nutrients from organic and inorganic forms (especially calcium). Calculations from nutrient data for mesic forests suggests that even very infrequent wildfire could be a dominant form of nitrogen loss from the ecosystem, exceeding leaching losses by many fold. Fire may also have delayed and even more pronounced effects on soil chemistry and nutrient budgets because of nutrient uptake and cycling by post-fire vegetation (which is often quite different from pre-fire vegetation). This paper reviews the effects of wildfire on soil chemistry and nutrient budgets in forest ecosystems and illustrates them with recent studies from the Sierra Nevada Mountains, USA, where wildfire is common.

**Restoration of forest sites affected by acid deposition.** Kulhavý, J., (*Mendel University of Agriculture and Forestry, Czech Republic; kulhavy@mendelu.cz*), Lomský, B., Šrámek, V. (*Forestry and Game Management Research Institute, Czech Republic*).

Long-term acid deposition has damaged approximately two thirds of the Czech Republic's forests. Reaching 2.5–7.0 kmol H<sup>+</sup>/ha/yr, acid inputs significantly exceed the soil's capacity for neutralization, decreasing forest ecosystem resistance to other factors such as climatic changes and acidification impacts. Of particular importance are leaching of cations (particularly Ca, Mg and K), release of aluminum ions and trends to excessive N nutrition. This paper presents research results on the application of different types of magnesium (Mg) fertilizers and liming to prevent or reduce yellowing of Norway spruce. Fertilizer was applied to 13,000 ha and liming to 34,000 ha in the Ore (North Bohemia) and the Eagle Mountains (Eastern Bohemia) from 2000–2003. The application rate of liquid and powder fertilizers was 70–100 kg Mg/ha. Dolomite was applied at 3 t/ha. We conclude that significant magnesium deficiencies in needles (Mg concentration < 500 mg/kg) resulting in yellowing of the spruce stands on poor, acid soils, in high acid deposition zones can be successfully compensated by the application of powder and liquid Mg fertilizers and dolomitic limestone.

**Restoring ecological functioning to former mine sites in the wet and dry tropics.** Lamb, D. (*University of Queensland, Australia; d.lamb@botany.uq.edu.au*).

It is often difficult to restore the original biodiversity to sites disturbed by mining because of the intensity of the disturbance these sites have experienced. On the other hand, it is feasible to seek to restore the key ecological processes and functions. The problem comes in identifying the nature of these processes and developing the most appropriate ways of re-establishing them. Should we seek to simply replicate the former successional pathways that may have operated at a site, or can we accelerate these and perhaps leapfrog over intermediates stages? I explore these questions by examining the way in which rehabilitation has been carried out at three contrasting mine sites. All are located in tropical or sub-tropical localities but the annual rainfall ranges from very dry (330 mm) to very wet (> 2400 mm). The sites also vary in the frequency of opportunities for regeneration, in the relative difficulty of re-establishing various ecological processes at each site and in the nutritional problems present. These differences mean quite different approaches are needed to restore ecological functions. I shall explore some of the dilemmas faced and the differing approaches used by managers at each site.

**The role of soil seed bank in natural regeneration of tropical forest fragments with different disturbance histories.** Martins, A.M.; Engel, V.L. (*UNESP-State University of São Paulo, Brazil; andreza\_martins@yahoo.com.br; veralex@fca.unesp.br*).

Soil seed banks are described as an important mechanism for forest regeneration in tropical ecosystems. This paper investigated this role in two semi-deciduous seasonal tropical forest fragments with different disturbance histories in Botucatu, southeastern Brazil. In each study site, 40 superficial soil samples (30 x 30 x 5 cm) were taken at the end of dry season, and repeated at the end of the rainy seasons. The experiment was established in a greenhouse, were all emerged seedlings were counted and identified. After the dry season, seed density was 314 and 419 seeds/m<sup>2</sup> respectively in the soil samples from the less (site1) and more disturbed (site 2) fragments. After the rainy season, seed density was 213 and 381 seeds/m<sup>2</sup> in the soil samples from sites 1 and 2 respectively. The Shannon-Wiener diversity index was higher in site 2 in both seasons, due mainly to a higher presence of invader herbs. Non-woody taxa predominated in both fragments, but tree species were better represented in the less disturbed forest. The results suggest a higher importance of the soil seed bank for regeneration of pioneer tree species in less disturbed forest fragments.

**What is the best countermeasure to cope with mass mortality of oak trees in old natural stands?** Nakashima, T., Futai, K., Yamasaki, M. (*Kyoto University, Japan; tnakashi@kais.kyoto-u.ac.jp; futai@kais.kyoto-u.ac.jp; risei@kais.kyoto-u.ac.jp*).

The Ashiu research forest (4200ha) is located in the northeastern border region of Kyoto Pref., Japan. The altitude range is from 355–959 m. This region is located in the transition between the temperate deciduous forest zone and the warm temperate forest zone. As a result, this forest has many species of flora and fauna. Half of this forest has old natural stands that contain large trees. Mass mortalities of oak trees occurred in this forest in 2001, and tree mortality was increasing in the whole area under 800 m in 2004. According to recent studies, mass mortality is the result of *Platypus uercivorus* (Murayama) (Coleoptera: Platypodidae) which is an ambrosia beetle with *Raffaelea* sp. The mechanism of mass mortality is not clear because of the complex relationship among trees, beetles and fungus. A reliable control method is forest cutting, but that is expensive and dangerous on steep slopes. Chemical control is a concern due to the influence on the ecosystem. In this report, we discuss not only control methods and research, but also forest conservation and the impact of human activity on forest.

**Liming of forest sites in different environmental conditions of the Czech Republic.** Podrazsky, V., Ulbrichova, I., Kunes, I. (*Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz; ulbrichova@fle.czu.cz; kunes@fle.czu.cz*).

Surface liming is a widely used ameliorative treatment in mid-European forestry. Its aim is to improve soil conditions for the growth of new plantations and to prevent, or to reverse, soil acidification. Large areas were limed in the Czech Republic in the period 1978–1991, including: the Ore Mts. (62,000 ha), Jizera Mts. (8000 ha), Giant Mts. (7409 ha) and Orlicke hory Mts. (2800 ha). Liming was recommenced in 2000, with two regions having large projects: the Orlicke hory Mts. and the Ore Mts. The aim of the presented study was to evaluate the effects of surface experimental liming on the growth and development of forest tree species and on the dynamics of the uppermost forest soil layers. There are three site and pollution types, requiring different management approaches for liming: 1) radical remedial measures including liming and fertilizing are required on heavily disturbed sites with removal of humus (bulldozing), 2) good results with liming and fertilizing have been achieved on areas with low to medium acid input and relatively vital forest stands with medium decline that do not have extreme conditions, and 3) chemical amelioration is required in salvage clear-cut areas due to mortality from air pollution (immission clear-cuts) with extreme site and ecological conditions.

**Post-fire rehabilitation of Greek forests.** Raftoyannis, Y. (*Department of Forestry, TEI Lamias, Greece; rafto@teilam.gr*), Spanos, I. (*Forest Research Institute, Greece; ispanos@fri.gr*).

After severe forest fires, the land management authorities often apply post-fire rehabilitation measures intended to minimize on-site erosion and restore vegetation cover. These methods include grass seeding, log and branch barriers, mulching, tree planting and logging. Although the post-fire recovery of many types of forests has been studied thoroughly, there are very few reports on the effects of post-fire management practices on the rehabilitation of those ecosystems. An overview of studies designed to evaluate the effectiveness of post-fire rehabilitation treatments on ecosystem recovery will be presented. Field evaluation methods included ground cover, plant growth, species composition and soil erosion. Case studies included the major forest types of Greece such as *Pinus halepensis* and *Pinus brutia* forests. The ecological, managerial and financial aspects of rehabilitation methods are discussed.

**Long-term effects of fertilizers on forest soil characteristics and ground vegetation diversity.** Rastin, N., Waschkowski, J. (*HAWK, Fachhochschule Hildesheim/Holzminde/Goettingen, Germany; rastin@hawk-hhg.de*), Hamester, F. (*Goettingen, Germany; flemminghamester@hotmail.com*).

From 1981–1983, numerous environmental, soil morphological, chemical and eco-chemical parameters were investigated at 172 different sites in Hamburg, Germany. The investigations were carried out to ascertain the impacts and extent of air pollution, to assess the degree of soil acidification, damage to litter decomposition, to find out in how far the forest ecosystems in Hamburg are destabilized, and to make suggestions for necessary measures. The results showed that the forest soils are strongly affected by the deposition of acids and, partly, of heavy metals. Topsoil on more than 90% of the sites investigated showed a high degree of acidification, and more than 70% had an insufficient supply of calcium, magnesium and potassium in plants. Almost all the investigated sites had very poor ground vegetation. To maintain forest values and biological diversity, fertilization is recommended to neutralize soil acidification, to retard the solubility of heavy metals and to stimulate the development of ground vegetation. From 1982–1990 the forests were treated with different amounts and compositions of fertilizers. To ascertain whether the treatments were successful, investigations of treated sites were carried out in 1986, 1992 and 2003 on soil morphological, chemical, eco-chemical parameters and ground vegetation. The results of these investigations will be presented.

**Restoration of Mexican pinyon pine forests (*Pinus nelsonii* and *Pinus cembroides*) affected by forest fires in the northeast of Mexico.** Salinas Castillo, W.E. (*University of Tamaulipas, Mexico; wsalinas@uat.edu.mx*), Vargas Tristán, V. (*Autonomous University of Tamaulipas; vvargas@uat.edu.mx*).

The increasing frequency of forest fires in the Sierra Madre Oriental has affected thousands of hectares of forests of different species. Two hundred hectares of Mexican pinyon pine forests of the species *Pinus nelsonii* and *P. cembroides* are currently being restored in five rural communities in the Mexican State of Tamaulipas by means of direct seeding in regions that are difficult to access, but important for the spreading of germplasm. The following parameters are being evaluated: seeding density, exposure of slopes, altitude, soil type, annual survival rate and level of impact caused by forest fires in the area. Depending on the results of the project, 7750 ha are expected to be restored by direct seeding at costs lower than production costs in nurseries or traditional plantations. The communities involved in the project are being trained in the conservation of Mexican pinyon pine forests, as well as in the prevention and control of fires.

**Impact of soil heterogeneity introduced by anthropogenic disturbance on forest restoration of mine sites.** Schaaf, W. (*Brandenburg University of Technology Cottbus, Germany; schaaf@tu-cottbus.de*).

Opencast lignite mining results in severe multiple disturbances of ecosystem functions on large scales up to the landscape level. In Germany, as the world's largest lignite producer, large regions are heavily affected by these mining activities. In the Lusatian lignite mining district of eastern Germany alone, an area of 80,000 ha is characterized by overburden dumps, tailings and mining lakes due to intensive lignite mining. On 60% of this area, forests have been restored, mainly with pine and oak. The young soils of these afforested sites are dominated by a mixture of overburden substrates containing various amounts of lignite and pyrite. Typically, extensive small-scale heterogeneity is found in the chemical and physical soil properties, caused by both substrate heterogeneity and intensive amelioration measures necessary to mitigate the phytotoxic site conditions prior to planting. Using intensive field measurements, small-scale monolith sampling and soil column experiments, we investigated the degree and effect of soil chemical properties and their effects on element turnover at various scales. The heterogenic distribution of soil properties affects water and element transport in the ecosystem, element transformation and soil development. Thus, soil heterogeneity must be considered for the nutritional status and the long-term stability of afforested stands.

**Spatial root distribution and rhizosphere chemistry in Scots pine forest ecosystems on reclaimed mine sites of the Lusatian post-mining landscape.** Schneider, B.U., Baumann, K., Fischer, Th., Hüttl, R.F. (*Brandenburg University of Technology, Germany; huettl@tu-cottbus.de*).

Chemical and physical heterogeneity of ash-ameliorated lignitic mine spoils prevents trees from developing normal, deep root systems. Detailed sampling was undertaken in a 19-year old *Pinus nigra* L. stand on a forest reclamation site in the Lower Lusatian mining district. Research questions were: what sampling strategy/scale can provide maximum information on the heterogeneity of soils and roots, how do roots compensate for resource limitations from heterogeneous and shallow root distribution, and how does spatial heterogeneity in root growth affect tree growth. Results indicate that even in the intensively rooted topsoil layer, a significant soil volume is lacking any fine roots. Greenhouse experiments showed that fine roots and mycorrhizal hyphae explore the scattered, porous lignite fragments. Analysis of seedlings provided evidence that mycorrhizal hyphae increased fine roots vitality, nutrient uptake and seedling drought resistance. These findings indicate that the intensive exploration of soil micro-habitats may partly compensate for heterogeneous, shallow roots. It was assumed that the localized absence of shallow fine roots and deep root systems may not prevent interspecific tree competition. Hence, it is argued that root growth limitations will impact structure and growth of trees, leading to different stand development than naturally grown trees, unless soil development allows roots to explore the soil more intensively.

**Effect of tailing amendment on *Eucalyptus pellita* growth for rehabilitation of devastated gold mining land in PT. Aneka Tambang Pongkor, Bogor, Indonesia.** Siregar, C.A. (*Forestry Research and Development Agency, Indonesia; siregar@forda.org*), Dharmawan, I.W.S. (*SEAMEO – BIOTROP, Indonesia; wayan@biotrop.org*), Siringoringo, H.H. (*Forestry Research and Development Agency, Indonesia*).

Tailings are abundant solid wastes from gold mining process and are stored in tailings dams. Tailings contain high concentrations of lead and iron and, if not properly managed, will cause severe soil and environmental pollution. This study was designed to evaluate possibility of recycling tailings as a plant growth media for rehabilitating degraded land in gold mining concession areas through incorporation of high levels of organic fertilizer and inoculation with mycorrhizal fungi. These amendments were expected to reduce the activity of heavy metals ions. Field research employed randomized, complete block design, with three replications and treatments tested were: control tailing, tailing with charcoal and solum, tailing with dung and solum, and tailing with charcoal, dung and solum. Soil plot size was 50 x 50 x 50 cm. Toxicity tests indicated that tailing soil mixed with compost at a ratio of 3:1 by volume produced the best performance of *Capsicum annum* and *Eucalyptus pellita* seedlings. Field research shows that organic fertilizer significantly affects the growth of four-month old, one-year old and two-year old *E. pellita*. The best plant growth was observed in the tailing, dung and solum treatment at a ratio of 1:1:1 by volume.

**Simulation of forest development after open-cut mining using an agent-based model.** Su, X., Duggin, J.A. (University of New England, Australia; [xsu@metz.une.edu.au](mailto:xsu@metz.une.edu.au)).

Rehabilitation strategies after open-cut mining aim to ensure development of long-term sustainable landscapes and ecosystems. Re-colonization and rehabilitation data collected over 20 years on an overburden dump at Boggabri, NSW, Australia, together with the scientific literature, were used to simulate and predict the impact of different rehabilitation strategies on forest development and rehabilitation trajectories using an agent-based model. Floristic dynamics from seed germination, seedling emergence, species competition and community construction provided the basic information for model development. Ecosystem composition and structure were simulated over 200 years for different rehabilitation strategies using a range of soil types and species seeds mixes. The results demonstrate that vegetation development after rehabilitation is site-specific and depends particularly on the treatment after mining, with species showing a significantly different response to soil types to get communities either dominated by shrubs or trees. Where shrubland communities develop, they tend to persist for a considerable time, upwards of 80 years, with slow, marginal encroachment by trees. Suitable seed mixes, matched to the specific site conditions, allow forest ecosystems to follow successional trajectories to the desired state. The forest community surrounding the site was used as a reference to measure recovery.

**Techniques for the recovery of logged-over secondary forests Malaysia.** Ochiai, Y. (Forestry and Forest Products Research Institute, Japan; [yukihito@affrc.go.jp](mailto:yukihito@affrc.go.jp)), Azman, H., Abd. Rahman, K. (Forest Research Institute Malaysia; [azmanh@frim.gov.my](mailto:azmanh@frim.gov.my); [rahmank@frim.gov.my](mailto:rahmank@frim.gov.my)).

The techniques for natural regeneration and enrichment planting are studied in a logged-over secondary forest of tropical hill forest in Malaysia. The studies are mainly carried out on logging roads, which suffer the most severe damage by logging operations. Site positions on logging roads are classified according to the topography: level ridge, sloping ridge and lower part of the slope. Natural regeneration of seraya (*Shorea curtisii*), the dominant species in hill forests, is found on the level and sloping ridge, but not on the lower part of the slope. On the other hand, the results of enrichment planting of six *Shorea* species show that the sloping ridge and lower part of the slope are suitable sites for the quick growth. Those results show that suitable sites for natural regeneration are slightly different than that for enrichment planting. The level ridge is the most suitable for the natural regeneration. The sloping ridge is suitable both for the natural regeneration and enrichment planting. The lower part of the slope is suitable for the enrichment planting, but not for natural regeneration. The results for natural regeneration are due to the inclination of the slope and the presence of the mother trees.

## **Towards sustainable forestry – The living soil: Soil biodiversity and ecosystem function**

Organizer: Susan Grayston University of British Columbia, Canada; [sue.grayston@ubc.ca](mailto:sue.grayston@ubc.ca)

**Roots and types of ectomycorrhizae as indicators of change in forest ecosystems.** Al Sayegh, P. (ERICo Ecological Research & Industrial Cooperation Velenje, Slovenia), Grebenc, T., Jurc, D., Kraigher, H. (Slovenian Forestry Institute, Slovenia; [hojka.kraigher@gozdis.si](mailto:hojka.kraigher@gozdis.si)).

The effects of pollution (N, S and O<sub>3</sub>) and silvicultural regimes on trees and forest ecosystems were estimated by comparative biodiversity, fine root turnover and physiological studies of ectomycorrhizae (ECM) through: 1) quantification of fine roots and diversity of ECM types as *in situ* indicators in the forest stands, 2) determination and quantification of selectively sensitive or insensitive ECM types as passive monitors, 3) development of ECM on spruce seedlings, planted on the studied sites (active monitors), and 4) development of ECM or specific physiological parameters in mycorrhizal seedlings, tested in the experimental set-up as *ex situ* testers of substrate pollution or fumigation. In contrast to studies with Norway spruce, ectomycorrhizal diversity indices in natural beech stands in highly diverse co-natural forest ecosystems in Slovenia did not show significant differences. Fine root turnover and types of ectomycorrhizae in Free-Air Canopy O<sub>3</sub> Exposure systems confirm the necessity to combine root and mycorrhizal activity in studies of effects of different stress factors (O<sub>3</sub> fumigation, sun and shade) on beech plants and the role of below-ground community and processes in carbon sequestration. The presentation is part of the 5FW EU project CASIROZ (<http://www.casiroz.de/>) and contributes to COST 631 UMPIRE and COST E38 WOODY ROOT PROCESSES.

**Influence of repeated prescribed burning on soil fungal communities in a eucalypt forest in south-east Queensland, Australia.** Bastias, B.A. (University of Western Sydney, Australia; [98122628@studentmail.uws.edu.au](mailto:98122628@studentmail.uws.edu.au)), Anderson, I.C. (Macaulay Institute, UK; [I.Anderson@macaulay.ac.uk](mailto:I.Anderson@macaulay.ac.uk)), Xu, Z.H. (Griffith University, Australia; [Zhihong.Xu@griffith.edu.au](mailto:Zhihong.Xu@griffith.edu.au)), Cairney, J.W.G. (University of Western Sydney, Australia; [j.cairney@uws.edu.au](mailto:j.cairney@uws.edu.au)).

A prescribed burning experiment has been maintained at Peachester State Forest, Queensland, Australia since 1972, and comprises unburned, biennial burning and quadrennial burning treatments, each replicated as three blocks. We have

investigated the influence of the burning treatments on soil fungal communities by direct extraction of DNA from soil, polymerase chain reaction amplification of the internal transcribed spacer 1 (ITS1) region, and analysis by denaturing gradient gel electrophoresis (DGGE) and terminal restriction fragment length polymorphisms (T-RFLP). UPGMA dendrograms based on DGGE profiles of ITS1 sequences suggest that fungal communities in the upper 10 cm of the soil profile of the quadrennial burning and unburned treatments are more similar to each other than to the biennial burning treatment. Results from buried sand in-growth bags suggest a similar general pattern for fungi that were active during a 7 month period. No clear grouping according to treatment was observed in ITS1 DGGE profiles of DNA extracted from the 10–20 cm section of the soil profile or sand in-growth bags buried in this section. These data will be compared and contrasted with those obtained by T-RFLP analysis and discussed in relation to the burning regimes and soil chemical properties.

**The impact of land-use change and residue management on nitrogen transformations in forest ecosystems of sub-tropical Australia.** Burton, J., Blumfield, T., Xu, Z.H., Ghadiri, H. (*Griffith University, Australia; j.burton@griffith.edu.au; t.blumfield@griffith.edu.au; zhihong.xu@griffith.edu.au; h.ghadiri@griffith.edu.au*).

A long-term field experiment was established to investigate the influence of land-use change from native forest to plantation forest and forest management on nitrogen (N) transformations. Adjacent undisturbed native forest, a 50-year old first rotation (1R) and a 3-year old second rotation (2R) hoop pine plantations were selected for this study. The 2R site consisted of experimental plots in both windrows and tree rows in order to examine the impact of residue management on N transformations. Gross soil N transformations were traced using *in situ* incubation cores and <sup>15</sup>N stable isotope labelling. Sampling was repeated every 28 days for 18 months. Microbial biomass carbon (C) and nitrogen (N) were measured seasonally. Preliminary results show that the native forest had significantly higher total C ( $p < 0.01$ ) and total N ( $p < 0.001$ ) than all other sites. Microbial biomass C and N were significantly lower ( $p < 0.01$ ) in tree rows than at other sites. Soil extracts are currently undergoing steam distillation and <sup>15</sup>N will be determined using isotope ratio mass spectrometry. These results will be discussed.

**Species richness, functional traits and facilitation: Unraveling the role of invertebrate diversity in soil.** Chauvat, M., Wolters, V. (*Justus-Liebig-University of Giessen, Germany*).

The functional implication of the enormous invertebrate richness in soil still is an unresolved problem of ecology. Most of our knowledge on the functional implications of biotic interactions in soil still is anecdotic, making it difficult to predict the consequences of changes in species richness, resource conditions, or specific interactions. Recent evidence suggests, however, that invertebrate effects in soil relate to certain functional traits rather than to the presence or absence of a certain species. This confirms the ‘step hypothesis’ predicting that: 1) even a small share of species with key traits dramatically increases the probability of a functional effect when species disappear, 2) the loss of function is related to the variety of key traits, and 3) it is very difficult to detect a relationship between species richness and function by studying ‘random communities’ since the chance of misinterpreting the results as an ‘idiosyncratic’ relationship between species richness and function is high. Despite the rather crude approach to diversity-function relationships in soil suggested by the step hypothesis, species richness strongly affects the persistence of a function under conditions of environmental change, since the number of species performing this function determines its ecological range. Moreover, facilitation opens another backdoor for species richness, because the ‘functional strength’ of a trait very often depends on mutualistic interactions with other species.

**Mycorrhizal fungi and sustainable forestry practices.** Durall, D.M., Jones, M.D. (*University of British Columbia – Okanagan, Canada; dmdurall@ouc.bc.ca*).

Forest management affects mycorrhizal fungal communities by removing or changing host species, and by altering physical, chemical and biological conditions in the forest floor. A recent re-examination of literature on ectomycorrhizal colonization of seedlings regenerating after clearcut logging concluded that there is a major change in fungal species composition but no reduction in the percentage of roots colonized. Much less is known about the effects of partial harvesting systems, but it is clear that ectomycorrhizal and arbutoid plants left on the site can act as important sources of fungal inoculum in the regenerating stand. Such so-called ‘refuge plants’ should therefore be considered as a part of sustainable forestry practice. Less is known about the effects of forest management on mycorrhizas in tropical forests, but most studies to date have found that abundance and species richness of arbuscular mycorrhizal propagules does not change after conversion of tropical forests to pastures. This is not the case, however, for areas of tropical forest that regenerate to vegetation types that are not dominated by arbuscular mycorrhizal plants. The influence of commercial harvesting on mycorrhizal fungal communities will be compared with that of natural disturbances such as fire.

**The influence of an organic-mineral gel on the soil properties.** Fedotov, G.N., Shalaev, V.S., Pakhomov, E.I., Zhukov, D.V. (*Moscow State Forestry University; Russian Federation; fedotov@mgul.ac.ru; shalaev@mgul.ac.ru*).

Assumptions have been made about the influence on soil’s properties of the organic-mineral gel, which is between a solid and liquid phases of the soil. The aim of this paper is to present results from a study on the influence of the

organic-mineral gel's structure on the electro-conductivity, stickiness, value of the non-soluble volume, structural-mechanical properties, speed of diffusion and some other properties. For the experiment, samples from A horizons of three soils (Histosol and Spodosol from the Moscow area, and Mollisol from the Krasnodar area, Russia) as well as greenhouse media were obtained. We found that the strength of soil structure is determined not only by capillary forces, but by the strength of the organic-mineral gel structure between particles. The organic-mineral gel structure restores itself after the addition of water, and its strength increases over time. From our study we conclude: the complicity and mobility of soil properties and their variability under environmental influences are determined by variability of the organic-mineral gel's mixture and structure.

**Ectomycorrhizal ability in vitro of different isolates of *Paxillus involutus* with poplar.** Gafur, A. (PT RAPP, Indonesia; gafur@uwalumni.com), Schützendübel, A., Polle, A. (University of Göttingen, Germany).

Isolates of *Paxillus involutus* (Batsch) Fr. collected from different hosts and environmental conditions were screened for their ability to form mycorrhizal symbiosis with hybrid poplar (*Populus tremula* L. x *P. tremuloides* Michx.) in vitro. Mycorrhizal ability varied within the fungal species. Some isolates were found to form ectomycorrhiza with poplar, while others failed. Failure of some isolates to associate successfully may indicate incompatibility of the isolates with poplar. These results support the idea that the fungus has a broad variation of host range at the isolate level. All isolates grew axenically in pure culture, although their growth rate varied, with some producing more rapid and dense mycelia during growth on agar-based media. However, despite the fact that both mycorrhizal ability and growth characteristics of *P. involutus* vary among isolates currently tested, the two traits do not seem to be correlated in the fungus. This lack of correlation between the two traits of ectomycorrhizal ability and mycelial growth should enable us to use the presently described model system to study plant-fungal interactions at the physiological and or molecular levels frequently requiring compatible and incompatible isolates of the fungus with optimal growing ability in pure culture.

**Earthworm populations to assess the forest health.** Giménez, R.A., Kesten, E. (Universidad de Buenos Aires, Argentina; rgimenez@agro.uba.ar; ekesten@qb.fcen.uba.ar), Mischis, C.C. (Universidad Nacional de Córdoba, Argentina; misch@com.uncor.edu).

To evaluate the effect of management practices in forests for timber (*Populus deltoides*), we compared the abundance of earthworms in a silvo-pastoral versus forestry system at the delta of the Río Paraná (Buenos Aires, Argentina) over two years, with four replicates of field plots on pseudo gley soil. The average production of timber was 25 tn<sup>3</sup>/ha/yr, and 0.8 cows/ha for cattle. Earthworms were extracted with formalin solution and hand sorted at the beginning of the test, and again at 6, 12, 18 and 24 months. We also examined soil and climatic patterns. The earthworm species were the same three in both systems: *Aporrectodea turgida* (Eisen 1874), *A. trapezoides* (Dugès 1828) and *Octolasion complanatum* (Dugès 1828). Earthworm densities and biomass, soil pH and carbon content of soils were higher in the silvo-pastoral than the forestry system. This research validates the contribution of the silvo-pastoral system to soil health. We confirm that earthworm abundance is a forest attribute that can be used to assess the environmental impact of different management approaches and to develop better value chains from forest to forest products.

**Soil biodiversity: Is it important for sustaining soil function after harvest?** Grayston, S.J. (University of British Columbia, Canada), Addison, J.A. (Royal Roads University, Canada), Basiliko, N. (University of British Columbia, Canada), Berch, S.M., DeMontigny, L. (BC Ministry of Forests, Canada), Durall, D.M. (Okanagan University College, Canada), Egger, K.N. (University of Northern British Columbia, Canada), Jones, M.D. (Okanagan University College, Canada), Modesto (International Forest Products, Canada), Mohn, W.W. (University of British Columbia, Canada), Panesar, T.S. (Royal Roads University, Canada), Prescott, C.E., Simard, S.W., Srivastava, D.S. (University of British Columbia, Canada).

Soils contain a vast array of organisms recognized as being vital for ecosystem functioning, and yet we know very little about who they are and what they do. It is only in the last decade that we have developed the tools to study these flora and fauna. In 2004 we began a project to determine the diversity and functioning of microorganisms and fauna in forest soils, and to assess the potential of variable retention of living trees to maintain soil function after harvesting. This project brings together a unique multi-disciplinary group of researchers to apply a range of molecular and biochemical methods to quantify changes in soil organisms in response to harvesting, using the STEMS installation on Vancouver Island, Canada. STEMS is comparing the ecological, biological and socio-economic effects of seven silvicultural systems (clear-cut, uncut, group selection, patch cuts, dispersed retention and aggregated retention). This experiment allows us to examine the same soils pre- and post-harvest. Our investigations are determining how soil communities change, whether key species are lost, and if retention of green trees of different aggregate sizes and density ameliorate modifications of these communities. Changes in rates of soil processes are being concurrently measured to determine if the observed alterations in soil communities have serious consequences for soil functioning.

**Types of ectomycorrhizae on beech trees fumigated with ozone.** Grebenc, T. (*Slovenian Forestry Institute, Slovenia*), Blaschke, H. (*TUM München, Germany; blaschke@wzw.tum.de*), Jurc, D., Kraigher, H. (*Slovenian Forestry Institute, Slovenia; hojka.kraigher@gozdis.si*).

In the Kranzberg forest near Freising (Germany), a novel 'Free-Air Canopy O<sub>3</sub> Exposure' (FACOE) system has been employed for analysing O<sub>3</sub>-induced responses that are relevant for carbon balance and CO<sub>2</sub> demand of beech trees (the FACOE system is presented at <http://www.casiroz.de>). The below-ground ectomycorrhizal community was studied in doubled ambient O<sub>3</sub> concentration fumigated 60-year-old trees (5 cores per sampling), in ambient single O<sub>3</sub>-fumigated trees (2 cores per sampling), and outside the experimental set-up (2 cores per sampling). Throughout the vegetation season in 2003, five samplings were done with 270 ml soil cores (0–18 cm below ground). All roots were carefully washed and separated into non-mycorrhizal roots, and vital and non-vital ectomycorrhizae. Types of ectomycorrhizae were determined after anatomical and molecular characteristics (ITS-RFLP database and GenBank comparisons), and counted. Twenty types of ectomycorrhizae were determined in 45 soil cores containing in total 21 180 mycorrhizal root tips (less than 1% were nonmycorrhizal), representing 19% of 110,562 vital and non-vital roots. *Cenococcum geophilum* was present in all soil cores at all sampling times (26% of all vital roots). It was also more frequent in samples from plots with doubled O<sub>3</sub> concentration. Other relatively frequent types belonged to seven spp. from the genus *Russula* and five from the genus *Lactarius*.

**Effects of site conditions on the nutrient cycling of several oak stands in Korea.** Kim, D.Y. (*Sungkyunkwan University, Republic of Korea; ydkim@skku.ac.kr*), Park, H. (*Sunchon University, Republic of Korea*), Son, Y.H. (*Korea University, Republic of Korea*), Lee, M.J. (*Kangwon University, Republic of Korea*), Jin, H.O. (*Kyunghee University, Republic of Korea*).

Natural oak stands in Korea are often become established after disturbances such as fire or human land use. *Quercus variabilis* and *Q. mongolica* were the most prevalent oak species at the study sites. We investigated the effect of site conditions on nutrient cycling at several natural oak stands in Korea. Nutrient cycling data were collected from four oak stands; one urban area and three remote forest areas. The amount of nutrients distributed in vegetation and soil were in a similar range in most of the oak stands, except for one site where trees were older than 45 years. The oak stands in the urban area showed the greatest amount of nutrient input from the atmosphere, and the greatest output through leaching (particularly N). The increased level of nutrient cycling at the oak stands in urban area seemed to be due to the urban environment, including air pollution. The oldest oak stands at the Kangwon site showed the lowest amount of nutrient input and output. However, internal nutrient cycling via plant uptake and litterfall was greatest at the Kangwon site where stand biomass was greatest among the oak stands. Nutrient cycling in the oak stands was influenced by site conditions such as atmospheric deposition, soil chemical properties and microclimate.

**Interaction between different species of *Armillaria* and *Heterobasidion* from forests in the Italian Alps.** La Porta, N. (*IASMA, Italy; nicola.laporta@iasma.it*), Grillo, R., Korhonen, K. (*METLA, Finland; k.korhonen@metla.fi*).

The common occurrence of butt rot considerably reduces the economical value of Norway spruce in north Italy. The butt rot is caused mainly by *Heterobasidion* species, but also other fungi, species of *Armillaria* in particular. However, the importance of different decay fungi in causing butt-rot in the forests of Trentino is not very well known. The interaction of the *Armillaria* species—*A. borealis*, *A. cepistipes*, *A. gallica*, *A. mellea* and *A. ostoyae*—with *Heterobasidion* species—*H. annosum* s.str., *H. parviporum* and *H. abietinum*—was investigated in the laboratory on agar medium and in small stem pieces of Norway spruce. As a rule, the *Heterobasidion* species were stronger on agar medium and grew over *Armillaria*, but some *Armillaria* strains showed antagonism against *Heterobasidion*. In spruce wood, *Armillaria* did not show antagonism but protected its occupations against *Heterobasidion* with a strong pseudosclerotial plate. The ability of different *Armillaria* species to resist the aggressiveness of *Heterobasidion* decreased in the following order: *A. borealis* and *A. mellea* > *A. cepistipes* > *A. gallica* > *A. ostoyae*. The three species of *Heterobasidion* showed only slight differences in aggressiveness towards *Armillaria*.

**Behaviour of mycorrhizal fungi community associated to different mix plantation systems with native species forest restoration.** Massoca, P.E. dos S., Engel, V.L., Paron, M.E. (*UNESP, Brazil; pmassoca@yahoo.com.br; veralex@fca.unesp.br; paron@fca.unesp.br*), Parrotta, J.A. (*USDA Forest Service, USA; jparrotta@fs.fed.us*).

This paper investigates the re-colonization process of a degraded site by arbuscular mycorrhizal fungi (AMF). The study site, a forest restoration project, had been planted in 1997 with different species mixes (plantation systems). The study had three plots (50 x 50 m) within each of six treatments, including a control involving a forest fragment. Soil samples were taken in each plot (a total of 54 samples). Spore density and the rate of root colonization were determined for each sample, and these variables were analyzed with regards to the distance from the nearest forest fragment. There were no significant differences among plantation systems and no correlation with the distance from the nearest forest. Otherwise, spore density was spatially related to the former land use, being higher inside the more

disturbed microsites. Spore density in the forest fragment plots was lower or similar to those corresponding to the plantation plots established in the lesser disturbed microsites. Preliminary analysis showed a high species richness, with at least 15 different species, corresponding to approximately 10% of all known AMF species of the planet.

**Structure and function of soil microbial communities in sugi plantations and semi-natural broad-leaved forests with different landuse history.** Matsushita, M. (*Kagoshima University, Japan; kga407u@student.miyazaki-u.ac.jp*), Ito, S., Meguro, S., Kawachi, S. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp; meguro@cc.miyazaki-u.ac.jp; s-kawa@of.miyazaki-u.ac.jp*).

Stabilizing forest ecosystems through maintenance of productivity is a global concern for the sustainable forest management. In conifer plantations, structure and functions of soil microbial communities are of great interests in terms of maintaining productivity through a proper decomposition system. Establishment of monoculture stands would have strong impacts on the natural soil microbial communities. Various land uses as human disturbances also could alter the forest soil characteristics and microbial functions in terms of the long-term effects. We investigated the structure and functions of soil microbial communities in sugi plantations and semi-natural broadleaved forests in southern Japan, with different land-use histories (previously managed as coppice woodlands or meadows), to examine the long-term and current vegetation effects on soil microbiology. Phospholipid fatty acid analysis revealed the contrasting communities structure: abundant fungi in semi-natural forests and abundant actinomycetes in former coppice sites. The dominant groups were functionally related to their wood decomposition abilities. These results suggested the relatively rapid changes of microbial communities by increasing a functional group fitting to the dominant species of above ground vegetation. On the other hand, influences of former land uses could be persistent for certain functional groups, presumably under the effects of the altered soil characteristics.

**Slash burning, faunal composition and their effects on nutrient dynamics in an *Eucalyptus grandis* plantation in South Africa.** Nadel, R., Scholes, M., Byrne, M. (*University of the Witwatersrand, South Africa; ryann@gecko.biol.wits.ac.za; mary@gecko.biol.wits.ac.za; marcus@gecko.biol.wits.ac.za*).

Sustainability of commercial plantations is dependent on the conservation of soil nutrients, especially on the ancient, leached soils of the tropics. This is especially important when limited fertilization is practiced. Management practices may negatively influence nutrient availability through losses associated with the burning and removal of slash residues. In *Eucalyptus grandis* plantations in South Africa, the site is usually burned following harvest and prior to replanting, potentially causing a marked disruption of soil faunal function and nutrient availability. Soil biological processes and soil faunal composition were the focus of this study. The in situ nitrogen mineralization rates were measured in six randomly located plots—three burned and three unburned—prior to, and after a low intensity fire. Results indicate that within the burned plots the nitrogen availability was enhanced four fold within the first month following the fire. Phosphorus availability was also enhanced as a result of the burning, however these effects on nitrogen and phosphorus availability were short lived. Soil faunal diversity was low and was more markedly influenced by season than by the fire, with millipedes dominating in spring, prior to the fire, and ants dominating in summer, after the fire.

**Fungal flora of an evergreen broad-leaved forest and its change caused by urbanization.** Ochimaru, T., Fukuda, K. (*University of Tokyo, Japan; takeochi@nenv.k.u-tokyo.ac.jp*).

Forests in city and suburb areas are affected by urbanization in various ways. As fungi play an important role in material cycling within forest ecosystems, knowledge of the fungal community structure in these forests is essential for understanding urbanization effects on ecosystem function. Thus, we investigated fungal flora for three years in three forests, dominated by *Castanopsis cuspidata* var. *sieboldii*, located in sites with different urbanization levels. Site 1 was in the city area of Tokyo, site 2 was in suburban-agricultural area of Chiba city 40 km from Tokyo, and site 3 was in mountain area near Mt. Kiyosumi 100 km from Tokyo. Species richness and diversity of litter decomposing fungi showed a positive correlation with the mass of litter, and that was higher in the suburban agricultural forest than in the others. This suggested that deciduous trees, which were increased by forest management, supported these fungi in this forest. Richness and diversity of mycorrhizal fungi showed lower score in the city and the suburban agricultural forest than in a mountain forest. This suggested that urbanization effects, such as chemical changes of forest soil caused by vegetation change and city climate, may have negative effects on mycorrhizal fungi.

**The control of root rot pathogens, *Phellinus noxius* and *Rigidoporus vinctus*, in Queensland hoop pine plantations.** Pegg, G.S., Ramsden, M. (*Department of Primary Industries and Fisheries, Queensland, Australia; Geoff.Pegg@dpi.qld.gov.au*), Whan, J. (*The University of Queensland, Australia*).

*Phellinus noxius* (Corner) G. Cunn. and *Rigidoporus vinctus* (Berk) Ryv. root rots are a widespread, serious problem throughout Queensland hoop pine (*Araucaria cunninghamii*) plantations, requiring the development of effective control



strategies to limit future losses. The main source of infection for root and butt rot diseases is generally the stump from the previous rotation. Previous research indicated that control of basidiomycete root rots in the second rotation should begin with strategies being implemented in the first rotation. A reduced amount of inoculum at the end of the first rotation will reduce losses in the second. We are conducting research into the effectiveness of potential biological and chemical control agents. The use of *Tyromyces* sp. in clearfell sites and *Trametes versicolor* in thinning sites have been successful in accelerating the decay of hoop pine stumps and reducing disease incidence. A Propiconazole based compound was tested in vitro on a range of *P. noxius* isolates with concentration of 1ppm required to eliminate the fungus. Investigations are also being conducted into factors such as aspects of soil nutrients and microbial activity that may be influencing disease incidence and severity.

**The conservation of the forest microorganism diversity in China.** Piao, C., Tian, G.-Z., Li, Y., Xiao, W.-F. (*Chinese Academy of Forestry, Beijing 100091, China; cfcc@forestry.ac.cn; tiangz@forestry.ac.cn*).

National nature reserves, forested parks and natural forest protection projects in various areas of China are the main avenue for conservation of forest microorganism resources. In addition, there have been increasing funds to support secondary forest management, and areas of farm land are being replanted and returned to forests. Scientific silvicultural measures, as well as introducing beneficial microbes into forest lands, have improved microbial community structure, diversity and forest health. These practices have played key roles in the renovation and reconstruction of destroyed and deteriorating forest and ecological system. In recent years, work on culture collection, management, interchange and utilization of forest microorganism have been undertaken with support from the national scientific projects. As a result, the levels of preservation and management of the forest microorganism resource have been rising significantly. Emphasis on basic microbial research, culture collection management, forest health and its monitoring, as well as the improvement of forest ecology and environmental quality should be important tasks for conserving forest microorganism diversity in China.

**Humus forms and silvicultural systems.** Remes, J., Podrazsky, V. (*Czech University of Agriculture Prague, Czech Republic; remes@fle.czu.cz; podrazsky@fle.czu.cz*).

Silvicultural systems and their use in forestry are broadly discussed topics of the forest management today. Goals of the ‘close-to-nature’ forestry and forest management sustainability represent one tendency, while the economical pressure ‘borealization, scandinavianization’ represents the other one. The environmental impacts of the application of particular silvicultural systems (clear-cut, shelterwood, selective systems) are evaluated from the point of view of humus forms. The surface layers in higher elevation sites represent the main source of nutrients and the main part of the rhizosphere. The amount and quality of the holorganic layers, and of the uppermost mineral horizon (i.e., humus forms) are analyzed. Results are compared with the humus form variations in the Natural Reserves—forests left for natural succession. It was found that the variation in humus forms are comparable, and thus the silvicultural systems studied do not present problems for regeneration or forest ecosystems.

**Rhizoplane and rhizosphere bacteria of naturally-growing Dipterocarpaceae in central Kalimantan acidic peat soil, Indonesia.** Sitepu, I.R., Hashidoko, Y., Osaki, M., Tahara, S. (*Hokkaido University, Japan; yasu-h@abs.agr.hokudai.ac.jp; irnayuli@abs.agr.hokudai.ac.jp*).

Central Kalimantan peat forests in Indonesia hold tremendous biodiversity, and are globally important as a carbon reservoir. However, they are now under threat of desertification due to massive disturbance by human activities, including forest fire, and are in need of reforestation. The dominant element in these tropical rain forests are highly valuable Dipterocarpaceae. We investigated bacteria associated with rhizoplane and rhizosphere of dipterocarpaceous seedlings growing naturally in central Kalimantan acidic peat soil (pH ranging from 2.7–4.4), by trapping them in nitrogen-free medium. The species included *Shorea teysmanniana*, *S. parviflora*, *S. balangeran*, *S. stenoptera*, *Dipterocarpus* sp. and *Hopea* sp. Identification by 16S rRNA gene sequencing revealed, in order of appearing frequency: *Burkholderia* sp., *Enterobacter* sp., *Frateuria* sp., *Erwinia* sp., *Sphingomonas* sp., *Rhizobium* sp., *Bacillus* sp., *Stenotrophomonas* sp., *Paenibacillus* sp., *Pseudomonas* sp., *Chromobacterium* sp. and *Serratia* sp. In our previous test, *Frateuria* sp., *Burkholderia* sp., *Rhizobium* sp. and *Enterobacter* sp. isolated from acidic alluvial soil in a plantation forest near Carita, Indonesia, promoted early growth of *S. selanica* and *S. balangeran*. Functional bacteria may assist nutrient mineralization, especially during the initial seedling growth in reforestation of disturbed areas with tropical peat soil. Tests of the growth performance of Dipterocarpaceae are in progress.

**The protection forests as a resource of soil mesofauna (Acari) during re-naturalization of forests.** Skorupski, M., Strzelifski, P. (*August Cieszkowski Agricultural University, Poland; maskorup@owl.au.poznan.pl; strzelin@owl.au.poznan.pl*).

Forests cover approximately 28% of Poland. Half of the forests have been established as protection forests, mainly to protect soil or water resources, but also adjacent to urban areas. However, protection of biodiversity is dedicated

primarily to 23 national parks and over a thousand nature reserves, which cover about 1.5% of Poland. Polish forests are dominantly (77%) coniferous, but considering site characteristics, half of these forests should be replaced by deciduous or mixed stands. Presently, there is a major program to re-naturalization the forests of Poland. Unfortunately 200 years of pine monocultures have significantly changed the soil environment. This research of forest soil mesofauna, conducted in several national parks, nature reserves and industrial forests, has found that the species composition does not change quickly following a change in forest type. Species composition of mesostigmatid mites were determined and compared in protected and industrial forests. Over 300 species of mites were collected and identified in protection forests, while the biodiversity in industrial forests was much lower.

**Fine root production and turnover in two *Eucalyptus* stands in Congo.** Thongo M'bou, A. (UR2PI, Congo; [thongo\\_mbou@yahoo.fr](mailto:thongo_mbou@yahoo.fr)), Jourdan, C. (CIRAD, France; [jourdan@cirad.fr](mailto:jourdan@cirad.fr)), Epron, D. (University of Henri Poincaré, France; [daniel.epron@sbiol.uhp-nancy.fr](mailto:daniel.epron@sbiol.uhp-nancy.fr)), Nouvellon, Y., Deleporte, P. (CIRAD, France; [nouvellon.ur2pi@cg.celtelplus.com](mailto:nouvelon.ur2pi@cg.celtelplus.com); [deleporte.ur2pi@cg.celtelplus.com](mailto:deleporte.ur2pi@cg.celtelplus.com)).

Fine root turnover is an important component of net primary productivity, carbon and nutrients cycle in ecosystems. Fine root production and turnover were studied in two eucalyptus stands (4- and 6-year-old) in Congo. Estimations were obtained from the in-growth cores method from May 2002 to September 2003. Every three months, two plots were installed in the two studied stands in order to sample the entire 15-month period covered by this study. In each plot, 32 initial cores were sampled with an auger (4 cm of diameter) in horizons [0–10 cm] and [10–30 cm]. Fine roots (diameter < 2 mm) of each sample were removed from the soil and the hole was refilled with the root-free soil of the same horizon. Eight in-growth cores were then sampled in each plot after 1, 2, 3 and 5 months from initial sampling. Results showed strong fine root dynamics. Fine root production and turnover was 3.19 and 2.32 t DM/ha/yr and 3.73 and 2.73/yr within the 4- and 6-year-old stands, respectively. This high fine root turnover suggest an important organic matter return to the soil, which may contribute to the fertility conservation in the reputed chemically poor soils of the study area.

**Nematodes as indicators of biodiversity and function in forest soils.** Yeates, G.W. (Landcare Research, New Zealand; [yeatesg@landcareresearch.co.nz](mailto:yeatesg@landcareresearch.co.nz)).

Forest litter and soil may contain >10 million individual nematodes per square metre, and regionally, >400 species. Root-feeding nematodes may be pathogenic to young plants, microbial-feeding nematodes may increase turnover of the microbial pool and predacious and omnivorous nematodes represent a higher trophic level. The spatial distribution and abundance of nematode species in forests reflect soil type, soil fertility, climate, canopy and floor plant species, litter depth, forest age and management. Nematodes may be important in nurseries: they occur throughout the rooting depth of forest trees, hyphal-feeding species may influence mycorrhizae and insect-vectored *Bursaphelenchus* species are a quarantine risk. Nematode populations interact with those of other soil animals (e.g., mites, tardigrades, enchytraeids and protozoa). The diversity and abundance of the nematode assemblage makes it a useful indicator of soil condition and soil processes. Patterns of nematode distribution will be analyzed in relation to forest type, management practices, bacterial- and fungal-mediated decomposition pathways and related to aspects of both nutrient cycling and ecosystem sustainability.

**Soil biodiversity and nutrient turnover in different forest types of Central Europe.** Zechmeister-Boltenstern, S., Pfeffer, M. (Forest Research Centre, Austria; [sophie.zechmeister@bfw.gv.at](mailto:sophie.zechmeister@bfw.gv.at)), Bruckner, A. (University of Life Sciences, Austria; [Bruckner@edv1.boku.ac.at](mailto:Bruckner@edv1.boku.ac.at)), Foissner, W. (University of Salzburg, Austria; [Eva.Herzog@sb.g.ac.at](mailto:Eva.Herzog@sb.g.ac.at)), Hackl, E., Sessitsch, A. (Austrian Research Centres, Austria; [evelyn.hackl@arcs.ac.at](mailto:evelyn.hackl@arcs.ac.at)), Milasowszky, N., Waitzbauer, W. (University of Vienna, Austria; [norbert.milasowszky@univie.ac.at](mailto:norbert.milasowszky@univie.ac.at)).

Twelve investigated natural forest stands sustained a large biodiversity of soil microbes, as well as micro-, meso- and macrofauna. However, the natural forests did not always have a higher biodiversity compared to managed forests, but they contained more rare species (e.g., spiders). Microbial biodiversity was most closely linked to nutrient turnover rates. Phospholipid fatty acid determination showed that tree species had a strong effect on microbial community composition. Pine forests were rich in actinomycetes and the fungal portion of the microbial biomass was high. Nutrient turnover was restricted to a shallow humus layer and hampered by drought. Microbes showed high respiration activity. The floodplain forests contained a large portion of gram-negative and gram-positive bacteria, as well as mycorrhizal fungi. Mineralization rates were fast, and all litter was decomposed within a short time. The application of molecular methods showed that in pine forests High-G+C gram positive bacteria were prevailing. In oak and spruce-fir-beech forests, representatives of the *Holophaga-Acidobacterium* group were most abundant. Nutrient turnover rates were highest in a spruce-fir-beech forest on limestone and with sufficient soil moisture. The nitrogen cycle was closed and only small nitrogen losses due to gas emission or nitrate leaching were measured.

## **Social and cultural values of forests: benefit for today's society**

Organizer: Elizabeth Johann *University of Applied Life Sciences Vienna, Austria; elis.johann@utanet.at*

### **Cultural factors and European forests: Challenging sustainability paradigms.** Agnoletti, M. (*University of Florence, Italy*).

The 1992 UN Conference in Rio defined the word 'sustainability' for managers and policy makers. This led to the first set of indicators for Sustainable Forest Management—a 'hierarchy' of values to represent national diversity and the experience of several experts and research bodies. However, cultural and historical values of forests are only one of the 11 sub-chapters appearing in criterion #6. We believe the role assigned to this issue requires reflection to address the way forest are studied and perceived. Although decades of forest history research has demonstrated the deep and profound interrelationship between man and forests, there is little awareness that cultural values are one of the most important issues in forestry. In many countries the conservation of the structure of the forest landscape, might well be the main criteria in the planning and management of forests. The underestimation of cultural values has often led to policies pursuing an idea of sustainability based on paradigms, such as 'pristine nature' as the desirable goal, ignoring that man often created higher diversity in nature. Resolution #3 of the 2003 Ministerial conference in Vienna stated the importance of preserving cultural values, indicating that it is time to review not only the indicators, but the approaches guiding sustainable forest management.

### **Discovering common goals in sustainable forest management: The divergence and reconvergence of European and American forestry.** Anderson, S. (*Forest History Society, USA; stevena@duke.edu*), Sample, V.A. (*Pinchot Institute for Conservation, USA; sample@pinchot.org*).

From the beginning of Gifford Pinchot's education at the École Nationale Forestière at Nancy in 1889, it was clear to him that European forestry would have to be significantly adapted to the American landscape and culture. Throughout most of the 20<sup>th</sup> century, American and European forestry continued to diverge from their common root, each responding to the particular needs of their respective societies, ecology, economy and social settings. This divergence is reflected in some of the enduring forestry institutions that Pinchot helped establish, foremost among them the US Forest Service (USFS). Today, as the USFS prepares to embark upon its second century, a reconvergence is taking place between American and European forestry, as forest managers, educators and policymakers strive to comprehend the complexities of sustainable forest management. Not only must forestry professionals be concerned with sustainable wood production to meet renewable resource needs, but they must discover new ways to conserve an ever-increasing array of public values—from protecting watersheds to sequestering carbon. This paper will explore the results of an academic and professional exchange held in early 2005 as two paired international symposia, the first in France and the second in the USA, on the common roots, the divergence starting in the late 19<sup>th</sup> century and the recent re-convergence of European and American forestry.

### **Arid afforestation techniques and their conclusions in Israel.** Avni, Z. (*KKL Forest Department, Israel; tzvikaa@kkl.org.il*).

More than half of Israel's area is desert or semi-desert. Rainwater-based afforestation can be relied upon in only 20% of this arid region, known as the Negev. Since the 1940s, efforts were made to plant trees in the semi arid parts of the country. This challenge brought about the development of suitable silvicultural techniques and the introduction of prospective, drought-tolerant trees from various desert areas around the globe. Today, 'Savanization' techniques, namely, widely planted arid-type trees, are used in the Negev. Trees are planted in small patches or strips into which local runoff flows. In addition, Limans (mini catchments) are created in order to capture runoff from the upslope areas, where the average ratio between contributing areas and the Liman is 100:1. One result of appropriate arid land afforestation is the protection of the readily created gullies from further erosion, as well as regulation of seasonal grazing. As a result of years of experimentation in tree selection, introduction and improvement, the success of seedling establishment and plantation survival increased tremendously. The most promising tree species proved in the Negev are from the Eucalyptus family, African and American Acacias, along with several native Mediterranean species. The main planted tree species in the Negev are: *Ziziphus spina-christi*, *Acacia gerrardii* subsp. *negevensis* and *Eucalyptus torquata*.

### **Using archaeological evidence and oral history in negotiating Aboriginal interest in Australian regional forest agreements.** Feary, S. (*Australian National University, Australia; Sue.Feary@anu.edu.au*).

Over the last decade, indigenous communities have become stakeholders in forest management in Australia, primarily through regional forest agreement processes. They have expressed a desire for their forest cultural heritage to be protected, to participate in decision making about forest management, and to derive economic and social benefits from forests. In most states, cultural mapping is being undertaken to ensure that indigenous values are factored into reserve

designs. A cultural map can depict aspects of Aboriginal secular or sacred associations with forests by using a range of information sources including ethnography, the ethnohistoric literature, oral history, traditional ecological knowledge and the archaeological record. Obtaining this information can be problematic, and results may be used in unforeseen ways. For example, the degree to which indigenous land management practices and in particular the use of fire have modified the forest environment continues to be a highly contested issue amongst land managers, academics and policy makers. Early records of Aboriginal burning have been used selectively to support or refute arguments that advocate greater or lesser fuel reduction in publicly owned forests. Similarly, evidence of Aboriginal presence in the archaeological record can be interpreted in different ways depending on the outcome sought, and oral history can be ignored if the informant is thought not to be credible.

**The social and cultural value of the Boab Tree, *Adansonia gregorii* Muell.: Benefits and challenges of a unique resource.** Heaver, A. (University of Edinburgh, UK; a.m.heaver@sms.ed.ac.uk).

The Boab tree, *Adansonia gregorii* Muell., North-west Australia's endemic baobab, provides important social and cultural benefits for that region, resulting in special challenges for management. Boabs are an important resource for cultural expression, and craft uses include engraved seed pods or 'boab nuts' (a popular aboriginal art form, frequently sold in arts centres and exhibited in museums). Small-scale food utilization has also occurred recently, contributing to Australia's 'native foods renaissance'. Utilization adds value to the species, but requires sustainable access to healthy tree populations. As an endemic, the species is also a unique component of landscape character, and is frequently used as an amenity tree within the region's towns; specimens have been cultivated (and original trees retained) within landscaping schemes, sometimes requiring sensitive planning of new developments. Many individual trees have heritage value due to their specific historic associations. Possessing memorial, educational and tourist values, such trees can pose additional management challenges where they are present, due to public access pressures and legal requirements. Meanwhile, traditional uses, stories and beliefs contribute to the species' role in the region's folk heritage. *Adansonia gregorii* is thus presented as an important species within the region, worthy of management attention.

**The case of the Kaskaskia watershed's "Sleeping Assets": A benefits-based management application for nature-based recreation.** Leahy, J.E., Anderson, D.H. (University of Minnesota, USA; leah0024@umn.edu; dha@umn.edu), Davenport, M.A. (Southern Illinois University, USA; mdaven@siu.edu).

'Our river has sleeping assets', explained a community member from the Kaskaskia Watershed, Illinois, United States when referring to the intangible benefits his community gains from living near the Kaskaskia River. Benefits-based management is an emerging research and planning framework designed to encourage planners and managers to adopt a more holistic view of outdoor recreation areas. It helps managers identify, communicate and manage benefits that are abstract and may go unnoticed otherwise. To date, little is known about the on- and off-site benefits that might accrue to community members living near nature-based recreation areas. These 'sleeping assets' can include such benefits as increased community pride and improved quality of life. Using a mailed survey of 1,600 community residents, the study a) identified benefits desired and attained by community members, b) identified social features of the area, management and local communities that influence benefit attainment, and c) gathered community member suggestions for increasing benefit opportunities in the future. In addition to expanding benefits-based management research into the arena of tourism and non-recreation benefits, this research also applied concepts and measures of place dependency to understand community benefits associated with a nature-based recreation area.

**Construction of social and economic criteria and indicators of forest ecosystem management in Taiwan.**

Lo, S.-L., Huang, Y.-J. (National Chung Hsing University, Chinese Taipei; a2470712@yahoo.com.tw).

The purpose of this research was to develop the framework for social and economic criteria and indicators for Taiwan's forest ecosystem management which is based on the pressure-state-response model. Four economic and four social C&Is were developed that recognize circumstances in Taiwan. The economic criteria are: production and consumption, investment in the forest sector, labour and economic policy. The social criteria are: culture, science and education, public participation and social policy. There 12 economic indicators and 18 social indicators. The 30 indicators were selected through a questionnaire survey with the Fuzzy Delphi method and 'brain storming' discussions. Relative weights for the criteria and indicators were assessed through the analytic hierarchy process (AHP). The weights of the first two economic criteria were: 32.5% for investment in the forest sector, and 31.8% for production and consumption. The weights of the first two economic indicators were: 16.1% for forest values of on-consumption, and 13.3% for forestry physical labour. The social criteria had equal weights. The weights of the first two social indicators were: 9.96% for performance evaluation of talent training and education, and 9.55% for preservation and restoration of aboriginal traditions cultural relate to the forestry.

**Quantification of the impact of forestry projects on ecological balance as defined by the land:man ecological ratio.** Odsey, M.S. (*ERDS, DENR -CAR, Philippines; msodsey@yahoo.com*).

An analytical tool was developed to quantify the impact of forestry projects on ecological balance as defined by the Land:Man Ecological Ratio and the Land:Man Development Ratio in a given period of time. The Land:Man Ecological Ratio involves the measurement of how much area of forestlands are sustaining the ecological needs of each person in a certain area. The Land:Man Development Ratio involves the computation of how much land is available for the development needs (e.g., residential land needs, agricultural land needs) of a person in a certain area. The analytical tool integrates the factors of the total area of forestlands when the projects started, the total area of reforested areas, the total area of denuded lands and population. Projections are done which showed the hypothetical situations with and without reforestation interventions, in a given period of time. The formula can be further enhanced and experimented on to analyze the impact on population of other forest phenomenon such as forest fires or intensive denudation of forest areas due to development activities. In the same way, the formula can also be used to look at the impact of rising population on man's ecological needs. The possibilities opened up by the formula are only starting to be recognized.

**Forestry as rural source of employment: gender aspects.** Wonneberger, E., Lewark, S. (*University of Freiburg, Germany; eva.wonneberger@fobawi.uni-freiburg.de; Siegfried.Lewark@fobawi.uni-freiburg.de*).

Gender comes into sight when we look at the separation of work in German forestry. Traditionally, women were excluded from leading positions in state and municipal forestry institutions. In forestry work, there was a clear division of labour: men used to do the heavy work around timber logging and extraction, whereas women used to be involved in planting and tending activities. Presently, there is a complete shift in the organization and form of forest work. Simultaneously with the rapid social change in Germany, new jobs are appearing, new societal demands emerging and the importance of the classical forest worker is decreasing. The increasing recognition of leisure and tourism, pedagogic events and ecological and environmental aspects of forests and National Parks create new opportunities for jobs in rural areas. As part of an interdisciplinary research project at Freiburg University, gender differences in the state forests, at forestry service contractors and freelancers were studied. Gender separation still takes place under old and new institutional and organizational conditions. Activities and necessary qualifications changed, but women are still more involved into ecological and educational tasks, whereas wood production and administration jobs remain mainly men's work. We see opportunities for future gender equality and jobs for women in forestry because of the increasing relevance of nature appreciation and eco-education.

**Alien pests threatening biodiversity of forest ecosystems**

Organizers: Naoto Kamata *Kanazawa University, Japan; kamatan@kenroku.kanazawa-u.ac.jp*, and Kurt Gottschalk *USDA Forest Service, USA; kgottschalk@fs.fed.us*

**Pathway analysis of the risk of introducing Asian Long-Horned Beetle to landfills outside of New York City.**

Auclair, A., Fowler, G., Hennessey, M.K., Hogue, A.T. (*USDA Animal and Plant Health Inspection Service, USA; Alan.N.D.Auclair@aphis.usda.gov*), Keena, M. (*USDA Forest Service, USA*), Lance, D.R., McDowell, R.M., Oryang, D.O., Sawyer, A.J. (*USDA Animal and Plant Health Inspection Service, USA*).

The risk associated with spread of Asian longhorned beetle (ALB), *Anoplophora glabripennis* (Coleoptera: Cerambycidae), from infested areas in New York City to the wide array of landfills across the eastern United States contracted by the City since 1997 was unknown, but of great concern. Landfills, some as far as South Carolina, Virginia and Ohio, occupied forest types and climates at high risk of ALB establishment. The City proposed a separate waste wood collection, estimated to cost federal and state agencies \$6.1–\$9.1 million annually. Pathway analysis was used to quantify the probability ALB was present in wood waste collected at curbside, would survive transport, escape burial at a landfill and form a mated pair. The study found that in seven alternate management scenarios, risks are very low, especially given existing mitigations. Mitigations included chemical control, removal of infested trees and burial of wood waste in managed landfills. Changes of policy or practice, however, such as illegal dumping or disposal at a single landfill increased risk many thousand fold. By rigorously maintaining and monitoring existing mitigations, it was estimated that taxpayers would save \$75–\$122 million dollars over the next decade.

**Biological and genetical impact of the invasive seed chalcid *Megastigmus rafni* on firs stands in Europe.** Auger-Rozenberg, M.A., Kerdelhué, C., Vincent, B., Magnoux, E., Roques, A. (*INRA, France; Marie-Anne.Auger@orleans.inra.fr; Carole.Kerdelhue@pierroton.inra.fr; bruno.vincent@univ-orleans.fr; magnoux@orleans.inra.fr; Alain.Roques@orleans.inra.fr*).

Although worldwide exchange and trade of tree reproductive materials is rapidly increasing with the development of plantations using exotic tree species, little information is available about associated invaders. Such exchanges are

highly favourable to the invasion of seed-borne organisms, which are not easily surveyed because of their cryptic way of life. Exotic seed chalcids belonging to the genus *Megastigmus*, specialized in the exploitation of fir seeds, have been introduced from North America to Europe during the 20<sup>th</sup> century. Among them, *Megastigmus rafni* (Hymenoptera: Torymidae) was identified in France at the beginning of the 1990s and is now present in many stands of native firs or plantations, where it seems to displace the competing native species, *M. suspectus*. Its impact on fir seed production can be severe and natural regeneration can be deeply affected. *M. rafni* was sampled in different localities throughout its zone of introduction. We then surveyed the ecological polymorphism of this invasive species compared with that of *M. suspectus*. A molecular phylogeography was done to understand the genetic diversity and structure of the alien populations. Our results show that the populations present a weak molecular variability and a long ovipositor that may be linked with a strong invasive potential.

***Phytophthora cinnamomi*: A threat to north temperate pine forests?** Bodles, B.J.A., Chavarriaga, D., Woodward, S. (University of Aberdeen, UK; s.woodward@abdn.ac.uk).

A number of fine root pathogenic fungi, including *Phytophthora cinnamomi*, *Pythium ultimum* var. *ultimum*, *Pythium undulatum*, *P. violae*, *Fusarium sambucinum*, *Verticillium albo-atrum* and *Verticillium rexiianum* were isolated from soils taken from under Scots pine trees at five sites in north Scotland, including semi-natural forests (Glen Strathfarrar, Glen Dye, Royal Balmoral Estate) and plantations (Alves, Culbin Forest). At least two root pathogens were recovered from each forest. Morphological and molecular data strongly supported the identification of the exotic species *P. cinnamomi* from three of the sites investigated. Although the pathogens had little effect on fine roots of pine seedlings under non-stressing conditions, climate change scenarios suggest that abiotic stresses may increase in the long-term, increasing the likelihood that these pathogens could cause major effects in the future. These non-specific pathogens may persist on the roots of understory and herbaceous plants in the pine forests. The possible ecological roles of these pathogens in northern pine forest ecosystems are considered.

**Asian Longhorned beetle in Canada: Another case study in the management of invasive species.** de Groot, P. (Natural Resources Canada, Canada; Pdegroot@NRcan.gc.ca), Gasman, B. (Canadian Food Inspection Agency, Canada), Smith, M.T. (USDA-Agriculture Research Service, USA), Ric, J., Doyle, J. (Economic Development, Culture and Tourism, Parks and Recreation, Toronto, Canada), Turgeon, J. (Natural Resources Canada, Canada).

The Asian longhorned beetle (ALHB), *Anaplophora glabripennis* (Coleoptera: Cerambycidae) was discovered in Greater Toronto, Canada, in September 2003. Initial conjecture suggested that the beetle had been established for several years, that the population was very likely to increase rapidly in the next year and that eradication was possible if the response was prompt and vigorous. This paper will describe how Canada integrated the scientific, operational and public relation components into a comprehensive program to eradicate ALHB from Greater Toronto. Specifically, this paper will discuss the structure and functions of the Asian Longhorned Beetle Project Management Team, how the infestation was delineated by the establishment of zones through intensive and extensive surveys, treatment strategies and tactics for eradication, the various techniques used to monitor and survey populations in 2004 and 2005, and the communication program. A key element in the program was the establishment of several research studies aimed to improve our understanding of the spatial and temporal distribution of ALHB, population dynamics, host preference and suitability, survey method efficiency and the development of site-specific treatment strategies. This paper will also report on the current status of the research projects.

**The pine wilt disease disturbs mycorrhizal relationships thereby inhibiting pine regeneration.** Futai, K., Taniguchi, T. (Kyoto University, Japan; futai@kais.kyoto-u.ac.jp).

Pine wilt disease has been spreading across Japan, through East Asian countries and to Europe. Defoliation of dead pine trees significantly increases litterfall, leading to eutrophication of soils. To examine the effect of eutrophication on the progress of pine wilt disease, we compared the spread of pine wilt between two 20 × 20 m experimental plots placed on a coastal sand dune, supplying one plot with fertilizer, and maintaining the other as a control. Pine wilt developed faster in the plot treated with fertilizer, where mycorrhizal development of pine trees seemed to be prevented. This inhibition of mycorrhizal development might reduce host resistance against nematode virulence. We studied regeneration of *Pinus thunbergii* in the stand devastated severely by pine wilt, where *Robinia pseudoacacia* trees were becoming dominant. In *R. pseudoacacia*-dominated stands, the regeneration of *P. thunbergii* is disturbed. This may be partly due to soil disease fungi. In addition, the ratio of ectomycorrhizal root tips to total roots is very low on the pine seedling regenerated and the predominant ectomycorrhizal fungi in the stand were different from those found in *P. thunbergii*-dominated stands. These results imply that pine wilt was brought about by soil eutrophication, and invasion of the stand by *R. pseudoacacia*, thereby attenuated the relationships between ectomycorrhizal fungi and *P. thunbergii*, and reducing regeneration of pine trees.

**Exotic plantation eucalypt pests threaten indigenous Australian forest ecosystems.** Glen, M., Tommerup, I. (CSIRO Forestry and Forest Products, Australia; Morag.Glen@csiro.au; Inez.Tommerup@csiro.au), Zauza, E., Alfenas, A. (Federal University of Viçosa, Brazil; edival@ufv.br; aalfenas@ufv.br), Mohammed, C. (CSIRO Forestry and Forest Products, Australia; Caroline.Mohammed@csiro.au).

Australia has over 800 species of eucalypts. About 795 are endemic, including many of the major industrial plantation hardwood species. Threats to biodiversity of native eucalypt ecosystems include land clearing, climate change and the introduction of severe exotic pests and diseases able to deplete the genetic diversity in provenances. *Phytophthora cinnamomi*, an exotic pathogen with a wide host range, has already severely impacted the biodiversity of some native Australian eucalypt forest ecosystems. *Puccinia psidii* is a current threat which has not yet caused an incursion into Australia, but should it do so, has the potential to become established in warm, moist regions. It attacks a wide range of Australian forest eucalypts and other Myrtaceae. The movement of eucalypt germplasm and forest products and equipment from infected to uninfected regions is a major risk to native forest ecosystems in Australia and commercial plantations worldwide. Molecular diagnostic tools have been developed to screen material including germplasm for this and other potentially devastating diseases, such as *Quambalaria eucalypti* shoot disease of *Eucalyptus* and *Fusarium circinatum*, pine pitch canker. These sensitive, specific tools can be used to underpin safe germplasm movement or assist in detection of breaches and/or incursions of exotic diseases.

**Tree composition change in cool-temperate deciduous forests caused by Japanese oak wilt, a newly emerged forest pest in Japan.** Kamata, N. (Kanazawa University, Japan; kamatan@kenroku.kanazawa-u.ac.jp), Esaki, K. (Ishikawa Forest Experiment Station, Japan), Kato, K., Igeta, Y. (Kanazawa University, Japan).

Japanese oak wilt (JOW) has been known since the 1930s, but in the last fifteen years epidemics have intensified and spread to the islands' western coastal areas. The symbiotic ambrosia fungus *Raffaelea quercivora* is the causal agent of JOW, and is vectored by *Platypus quercivorus*. This is the first example of an ambrosia beetle fungus that kills vigorous trees. Mortality of *Quercus crispula* was approximately 40%, but much lower for associated species of Fagaceae, even though each species had a similar number of beetle attacks. It is likely that other oaks resistant to the fungus evolved under a stable relationship between the tree, fungus and beetle during a long evolutionary process. *Quercus crispula* was probably not part of this coevolution. *Platypus quercivorus* showed the least preference for *Q. crispula*, yet exhibited the highest reproductive success in this species. Therefore, *P. quercivorus* could spread more rapidly in stands with a high composition of *Q. crispula*. In these forest stands, tree composition changes rapidly with a high mortality of *Q. crispula*.

**Biodiversity and the invasion of novel ecosystems.** Kay, N. (NZ Forest Research Institute, New Zealand; nod.kay@forestresearch.co.nz).

The threat of invasive organisms is of major concern to agencies endeavouring to protect the integrity of indigenous and production forest ecosystems. However, the prediction of a specific organism's invasive potential has proven to be difficult. Predictors to gauge the establishment success of novel organisms have usually relied on characteristics of the potential invader. An alternative, macro-ecological approach is to assess the character of the ecosystem under threat. The role of biodiversity in the functioning of ecosystems has been at the forefront of ecological debate over the last decade. Although a poorly understood concept, biodiversity is considered of primal importance to ecosystem stability and, by supposition, ecosystem resilience to disturbance or invasion. The theory of island biogeography has long perpetuated a concept of the invasibility of island ecosystems and ecosystem simplicity has been construed as vulnerability to disturbance. However simple ecosystems, such as bogs, boreal forests and oceanic islands, are stable and persist in the absence of man. Using examples from the establishment of exotic organisms in novel, principally island ecosystems, it can be shown that alternative predictors of invasibility are available. An explanation of the role of biodiversity in elucidating predictors of establishment and host range expansion is postulated.

**Genetic structure of *Ips duplicatus* populations from Europe and Asia.** Lakatos, F. (University of West-Hungary, Hungary; flakatos@emk.nyme.hu), Grodzki, W. (Forest Research Institute, Poland; zxgrodzk@cyf-kr.edu.pl), Zhang, Q.-H. (Sterling International Inc., USA; zhangq@ba.ars.usda.gov), Stauffer, Ch. (University of Natural Resources & Applied Life Sciences (BOKU), Austria; christian.stauffer@boku.ac.at).

The distribution of the double spined spruce engraver beetle, *Ips duplicatus* (Sahlberg, 1836) (Coleoptera, Scolytidae), ranges from Scandinavia and northeastern Europe to Northern Asia. *I. duplicatus* has been recently reported in central Europe, where the species has become an important pest in the southern part of Poland, the Czech Republic, Austria and Slovakia. *I. duplicatus* usually occurs together with *I. typographus* on Norway spruce, *Picea abies*, and due to morphological similarities and similar gallery construction, the damage and significance of *I. duplicatus* are often underestimated. The aim of this study was to compare native *I. duplicatus* populations from northern Europe, central Europe and Asia by genetic means using analysis of the mitochondrial DNA. Individuals of *I. duplicatus* populations were

collected from China, northern Poland, Russia, Sweden (autochthonous range) and the Czech Republic, southern Poland and Slovakia (allochthonous range). A fragment of the mitochondrial DNA (COI gene) was screened and sequence divergence was found between the populations from China and central Europe, confirming the differences in the pheromone production and reaction behaviour of the two groups.

**Alien pest species as players in the game of forest succession.** Liebhold, A., Gottschalk, K. (*USDA Forest Service, USA; aliebhold@fs.fed.us; kgottschalk@fs.fed.us*).

Given the trend of escalating globalization, increased numbers of alien pests are inevitable and can be expected to be one of the dominant influences in the world's forest ecosystems over the next century. When considering the likely impacts of these invaders, it is necessary to consider more than just effects on forests as they currently exist, but to regard forests as dynamic systems and evaluate the role that invaders play in altering long-term forest succession processes. In some cases we can observe that invaders may cause spectacular short-term impacts (e.g., high levels of tree mortality), but if these effects mimic disturbances caused by pre-existing, natural disturbance agents then their effect on long-term patterns of forest dynamics may be minimal. In contrast, other alien species may induce changes to forest ecosystems, unlike any pre-existing disturbance agents, and these impacts may destabilize natural cycles of forest dynamics, ultimately leading to drastic changes in ecosystem properties and ecosystem services. We illustrate these varying roles played by alien invaders using examples from eastern North America.

**Detecting new and emerging pests of eucalypt plantations in Queensland: the value of systematized forest health surveillance as a management tool.** McDonald, J., Lawson, S. (*Department of Primary Industries and Fisheries, Queensland, Australia; janet.mcdonald@dpi.qld.gov.au; simon.lawson@dpi.qld.gov.au*).

Systematized forest health surveillance has been carried out in eucalypt plantations in southeast Queensland since 2000. Surveys are carried out using two main methods: drive through and walk through. When severe problems are detected, intensive monitoring of pest damage and their effects on growth in targeted plantations is carried out by establishing medium-term monitoring plots in which crown damage index (CDI) and growth parameters are assessed, and by using the newly established national standard for CDI assessment. These results feed directly into hardwood research programs. Call outs from plantation managers and operational staff also forms part of the surveillance. The disparate nature of the plantation resource in southeast Queensland means that not all plantations can be visited yearly. Since surveys have been carried out, a number of new and emerging pests have been detected. These include an eriophyoid mite (*Rhombacus* sp.) causing severe damage to spotted gums, a plate-galling wasp (*Ophelimus* sp.) on western white gum, *Creiis lituratus* psyllids on Dunn's white gum, and leafblister sawfly (*Phylacteophaga* spp.) on a number of hosts. Spatial analysis of the distribution and severity of damage by the eriophyoid mite is illustrated and data on damage caused by the other emerging pests provided.

**The development of a DNA-based detection system for western gall rust.** Ramsfield, T.D. (*Forest Research, New Zealand; Tod.Ramsfield@forestresearch.co.nz*), Vogler, D.R. (*USDA Forest Service, USA; dvogler@california.com*).

Western gall rust (*Peridermium harknessii* syn. *Endocronartium harknessii*) is a serious threat to exotic *Pinus radiata* forests in New Zealand. As the pathogen is not present in New Zealand and because of the long period of time between infection and spore production, a DNA-based marker has been developed that is able to detect the presence of pathogen DNA within galled tissue prior to sporulation. Initially, the DNA-based system was targeted at the internal transcribed spacer region of the ribosomal DNA and a marker was developed that could detect western gall rust within *Pinus radiata* but the marker could not distinguish *P. harknessii* from its close relative *Cronartium quercuum*. In order to increase the specificity of the marker system, the intergenic spacer region of the ribosomal DNA of *E. harknessii* and all four formae specialis of *C. quercuum* was sequenced and compared. This allowed the development of a marker system that was able to distinguish *E. harknessii* from all *C. quercuum* formae specialis with the exception of *C. quercuum* f. sp. *banksianae*. IGS sequence alignment has been used to construct a phylogeny to compare *P. harknessii* and *C. quercuum*.

**Introduced *Eucalyptus* psyllids in Brazil.** Santana, D.L. de Q. (*Embrapa Florestas, Brazil; dalva@cnpf.embrapa.br*).

In spite of the countless phytosanitary barriers and millions of dollars invested in the early detection, pest introductions are frequent in different countries. Forest pest introductions such as the gypsy moth, the Chinese beetle and the woodwasp required a great amount of resources to reduce the damage caused by them. In the last ten years four species of psyllid were detected in eucalyptus in Brazil: *Ctenarytaina spatulata* in 1994, *Blastopsylla occidentalis* in 1997, *Ctenarytaina eucalypti* was introduced from the USA in 1990 (requiring the introduction of a specific parasitoid to minimize damage). In Brazil, it was detected in 1998 and the parasitoid, *Psylaephagus* sp, in the following year. *Glycaspis brimblecombei* was introduced in June of 1998 in the USA; Mexico, 2000; Chile, 2002. In Brazil, it was detected in June of 2003, in São Paulo. Now it has spread to Minas Gerais, São Paulo, Paraná and Goiás states. The



parasitoid *Psyllaephagus bliteus* was detected in the same year. With the detection of this parasitoid it is hope that the population of this psyllid will stabilize.

**No place to hide: Invasion by a non-native pathogen.** Schoettle, A.W. (*USDA Forest Service, USA; aschoettle@fs.fed.us*).

High-elevation white pines are among the oldest and most majestic pines in North America. They define the most remote alpine-forest ecotones in western North America yet they are not beyond the reach of a non-native pathogen. White pine blister rust, a native of Asia, was introduced into northwestern North America in 1910 and continues to spread through white pine ecosystems. Genetic resistance to this lethal pathogen is low (<5%), therefore accommodation will require sustained selection and establishment of rust-resistant pine genotypes. This process will require multiple pine generations and a considerable amount of time for these slow growing species. Given the known unique ecological roles played by these species, tree mortality and reduced regeneration success caused by blister rust will have a cascading effect on biodiversity. A synthesis of current knowledge will assess: 1) the potential long term consequences of this disease on ecosystem biodiversity and sustainability, 2) the prospects for successful intervention to restore ecosystem biodiversity and function in impacted areas, and 3) in those areas not yet impacted, the prospects for proactive management to sustain critical ecological interrelationships and preserve biodiversity during naturalization.

**Vertebrate invasion and biodiversity of New Zealand forests.** Stewart, G.H. (*Lincoln University, New Zealand*).

Although New Zealand lacks native terrestrial mammals (except for 2 species of bats), more than 50 species of mammals have been introduced, and over 30 species have naturalized since the late eighteenth century. The native vegetation has been severely impacted by mammal browsing, but the degree to which natural processes are being impaired is highly variable. In this paper I examine the effects of introduced browsing mammals on forest dynamics and patterns of diversity.

## **Linking experience with disciplinary science to address sustainable forest management's greatest need—reliable prediction**

Organizer: Peter Attiwill *University of Melbourne, Australia; attiwill@unimelb.edu.au*

**Native forests: Science and government policy in Australia.** Adams, M.A. (*University of Western Australia, Australia; adamsma@cyllene.uwa.edu.au*), Attiwill, P.M. (*University of Melbourne, Australia; attiwill@unimelb.edu.au*).

By the time of this conference, the area of native forests logged each year will either be close to zero or in significant decline in every state. In part that decline is predicated by long-term planning at the state level – planning that also included an *increase* in logging in future years as regenerating forests mature. However most of the decline is the direct result of political, as opposed to scientific, decisions. In the present environment it seems unlikely that any Australian state government will take the political risk of increasing logging, irrespective of the state of either the forests or the science. Here we discuss what we believe to be an unsustainable policy position. Internationally, many of Australia's nearest less-developed neighbours continue to supply wood from native forests to satisfy growing demand, including demand from Australia. While the Australian Federal Government seeks to help neighbouring countries prevent exploitation of their forest resources, Australian State Governments increase the pressure for exploitation by reducing supply from Australia's native forests. Short-rotation plantations are seen as the practical and political solution. Nationally, water yield from forests will be perhaps the single most important natural resource issue for state governments for the foreseeable future. Fires also pose a huge risk for state governments and much of the catchments in the southern half of Australia are now heavily loaded with fuel and impossible to protect completely from fire – even if that were scientifically desirable. Water yield will plummet catastrophically in the decades after major fires in catchments. We urge politicians to show leadership and adopt the precautionary principle. Overwhelmingly, we know that both logging and fires preserve biodiversity, ecological values and water yield. We have almost no evidence that stopping (or trying to stop in the case of fires) these activities will not have serious social, ecological and economic implications for future generations.

**A Bayesian framework for model parameterization: a scientific approach for inclusion of different sources of knowledge in model predictions.** Astrup, R., Larson, B. (*University of British Columbia; Astrup@interchange.ubc.ca; bruce.larson@ubc.ca*).

A prevailing predictive tool in forest management is computer simulation. Current models are often both complex and process orientated. Consequently, model parameterization can be very complicated, expensive and laborious. Data required

for model parameterization are often not available or are weak. Consequently, model developers often collect and select data from different sources and combine them to achieve the required set of parameters. Thus, the model becomes an expert system. This approach often works well, but it is non transparent and the assumptions behind the different choices of data are rarely stated. Consequently, it is difficult for outsiders to contest or trust model predictions. Here we present a framework that facilitates transparent and systematic combination of data from different sources into parameters for a simulation model. The framework is created with Bayesian methods where sources of existing data or expectations can be combined with newly-collected data to determine parameters for which there is greater cumulative evidence. The framework allows researchers to place greater trust in selected sources of information. This framework combines data as is done by many model developers, but it forces assumptions and decisions about data sources to be transparent. Consequently, the modeling process becomes more trustworthy and scientific.

**Predicting dieback in US forests: Concepts and application of a forest health decision support system.** Auclair, A. (*USDA Animal and Plant Health Inspection Service, USA; Alan.N.D.Auclair@aphis.usda.gov*), Heilman, W.E. (*USDA Forest Service, USA*).

There are important reasons to predict accurately the onset and progression of forest dieback episodes in the United States and elsewhere. These include extensive on-going dieback and the expectation of increased levels as climate becomes warmer, drier and more variable. The wealth of new spatial information in the US Forest Health Monitoring Program (FHMP) on the incidence of symptoms and on inciting factors has enabled us to develop and calibrate an early warning predictive landscape-level model of risks to forest dieback. The test model is based on a series of risk indicators using dieback etiology, stand species composition, age and structure, site conditions (soils, aspect, catena), and high resolution, real-time temperature and precipitation (i.e., daily) data at 850 weather stations across the north-eastern USA. Plotted in ArcInfo GIS, maps will form part of the Agency's Forest Health Decision Support System available on the Web to assist managers in identifying areas at risk and options for timely intervention and treatment. Feedback over time from the continual stream of new FHMP data and, from new applications of the model, is expected to significantly improve mapping resolution and indicator efficacy. Limitations as a decision tool and the potential for wider use across other forest regions will be discussed.

**Science and sustainable forest management: An Australian perspective.** Davey, S.M. (*Bureau of Rural Sciences, Australia; stuart.davey@brs.gov.au*).

Over the last decade science has played an increasingly important role in sustainable forest management in Australia. Science has had an important role in the development of Australian regional forest agreements, development and reporting of sustainability indicators, design of the Australian Forest Standard, understanding and application of sustainable forest management in terms of forest practice, systems and processes and in application of the ecosystem approach to Australian forests. This paper describes how science has influenced these processes and the role it has played in improving sustainable forest management in Australia. To further strengthen sustainable forest management in the future will require science to become more integrated and evidence relevant, so that it can be used more effectively and efficiently in evidence-based (science-based) decision making for environmental and resource management of forests and its associated goods and services. Particularly important will be the further development of systems that can assist in monitoring, reporting and predicting the sustainability of forest-related values associated with sustainable forest management.

**Interactive forest growth models: a new paradigm for integrating science and forest management.** Hauhs, M. (*University of Bayreuth, Germany; michael.hauhs@bitok.uni-bayreuth.de*).

Forest growth modeling is perceived as applied science. Scientific process-level understanding is scaled to the management unit level. Results of such modeling are expected to provide predictions for ecosystem fluxes or pools, reflecting the modeling paradigm of dynamic system theory typical of physics. Its successful applications include complex non-living (geo)-systems such as the atmosphere. However, to our knowledge, no case exists where it produced a non-trivial correct prediction in forest ecosystems relevant for managers in the sense of substituting lack of experience. This is usually taken as indicative of ecosystem complexity. Foresters often reject such a 'rigorous' process-based approach—experience remains a superior source of knowledge. However, interactive modeling is more appropriate to forestry because the issues can be resolved through interaction rather than complexity. In forest growth modeling it may become a 'dual' with respect to the algorithmic paradigm of dynamic system theory. In this light, experience from interaction with a forest ecosystem under novel boundary conditions remains unpredictable in principle. However, what interactive models can do is to document, disseminate existing experiences in much more efficient ways, and support valuation and decision making without invoking predictions. Interactive platforms provide a basis to value the environmental benefits of forests. Sustainable forest management is suggested as a case in which principle limits of modeling may exist in the sense of basic sciences.

**Science to assist forest management in New Zealand.** Mason, E., Sands, R. (*University of Canterbury, New Zealand; roger.sands@canterbury.ac.nz*).

We agree with others that isolated and unconnected pieces of reductionist research, no matter how well done, have not always helped, and have sometimes hindered, predicting the behaviour of complexities such as forest ecosystem management. We agree that development and use of ecosystem management and social value models is the logical and best way to proceed. This does not mean though that superior quality predictive models necessarily will determine practice. For example, the forestry sector in New Zealand is strongly polarized. Virtually all of the timber production (>99%) comes from plantations of almost one species (*Pinus radiata*). All of the government-owned indigenous forest (83.5% of total) is 'preserved' with no semblance of forest ecosystem management permitted, and the majority of this forest continues to decline under the influence of exotic pests. This was a socio-political decision in which science was either ignored or twisted to serve a political end. The challenge is not only to produce more convincing models but to improve the image of science in the community. We will outline the progress, or otherwise, of the development of 'science to assist forest management' in New Zealand and the current position in the development of predictive models.

## **Impact of exotic invasive plant species on the forest ecosystems**

Organizer: Ravinder Kohli *Panjab University Chandigarh, India; rkkohli45@hotmail.com*

**Using herbicides to remove exotic grasses and restore native grasslands in the eastern USA.** Barnes, T.G. (*University of Kentucky, USA; tbarnes@uky.edu*).

Globally, grasslands are among the most threatened ecosystems. More than 97% of the tall-grass prairie of eastern North America has been destroyed and in some states less than 0.1% of the original acreage still exists. In Kentucky, 7 of the 12 rare plant community types in peril are grasslands. Many grassland communities occur in small forest openings and need to be managed differently to protect their unique plant and animal resources. This paper summarizes more than a decade of research on removing the exotic grasses tall fescue in the southeastern and mid-western states, common Bermuda and bahiagrass in the southeastern states, quack grass in the northern and Great Plains regions, smooth brome and reed canary grass in the northern Great Plains and old world bluestems along the coast of Texas. New selective herbicides are used to remove exotic grasses from remnant native grasslands with a single spring application. In some cases, seeding is dictated because there are few native species in the existing grassland community. I will summarize information eradication of the exotic species and seeding of native species. The results of various studies have provided standardized protocols on timing and rates of various herbicides that result in significant reductions in exotic grasses.

**Woody invasive species in the Argentine "pampas" edaphic forest.** Boffi Lissin, L.D., Filloy, J., de Urquiza, M., Ruiz Selmo, F. (*Universidad de Buenos Aires, Argentina; lucilabl@medioambiente.gov.ar*).

In the Argentine 'pampas', one of the few native forests is that dominated by *Celtis tala* and *Scutia buxifolia*. The 'talares' are associated with calcareous soil shaped by the quaternary period marine incursions. This woody community is invaded by the Asiatic *Ligustrum lucidum* and *Ligustrum sinense* and the North American *Gleditsia triacanthos*. These Asiatic species are recognized as invaders in Australia, New Zealand, Europe and North and South America. We studied the invasive species, comparing them with the native ones. We studied fruit production, seed dispersal, seedling emergence, establishment, and juvenile and adult growth and mortality. We found that the invasive species have significant higher rates of almost all the variables studied than the native species, and that there is a certain synergism between *L. lucidum* and *G. triacanthos*. Land use, especially cattle pasturing, modifies the invasion pattern and also the invasion rate. The rapid growth and spread of the exotic species are changing both ecosystem structure and function. Nowadays, though we still call these forests talares, *L. lucidum* is the most abundant species in the area. Finally, we propose a management program to control the invasion process that includes an easy checklist to make a quick diagnosis in the field of the degree of invasion.

***Phytophthora ramorum* surveys in Pacific Northwest Christmas tree and bough production areas.** Chastagner, G.A. (*Washington State University, USA; chastag@wsu.edu*), Osterbauer, N. (*Oregon Department of Agriculture, USA; nosterba@oda.state.or.us*), Falacy, J. (*Washington State Department of Agriculture, USA; jfalacy@agr.wa.gov*).

*Phytophthora ramorum* is the recently identified exotic pathogen that causes sudden oak death and ramorum leaf blight and/or shoot dieback on over 60 host plants. Douglas and grand fir are natural hosts of this pathogen under certain conditions in California. In addition, a large number of conifers, including noble fir, have been shown to be susceptible to this pathogen in laboratory studies. During the past two years there has been increased concern about the potential disruption of shipment

of Christmas trees and boughs from the Pacific Northwest because of potential quarantines relating to this pathogen. About one third of the 25 million Christmas trees produced annually in the USA come from western Oregon and Washington. Douglas-fir, noble fir and grand fir account for 55, 36 and 5% of the production, respectively. In addition, about 20,000 tons of noble fir boughs are harvested from natural stands of trees in the Cascade Mountains. During 2004, 669 and 116 Christmas tree plantations in Oregon and Washington, respectively, were surveyed for the presence of this pathogen. A total of 441 noble fir bough production stands were also sampled. *P. ramorum* was not detected during these surveys.

**Invasive plants in tropical forests: Historical artifact or resistant communities?** Denslow, J.S. (*USDA Forest Service, USA; jdenslow@fs.fed.us*), DeWalt, S.J. (*Rice University, USA; sdewalt@rice.edu*).

The ecological impact of invasive exotic species has not surfaced as a major conservation and management issue for forests in tropical environments. A previous review confirmed that alien species generally comprise a smaller portion of tropical than temperate floras. Tropical islands are notable exceptions. We examine the current literature as it addresses several hypotheses, including high pest loads, high species diversity and high competitive pressure, that predict low invisibility of tropical plant communities, and discuss whether historically observed patterns are likely to be good predictors of future conditions. Further, we use comparisons between tropical mainland and island ecosystems to examine processes, such as effective resource capture, that may influence invisibility of tropical forests and suggest conditions under which we expect invasive species to be most problematic in tropical forest environments.

**Impact of exotic tree *Salix alba* on the understory vegetation in the temperate northwestern Indian Himalayas.**

Dogra, K.S., Kohli, R.K. (*Panjab University, India; ksdogra2121@yahoo.co.in; rkkkohli45@yahoo.com*).

Invasive exotic plants, either introduced or accidentally entered, pose a long-lasting threat to the indigenous plant communities. A number of tree species have been introduced around the world into new habitats for either monetary gains or aesthetic value. In the alien environment, these exotic tree species grow very fast with effective resource utilization mechanisms at the cost of native tree species. In the invaded habitats, they disturb the community dynamics, structure and composition of under canopy vegetation. In the temperate forests of northwestern Himalayas, *Salix alba*, a native of China, has been introduced for landscaping and aesthetic value. However, the trees are observed to have a negative impact on the native flora, including medicinal plants. This paper presents a discussion on the impact of *S. alba* on the medicinal flora of the temperate Himalayas, and the possible mechanism underlying the exclusion of vegetation underneath them.

**Management tools for assessing stem tissue viability and tracing herbicide damage in invasive woody vines and shrubs.** Fuchs, M.A., Geiger, D.R. (*University of Dayton, USA; fuchsmaa@notes.udayton.edu; Donald.Geiger@notes.udayton.edu*).

Since their introductions, non-native invasive shrubs have largely contributed to the decline in native plant biodiversity in forests of the eastern United States. In an attempt to discern the effectiveness of control methods, a selection of known visible and fluorescent viable biological dyes were assessed for their ability to distinguish living or dead tissue within intact plant stems of nine non-native invasive and eight native plant species common to the eastern and mid-western USA. Comparison of stem tissue incubated with 2,3,5-triphenyltetrazolium chloride (TTC) or the fluorescent dye 6-carboxyfluorescein diacetate (CFDA), with similar non-incubated tissue viewed under light, fluorescent and scanning electron microscopy confirmed the effectiveness these dyes had in locating and identifying living and metabolically active tissues within woody plant stems. Further identification of anatomical structure and metabolic activity verified the location of viable cells within the primary xylem, xylem rays and phloem tissues. Using this technique, it was possible to determine the site and trace the extent of tissue death in plants treated with foliage sprays of Roundup. It is envisioned that this procedure can be successfully incorporated into formulating sound restoration efforts designed to scientifically and systematically evaluate the effectiveness of control methods in invasive woody plants.

**Alien plant invasions in forests: a problem or a facilitation in rehabilitation of natural evergreen forest?**

Geldenhuys, C.J. (*University of Stellenbosch, South Africa; cgelden@mweb.co.za*).

Natural evergreen forests in South Africa occur in small, fragmented and widely distributed patches in relatively marginal environments for forests. In the past, natural fires in the landscape outside the forests confined forests to fire refugia, but changes in the fire regime through commercial forestry, intensive agriculture and urban development, have allowed trees to return to the landscape. However, invader plant species were the first to become established. The shade-intolerant pioneering invaders facilitate or nurse the establishment of shade-tolerant forest species. Inside natural forests, the natural disturbance regime creates small gaps (generally <150 m<sup>2</sup>), preventing the establishment of shade-intolerant invader plant species. Knowledge obtained from research provides the basis for guidelines to manage invader plant stands and natural forests through controlling gap size. This approach has been used to develop a new control policy, and is used to convert

stands of invader plants to re-establish natural (regrowth) forests. This presentation reviews the studies that contributed to this understanding, and provides examples of how naturalized and planted stands of invader species were managed to develop regrowth forest, and to develop the resource base for small businesses in the field of traditional medicine in rural environments. The costs and benefits of this case of alien plant control in the natural forest environment will be presented.

***Lantana camara*: an alien invasive inhibits the germination and growth of some agricultural crops.** Hossain, M.K. (Chittagong University, India; [hossainmk2001@yahoo.com](mailto:hossainmk2001@yahoo.com)), Ahmed, R., Uddin, M.B. (Shahjalal University of Science and Technology, Bangladesh).

*Lantana* (*Lantana camara* L.), a highly aggressive exotic weed established throughout the south-eastern regions of Bangladesh, is able to displace some of the native vegetation through its vigorous growth and allelopathic effects. The paper describes the growth inhibitory effects of aqueous extracts of *L. camara* on some agricultural crops: *Cicer arietinum* L., *Brassica juncea* (L.) Czern & Coss, *Cucumis sativus* L., *Phaseolus mungo* L., *Raphanus sativus* L. and *Vigna unguiculata* (L.) Walp. The experiment was conducted in sterile petri dishes with a photoperiod of 12 hours and an average temperature of 29 °C. The effect of different concentrations of aqueous extracts was compared to distilled water as a control. The different concentration of aqueous extracts of *Lantana camara* leaf caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of receptor crops. Bioassays indicate that the inhibitory effect was proportional to the concentrations of the extracts with higher concentrations having a stronger inhibitory effect, whereas the lower concentrations showed stimulatory effect in some cases. The study also revealed that inhibitory effect was more pronounced in main and lateral root development rather than germination and shoot development.

**Invasion of tropical American flora in Bangladesh and its ecological and economical consequences.** Hossain, M.K., Pasha, M.K. (Chittagong University, India; [hossainmk2001@yahoo.com](mailto:hossainmk2001@yahoo.com)).

Bangladesh has a long history of plant introduction. Most of the species were aggressively introduced for economic reasons, but some species were introduced accidentally. The paper presents the results of a study of exotic plants in Bangladesh. A total of 110 species are from the tropical Americas: trees (11), shrubs (30) and herbs and lianas (69). Each species was documented alphabetically by family name, local and English name, place of origin and the present status in the ecosystem. Herbs and lianas are the dominant exotics flora followed by shrub and tree species. The majority of the economic plants in Bangladesh are actually introduced, and approximately 50% are from South America. Many exotic species have successfully naturalized and become an integral part of the present day flora of Bangladesh. Though some species contribute significantly economically, some species are very aggressive and have degraded the ecosystems economically and ecologically. This paper briefly discusses the consequences of some of the invasive species in the different ecosystems of Bangladesh.

**Impacts of the exotic invasive *Imperata cylindrica* on diversity and productivity of ecosystems in the south-eastern USA.** Jose, S., Collins, A., Daneshgar, P., Ramsey, C. (University of Florida, USA; [sjose@ufl.edu](mailto:sjose@ufl.edu)).

*Imperata cylindrica*, a perennial grass native to Southeast Asia, has invaded forestland in the southeastern United States at an alarming rate. Its role in altering the diversity, structure and function of these ecosystems is becoming apparent. Studies conducted in both flatwoods and sandhill savanna ecosystems show that it displaces most native vegetation except large trees. It also changes soil chemistry, nutrient cycling, hydrology and disturbance regimes of infested sites. *I. cylindrica* has been shown to exert intense competition on indigenous species for light, water and nutrients. For example, surface soil water content was reduced as much as 50% by *I. cylindrica* compared to sandhill vegetation, owing to a five to ten fold increase in the rhizome-root biomass. It can act as a physical barrier to seedling establishment. The competition for resources is demonstrated by a 70% reduction in growth rate of two-year-old *Pinus taeda*. Higher biomass accumulation and high foliar silica content of *I. cylindrica* creates a severe fire hazard with temperatures well above 450 °C if burned. These fires result in shifting species composition to undesirable trees in natural stands and loss of productivity from fire damage in plantations. Overall, *I. cylindrica* is threatening the ecological and economic integrity of the southeastern US ecosystems. Integrated pest management strategies are being explored to combat the problem.

**Impact of some invasive plants on the forest floor vegetation of Shivalik Himalayas in northwestern India.** Kohli, R.K. (Panjab University, India; [rkkohli45@yahoo.com](mailto:rkkohli45@yahoo.com)).

The understory vegetation of Shivalik Himalayas of northwestern India is rich in herbal plants that have been used as medicinal plants since ancient times. For the past two decades, invasive plants have created a threat to diversity of this vegetation. The climate in the Shivalik Himalayas is subtropical, favorable for the establishment of invasive plants. The invasive plants include: *Ageratum conyzoides* (Asteraceae), *Parthenium hysterophorus* (Asteraceae), *Eupatorium odoratum* (Asteraceae) and *Lantana camara* (Verbenaceae). The fast establishment of these exotics here can be attributed to their fast growth rate, and quick regenerative and reproductive potential. This results into a loss of biodiversity of native plants in the

understorey of forests. During the work conducted under a B.P. Pal National Environment Fellowship award of the Government of India, it was observed that diversity, evenness and richness are drastically decreased in the understorey forests invaded by the exotics. The situation is alarming and needs immediate attention. The paper presents the establishment and impact of invasive weeds on the floor vegetation of forests in the Shivalik Himalayas of northwestern India.

**Ecology and management of Cogongrass in the south-eastern USA.** MacDonald, G. (*University of Florida, USA; gemac@ifas.ufl.edu*), Byrd Jr., J.D. (*Mississippi State University, USA; jbyrd@weedscience.msstate.edu*), Shilling, D.G. (*University of Georgia, USA; dgs@uga.edu*).

Cogongrass [*Imperata cylindrica* (L.) Beauv.] continues to be a serious threat to many natural and managed forest ecosystems in the south-eastern USA. This species was introduced in the 1920s and currently infests over 1.5 million ha, predominantly in the states of Florida, Mississippi and Alabama. Cogongrass was initially spread through rhizomes, but recent evidence points to a rapid increase in seed dispersed populations. This species colonizes disturbed lands and natural areas, and is becoming increasingly problematic in managed pine (*Pinus* spp.) plantations. In addition to direct competition, allelopathy and altered fire ecology are serious concerns with cogongrass infestations. Management of cogongrass in the USA relies heavily on chemical control, mainly glyphosate and imazapyr herbicides. Studies have shown very good short-term control with this approach, but re-infestation is common. Current management strategies employ burning to remove thatch and stimulate regrowth, chemical applications in the autumn season to increase herbicide movement to rhizome tissue and aggressive revegetation species. The integration of bio-control agents is also being evaluated for cogongrass management.

**Impact of invasive Siam weed on plant species composition and community structure of natural fallow systems: A case study in southern Cameroon.** Ngobo, M., Weise, S. (*IITA, Cameroon; m.ngobo@cgiar.org; s.weise@cgiar.org*).

Of particular concern for forest and land use managers in southern Cameroon is the invasion of natural fallow systems by the exotic shrub *Chromolaena odorata* (L.) King & Robinson. This study assessed the species composition, functional diversity and vegetation structure in three natural fallow types characterized by different land use histories. Vegetation surveys were carried out at Mengomo. Results showed that as the number of fallow-cultivation cycles increases, *C. odorata* becomes more abundant, and many forest species disappear, gradually replaced by more competitive plants. Ordination analyses showed a clear pattern of distribution of species along a gradient associated with land use intensity: recurrent *C. odorata*-dominated fallows (reflecting high land use intensity) were clearly separated from fallow sites that had been forests in the previous cropping cycle (lower land use intensity). The results of this study suggest that invasion by *C. odorata* will initially have little effect on the species diversity of the fallow plant community. However, as the link to the forest is reduced (i.e., as the number of fallow-crop cycle increases) altering the site vegetation structural characteristics and decreasing shade (leading to a more homogeneous microclimate), there will be an adverse effect and the fallow species richness will decline.

**Invasive characteristics and stand dynamics of abandoned bamboo forests in western Japan.** Sakamoto, K., Saroinsong, F.B., Takahashi, H., Naoko, M., Yoshikawa, K. (*Okayama University, Japan; skmtelm@cc.okayama-u.ac.jp; erkebaby@yahoo.com; hiro-z@kcc.zaq.ne.jp; miki@cc.okayama-u.ac.jp; kenchan@cc.okayama-u.ac.jp*).

Most secondary forests in Japan that were artificially maintained have been abandoned since the 1960s, because of the decline in their economical value. Bamboo forests are among these abandoned secondary forests. The abandoned bamboo forests have been expanding into other secondary forests, and the expansion results in the degradation of biodiversity and landscape heterogeneity. The objective of this study was to determine the expansion pattern and the stand dynamics of abandoned bamboo forests in western Japan. In the border zones between bamboo forests and other secondary forests, annual occurrence number of new culms exceeded that of the dead culms. The relative increments in the biomass of culms were larger in the border zones than in the interiors of the bamboo forests. The culms gradually invaded other secondary forests, and the bamboo forests expanded their area. In the abandoned bamboo forests that are surrounded by artificial matrices and cannot expand their area, the turn-over rates and the biomass increments of the culms were significantly higher on the edges than in the interiors of the bamboo forests. It is suggested that the expansion pattern for abandoned bamboo forests is from the border zones.

**Invasive plant species affect native bee behaviour and fruit set of forest understory native plants in Acadia National Park.** Stubbs, C.S., Drummond, F. (*University of Maine, USA; connie.stubbs@umit.maine.edu; frank.drummond@umit.maine.edu*), Ginsberg, H. (*University of Rhode Island, USA; Howard\_S\_Ginsberg@usgs.gov*), O'Neal, A. (*University of Maine, USA*).

*Berberis thunbergii* (Japanese barberry) and *Frangula alnus* (glossy buckthorn) are invasive species that often reduce native plant species diversity in the understory of forests in the eastern United States. Since 2001, we have been examining the roles these invasive non-native species have on native pollinator behaviour and fruit set of co-flowering native plants in

Acadia National Park. Native bee visitation to *Vaccinium angustifolium* (lowbush blueberry) was significantly reduced in the presence of *B. thunbergii*. In contrast, bee visitation to native *Viburnum nudum* (wild raisin) was significantly greater when *F. alnus* was present. Fruit sets for *V. angustifolium* and *V. nudum* were not adversely affected at sites where the invasives were present. Measures of pollen availability, nectar volume and sugar concentration, indicate *B. thunbergii* and *F. alnus* are highly attractive floral resources for native bees, such as *Bombus* (bumble bees) and *Andrena* (miner bees). Fruit sets of the invasives increased as native bee visitation increased. This suggests that control measures for invasive plant species, that are highly attractive to bees and other insects and that benefit reproductively from insect-mediated pollination, might also consider developing measures which reduce pollinator visitation.

**Impacts of exotic invasive plants on areas of conservation significance: an economic assessment.** Tumaneng-Diete, T. (*Department of Natural Resources and Mines, Queensland, Australia; tessie.tumaneng@nrm.qld.gov.au*), Page, A. (*AEC Group Pty. Ltd., Australia; Ashley@aecgroup.com.au*), Binney, J. (*Department of Natural Resources and Mines, Queensland, Australia; jim.binney@nrm.qld.gov.au*).

Exotic plant species can threaten the integrity and biodiversity of a forest ecosystem by altering the composition and structure of native forest communities. State forests and national parks are often impacted by exotic plant species as plant matter is transported from already affected habitat, often as a result of human activities. When established in its new habitat, these exotic plants compete with native species and threaten the long-term sustainability and integrity of forest ecosystems. The economic impacts of exotic species in areas of conservation significance, such as National Parks, have not been assessed in the past in Queensland, Australia. This study assesses the value placed by the state's population on the importance of controlling exotic plants in areas of conservation significance. The outcomes of the study can be valuable information for policy makers in making informed decisions about control measures for exotic species in natural areas and the overall value of natural areas to the wider community.

**Developing optimal management strategies for invasive species: Linking physiological ecology with operations research.** Volin, J.C., Volin, V.C. (*Florida Atlantic University, USA; jvolin@fau.edu*).

Invasive non-indigenous species are a significant component of global environmental change. Once a non-indigenous species has spread beyond a quick eradication, sound studies about the species life history become fundamental to develop effective control management. The problem of managing invasive species can be viewed as a mathematical programming problem, where growth, dispersal and control models are merged to optimize resource allocation strategies within the constraints dictated by available information on the biological, life history and landscape ecology of the target species. Operations research is a tool widely used in industrial engineering and natural resource management. Here we present a case study of one of the worst invasive species in the Florida Everglades, *Lygodium microphyllum*. We combine an operational research approach with a landscape growth and dispersal model we have developed using several life history characteristics of *L. microphyllum* that we have studied across different scales, from the spore up to the landscape. The resulting optimization model provides land managers with the cost and effectiveness of different control management scenarios, where management effectiveness is represented by the amount of pest population extermination versus the amount of management effort. The approach is a powerful tool for managing invasive species worldwide.

## Forests in the global balance: Changing paradigms

Organizer: Gerardo Mery *IUFRO–WFSE, Finnish Forest Research Institute, Finland; Gerardo.Mery@metla.fi*

**Implications of on-going paradigm changes for policy decisions in forestry and related sectors.** Alfaro, R.I. (*Natural Resources Canada, Canada; Rene.Alfaro@nrcan-nrcan.gc.ca*), Kanninen, M. (*CIFOR, Indonesia; m.kanninen@cgiar.org*), Mery, G. (*Finnish Forest Research Institute, Finland; Gerardo.Mery@metla.fi*), Lobovikov, M. (*International Network for Bamboo and Rattan INBAR, P.R. China; mlobovikov@inbar.int*).

The IUFRO Special Project on World Forests, Society and Environment (IUFRO–WFSE) has been working along with numerous authors from around the world, on critically analyzing the existing knowledge on selected topics of forests and related issues and the paradigm shifts that have occurred in relation to the sustainable development of world forests in the last few years. The focus is on changing paradigms on the interrelations between forests, society and the environment. In this presentation we summarize results of a workshop between authors and policy specialists who analyzed the contents of the book and provided a basis of scientific knowledge for policy formulation and implementation in forestry and forest-related sectors, with the goal of amending the existing gap between science and policy. The result of the debates were used for composing the Policy Brief booklet produced by the IUFRO–WFSE project.

**An integrated approach to forest ecosystem services.** Campos, J.J. (*Centro Agronómico Tropical de Investigación y Enseñanza CATIE; jcampos@catie.ac.cr*), Alpizar, F. (*Centro Agronómico Tropical de Investigación y Enseñanza CATIE; falpizar@catie.ac.cr*), Louman, B. (*World Wildlife Fund Inc., Peru; bastiaan@wwfperu.org.pe*), Parrotta, J.A. (*USDA Forest Service, USA; jparrotta@fs.fed.us*).

This paper discusses the life-supporting services provided by forest ecosystems and the effects that land use and forest management practices have in the provision of forest ecosystem services (FES). It also discusses the role markets can have in providing an enabling environment for a sustainable and equitable provision of FES and describes an approach for designing effective market-based mechanisms such as payments for ecosystem services (PES), taking into consideration the biophysical, demand (beneficiaries) and supply (providers) components, as well as the institutional requirements. The challenges to implementing such schemes include the characterization of FES, establishment of sustainable financing mechanisms, design and implementation of effective payment systems and the establishment of adequate institutional frameworks. Research, management and decision-making processes need to take into consideration larger temporal and spatial scales, and to work towards integration of different land-use components at these larger scales. Finally, we assess some potential limitations for the use of market mechanisms for sustaining the provision of forest ecosystem services, such as difficulties to demonstrate that services are actually being provided, the lack of an effective demand for the services or restrictions from the supply side, and limitations related to institutional capacity and scale.

**Traditional knowledge and human well-being in the 21st century.** Colfer, C.J.P. (*Center for International Forestry Research, Indonesia; c.colfer@cgiar.org*), Colchester, M. (*Forest Peoples Program; marcus@forestpeoples.org*), Joshi, L. (*World Agroforestry Center, Indonesia; L.Joshi@cgiar.org*), Nygren, A. (*University of Helsinki, Finland; anja.nygren@helsinki.fi*), Puri, R. (*University of Kent, UK; R.K.Puri@kent.ac.uk*).

This poster presents 10 observations on traditional knowledge, with accompanying policy recommendations, of interest to the forestry community. These relate to 1) the invisibility of traditional knowledge in policy contexts; 2) the difficulties gaining access to it, because of non-dominant languages; 3) qualitative differences in how knowledge systems function; 4) epistemological differences; 5) utility of traditional knowledge in forestry fields; 6) property rights pertaining to traditional knowledge; 7) the cultural embeddedness of traditional knowledge; 8) intra-community variation in knowledge; 9) similarities between multiple use forestry and traditional knowledge of forests, and finally 10) the utility of bringing the two kinds of knowledge together. Recommendations include conducting studies of traditional knowledge; providing foresters and extension personnel training about local languages, customs and social science methods; changing attitudes among forestry professionals; making bureaucracies more flexible, bottom up and receptive to location-specific feedback; and protecting indigenous property rights.

**The structure of the human ecosystem.** Force, J.E. (*University of Idaho; joellen@uidaho.edu*), Machlis, G. (*University of Idaho; gmachlis@uidaho.edu*), Burch, W.R. Jr. (*Yale University; JudithHBurch@cs.com*).

The organization and description of a comprehensive ecosystem model useful to ecosystem management is necessary. We describe the structure of human ecosystems and the application of the structure as usable knowledge. We define the synergistic combination of organization (the component parts of a system), flow, pattern and process within the human ecosystem. We propose the human ecosystem as an organizing concept for ecosystem management. The key components of a human ecosystem model are the (1) critical resources – biophysical (energy, air & water, land, flora & fauna, nutrients and materials); socioeconomic (information, population, labour and capital); and cultural resources (organization, beliefs, arts and crafts, and myth); (2) social institutions; (3) social cycles; and (4) social order (identities, norms and hierarchies). We provide general definitions and descriptions of the variables in the model and suggest ways they can be measured. Selected examples are given from around the world of how this work has been and can be used to better understand the human ecosystem and the relationships between the components examined in more traditional biophysical approaches to ecosystem science and the inclusion of humans in the world's ecosystems.

**Changing paradigms in the forestry sector of Latin America.** Galloway, G. (*Centro Agronómico Tropical de Investigación y Enseñanza CATIE, Costa Rica; galloway@catie.ac.cr*), Kengen, S. (*skengen@terra.com.br*), Louman, B. (*World Wildlife Fund Inc., Peru; bastiaan@wwfperu.org.pe*), Stoian, D. (*Centro para la Competitividad de Ecoempresas CeCoEco, Costa Rica; stoian@catie.ac.cr*).

The poster presents a brief overview of interrelations among important stakeholders and factors in an ideal case of a sustainable forest sector. Selected paradigm shifts in Latin America relating to forest users, the forest resource, markets and commercial aspects, the institutional settings, the political-legal framework are indicated, including social and cultural considerations. Persisting problems, challenges and limitations impeding sustainable forest management are also provided. Sustainable forest management requires adequate progress in all dimensions and conditions necessary for forest management. The complexity of sustainable forestry management makes clear the importance of multi-stakeholder platforms for strategic and operational planning, and a shared implementation of progressive



initiatives. Cooperation within these platforms creates invaluable opportunities to objectively evaluate progress towards SFM in all its dimensions. Above all a true commitment to greater participation in SFM is required, reflected in an enabling environment which facilitates rather than hinders this participation.

**Change in the governance of the forest resource.** Glück, P. (*University of Natural Resources and Applied Life Sciences, Austria; peter.glueck@boku.ac.at*), Rayner, J. (*Malaspina University, Canada; rayner@mala.bc.ca*), Cashore, B. (*Yale University, USA; benjamin.cashore@yale.edu*), Mery, G. (*Finnish Forest Research Institute, Finland; gerardo.mery@metla.fi*).

Until relatively recently, forest governance across the globe followed a ‘top down’ or hierarchical approach. In this traditional model, policy goals were determined and developed within the confines of the nation state and implemented by state officials by invoking a variety of ‘command and control’ policy instruments. However, the limitations of traditional forest governance produced ‘bottom up’ approaches, which emphasized interdependence, collaboration and policy learning among state and societal organizations. New patterns of interaction, known broadly as ‘policy networks’, have since led to the development of an array of new institutional arrangements within the forest sector including: international forest deliberations, national forest programmes, forest certification, decentralization, devolution of public rights and forest self-organization. The causes of the shifts in forest governance are related to the increasing demands from civil society at national and international levels, as well as to the processes of globalization and internationalization. The strength of these shifts, and the reactions to them, differ between industrialized and developing countries, and between countries with low and high forest cover. New governance initiatives often encourage voluntary, self-regulatory or market mechanisms that raise important issues of accountability and legitimacy. We argue that rather than reducing the role of nation-states these initiatives create new challenges for them. The main issues for future research are the interaction between state and non-state authority, and the ability of new governance arenas to simultaneously promote democratic governance and address global forest problems.

**Forests in the global balance: Changing paradigms.** Kanninen, M. (*CIFOR, Indonesia; m.kanninen@cgiar.org*).

The ‘Forests in the Global Balance – Changing Paradigms’ book contains a critical and innovative review of the on-going changes in the global paradigms in forestry and the interface between world forests, society and environment. In the section called ‘Global Forum’, the changing paradigms are analyzed globally from different points of view, including governance, environmental services, livelihoods and planted forests. In addition, the ‘Regional Forum’ analyzes changing paradigms in six different regions. The articles will focus on selected topics of current global concern and they include analyses on future prospects and policy recommendations.

**Moving from capacity building to capacity development.** Kleine, M. (*IUFRO, Austria; kleine@iufro.org*), Appanah, S. (*FAO Regional Office for Asia and the Pacific; Simmathiri.Appanah@fao.org*), Galloway, G. (*Centro Agronómico Tropical de Investigación y Enseñanza CATIE, Costa Rica; galloway@catie.ac.cr*), Simula, M. (*INDUFOR, Finland; markku.simula@ardot.fi*), Spilsbury, M. (*CIFOR, Indonesia; m.spilsbury@cgiar.org*), Temu, A. (*World Agroforestry Centre, Kenya; a.temu@cgiar.org*).

Capacity building, which in the past was defined as the training of individuals, has been expanded to the much broader concept of capacity development. The latter encompasses the skills and abilities of individuals, institutions and entire systems to perform functions and set and achieve objectives. This broad concept provides the basis to successfully resolve the complex problems of sustainable forest management (SFM) in all its dimensions. With the broadening of the capacity development concept, new dimensions and fields of expertise have been introduced. Traditional subjects such as ecology, forest management and economics have been complemented by new areas, such as policy, governance, livelihood theory, environmental services and information and communication technology. The trend to learn from other disciplines and introduce new fields of expertise provides the basis to address and reduce the many constraints in the enabling environment hampering SFM implementation. Inter-sector as well as national, regional and global environmental and economic policies, for example, need to be formulated and applied in such a way as to support SFM. New knowledge, new skills and new institutional arrangements – including multi-stakeholder platforms – are needed in order to contribute effectively to such policies. This poster explains the paradigm shift from narrow capacity building to the broader concept of capacity development. Photographs and short statements underline this evolution, and show both traditional skills and the range of new expertise that is indispensable for sustainable forest management in the 21st century.

**Profitability of multinational forest industry companies and the location of production.** Laaksonen-Craig, S. (*University of Toronto, Canada; susanna.laaksonen.craig@utoronto.ca*), Toppinen, A. (*Finnish Forest Research Institute, Finland; anne.toppinen@metla.fi*).

The increasing pressure from the low-cost producers in Asia and South America has pushed companies in North America and Scandinavia to seek consolidation for economies of scale leading to the rapid globalization of the forest

industry. This global presence may have an impact on company performance by helping to alleviate the uncertainty related to exchange rates or by ensuring the quality and efficiency of the raw materials. We compared economic performance, as measured by return on capital employed (ROCE), of the twenty largest companies in North America and Scandinavia between 1996 and 2002. On average the more globally diversified firms in Scandinavia were found to outperform slightly their competitors in North America during this period. However, financial performance of individual forest industry companies has varied very strongly, between 1 and 19% annually. Saturating traditional forest products markets in North America and Europe will put pressure on firms located mainly in these regions to diversify even further in the future, especially since the investors and stock markets increasingly value short-term performance. This is also leading to streamlining of operations and cutting down less profitable production units, which has a severe backside on local livelihoods of rural communities in forestry dependent areas.

**Plantation history and changes in its roles in Korea.** Lee, D.K., Park, Y.D. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr; forest\_park@hanmail.net*), Park, D.K. (*Northeast Asian Forest Forum, Republic of Korea; pdk5920@korea.com*).

After more than 50 years of social and political upheaval, the Republic of Korea (ROK) faced a massive environmental problem of forest degradation and severe soil erosion. In addition, rural populations looked to the remaining forests to supply fuelwood for domestic heating and cooking needs. The Korean government responded in the late 1950s with a series of 10-year Forest Development Plans that attempted to meet the most pressing immediate needs and begin the long-term restoration of the country's forests. Beginning with the First and Second Forest Development Plans, fuelwood plantations were successfully established and most of the degraded forests rehabilitated. Although it was driven by government programs, forest restoration was truly a national undertaking expressed as the national campaign. In the 21<sup>st</sup> century, society is characterized by people's participation as well as by the roles of non-governmental organizations (NGOs). The NGOs in Korea follow the global trend and, since the 1980s, have become involved in both political and more practical aspects of supporting rehabilitation of degraded forests. The challenges faced in the ROK are similar to those facing other nations in the region and it is hoped that the experience gained in the ROK will be shared through international cooperation by governmental and non-governmental levels.

**Forest assessment for changing information needs. Monitoring forest condition in Europe.** Lorenz, M., Fischer, R., Becher, G., Mues, V. (*Federal Research Centre for Forestry and Forest Products, Germany; lorenz@holz.uni-hamburg.de; fischer@holz.uni-hamburg.de; gbecher@holz.uni-hamburg.de; mues@holz.uni-hamburg.de*).

Forest condition in Europe has been monitored for over 20 years by the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). In cooperation with the European Union and with 42 countries including Canada and the USA participating, ICP Forests assesses variations of forest condition over space and time in relation to environmental factors, especially air pollution, on more than 6100 plots in Europe. Causal relationships are studied on about 860 intensive monitoring plots covering the most important forest ecosystems. ICP Forests has detected increasing defoliation on several main tree species in large areas of Europe, but also recuperation has been observed. Crown condition is explained by tree age, weather extremes, biotic factors and, to a smaller degree, by air pollution. Air pollution is also related to soil condition, foliage chemistry and tree growth. Nitrogen depositions have been shown to exceed critical loads, but positive effects of decreasing sulphur emissions resulting from air pollution abatement policies under CLRTAP have been found. With its comprehensive database and infrastructure, the programme has started to contribute to further processes of international environmental policies.

**Introduction to the IUFRO–WFSE Project.** Mery, G. (*Finnish Forest Research Institute, Finland; Gerardo.Mery@metla.fi*).

The objective of IUFRO's Special Project on World Forests Society and Environment (IUFRO–WFSE) has been to collate and critically analyse the existing scientific knowledge on selected issues on the interrelations between forests, society and environment and to disseminate the results. In addition, the project has provided an innovative forum for analysing changing paradigms in the above mentioned interface, and challenging and testing new ideas using a scientific approach. This output has been used to produce, in 2005, the book *Forests in the Global Balance – Changing Paradigms* and the accompanying Policy Brief and other dissemination material. The active dissemination of the book will provide the new critical views to scientists, researchers and professionals. The Policy Brief has policy makers and opinion formers as a target audience and will provide them scientific basis for policy development and formulation. The other dissemination material – for capacity building, internet communications, posters, brochures – will support training and extension activities and increase public awareness on these topics.

These outcomes, produced by a wide and open network of researchers and experts from around the world, have made it possible to attain one of the project's goal: to contribute to amend the existing gap between policy-makers and scientists in the formulation and application of policies in forestry related issues, in the support of sustainable development and well-being of people.

**Forests as local and global livelihoods support systems.** Roda, J.-M. (*CIRAD-Forêt, France; jean-marc.roda@cirad.fr*), Campbell, B. (*Charles Darwin University, Australia; b\_campbell@site.ntu.edu.au*), Kowero, G. (*g.kowero@cgiar.org*), Mutamba, M. (*CIFOR, Zambia; m.mutabma@cgiar.org*), Vanhanen, H. (*Finnish Forest Research Institute, Finland; heidi.vanhanen@metla.fi*).

The central role of forests in rural livelihoods, especially for the poor and the marginalized suggest that these resources could actively support pathways out of poverty if their full potential is captured. However, most forest-based poverty alleviation pathways are not necessarily accessible to the poor, who are often constrained by low levels of education, low levels of asset holding, poor health, weak local institutions, unfavourable institutional frameworks and lack power and opportunities to be heard. In some areas, forests clearly have potential to lift rural people out of poverty by enabling significant income generation, mobilization of savings, capital accumulation and asset-building. This paper explores the opportunities for forest-based poverty alleviation and current approaches aimed at helping poor people to capture the full benefits of their forest resources. The discussion highlights the need for identifying and developing promising opportunities for forest-based poverty alleviation and circumstances under which these are applicable. Despite the potential of forest based poverty alleviation, much of the evidence presented suggest that sustained welfare gains for the great majority of forest dependent people in many areas will require broader macro-level investments beyond forests and natural resources. Multi-scale, integrated and holistic development approaches, which take advantage of the positive links between rural livelihoods and other sectors, will be the key for achieving poverty alleviation at the scale of Millennium Development Goals.

**Forests in North America: Responding to social, economic and ecological pressures.** Stennes, B., Wang, S. (*Natural Resources Canada, Canada; bstennes@pfc.cfs.nrcan.gc.ca; senwang@pfc.cfs.nrcan.gc.ca*), Luján Alvarez, C. (*Universidad Autonoma de Chihuahua, México; clujan@uach.mx*), McDermott, C. (*Yale University, USA; constance.mcdermott@yale.edu*), Wilson, B. (*Natural Resources Canada, Canada; bwilson@pfc.cfs.nrcan.gc.ca*), Cashore, B. (*Yale University, USA; benjamin.cashore@yale.edu*), Peter, B. (*Natural Resources Canada, Canada*).

Over the past two decades, forest values and practices have evolved to encompass economic, environmental, social and cultural considerations. As a result, sustainable forest management and/or ecosystem management have emerged in North America as a new paradigm. The meaning of the paradigm shift differs between the three countries. In Mexico, sustainable forestry has led to a stronger emphasis on rural development and equitable benefit distribution. In Canada and the US, a higher level of economic development has led to a more exclusive focus on the environment, and increases in wealth, education and life expectancy in these two countries have led to greater demands for a wide array of environmental services from forests. Significant changes have also taken place in forest policies and governance arrangements of the three countries. The reasons for this have been changing government priorities, the influence of forest interest groups, new knowledge about natural disturbances, climate change and dynamics at the forest landscape level, as well as the influence of global initiatives with respect to forest practices. Different management models and approaches have emerged for the purposes of diversifying livelihoods in the case of non-timber forest products, and promoting forest products trade in the case of implementing various forest certification vehicles.

**World forests in the global balance: Global trends in population and land use.** Vanhanen, H. (*Finnish Forest Research Institute, Helsinki, Finland; heidi.vanhanen@metla.fi*).

Over the next 25–30 years, all the growth in the world population, estimated at 2 billion persons, will be concentrated in urban areas and in the less developed regions. Only Africa is the exception, where the rural population continues to grow. The pressures on natural resources, including productive land, will persist. Demand for forest and tree products will grow, both for industrial, small-scale and subsistence use. Only after 2075, after reaching a peak of 9.2 billion persons, will the world population grow very slowly, if at all. Until that time, an extra one billion tonnes of cereals will be demanded annually, mainly for urban consumption. Thus, in the next 25–30 years, developing countries will need an additional 120 million hectares for crops – an area equivalent to 3% of the world forests or 6% of forests of the developing countries. In population-growth regions, land-use must balance between local (rural) and regional (urban) needs. The trend is clearly towards more integrated land-uses, including intercropping, agroforestry and tree cultivation for wood and other products on farms and outside forests. The challenge will be to manage land for food security, for tree resources for consumption and processing and for safeguarding the environmental services, including land productivity: soil conservation and fertility.

**Tree planting and afforestation increase China's forest cover and rural incomes.** Vanhanen, H. (*Finnish Forest Research Institute, Finland; heidi.vanhanen@metla.fi*), Cao, Y. (*Northeast Forestry University, P.R. China*).

According to forest inventories, forest cover in China increased from 13.9% to 18.2% of the land area in the ten years between the 1989–1993 and 1999–2003 inventories. Planted forests, both for timber and various non-wood products, covered nearly one third or 46.7 million ha of China's forest area in 1998. Following the reforms in rural tenure in mid 1980s, the majority of the collective sector forests – 58% of all forest land – are managed and used by individual rural households through different contractual arrangements, while collective land ownership is officially maintained. The private sector planting of non-wood tree crops, such as oil, fruit and nut trees, the so-called 'economic trees', is one of the most noticeable changes in rural China. The area under small-scale 'economic forests' more than tripled between 1978 and 1998, reaching 20.2 million ha and covering 13% of China's total forest area. There are several reasons why farmers prefer planting 'economic trees' to timber production. Although forestry contributes only 2% to farm-derived rural cash income at the national level, 'economic tree' crops contribute up to 80% of farmers' income in forest-rich counties, create rural employment and generate local tax revenues. The value of non-wood products now accounts for one quarter of foreign trade in forestry.

**Changes in planted forests.** Varmola, M. (*Finnish Forest Research Institute, Finland; martti.varmola@metla.fi*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr*), Montagnini, F. (*Yale University, USA; florencia.montagnini@yale.edu*), Gautier, D. (*CIRAD-Forêt, France; denis.gautier@cirad.fr*), Saramäki, J. (*Finnish Forest Research Institute, Finland; jussi.saramaki@metla.fi*).

The importance of planted forests is much greater than their share of the forest area, and their importance will increase with time. This article presents statistics on and trends of planted forests area development along with the global supply from plantations. Ongoing changes in the definitions of plantation and planted forest make it almost impossible to derive precise global trends regarding future plantation area development. Planted forests have many purposes and fulfill different functions, e.g., roundwood, fibre and fuelwood production, carbon sequestration, combating desertification, rural landscape diversification, maintenance of biodiversity and environmental rehabilitation for soil and water conservation. Because of the widening of the definition, plantations such as rubber, coconut and oil palm plantations are included in wood production. The use of exotic and indigenous species in planted forests is also discussed as well as the advantages of planted forests with mixed species. Changes in plantation size and ownership are favouring smaller plantations maintained by communities and smallholders. We discuss the mechanisms of plantation development, including the transformation of natural forests, plantations in degraded areas, natural grasslands and open areas, as well as the reasons for forestation and methods of plantation establishment. The benefits of plantations for industry, society and local farmers are shown. We present examples of plantation forestry in the context of forest management systems, ecosystem management and biodiversity in plantations.

## **Forests, trees and human health and well-being**

Organizer: Kjell Nilsson *The Royal Veterinary and Agricultural University, Denmark; kjni@kvl.dk*

**The importance of green space for urban liveability: empirical evidence regarding outdoor recreation.** de Vries, S. (*Alterra, Green World Research, The Netherlands; sjerp.devries@wur.nl*).

The Dutch government aims to offer sufficient outdoor recreational opportunities that are available, reachable and accessible to everyone. But: what constitutes an available, reachable and accessible recreation opportunity? And: how many of these opportunities are needed? A normative planning model, entitled AVANAR, tries to answer these questions. The model identifies where shortages exist, how large they are and how much additional green space they require. AVANAR has already been applied to the cities of Amsterdam, Rotterdam and The Hague, and indicated substantial shortages within these cities. This study investigates to what extent such calculated shortages are related to the liveability of a neighbourhood. Can the normatively defined shortages be shown to have actual negative consequences? Based on secondary analyses of national surveys, all enriched with the AVANAR data on shortages, some first answers are given. Liveability aspects that have been investigated in this way are: quality of recreational experiences, recreational behaviour, leisure mobility, attractiveness of own neighbourhood, compensatory behaviour, composition of the local population. Thus far most of the aspects showed clear relations with the calculated shortages. Further investigations are needed to determine the causality of these relations. Evidence-based spatial claims for outdoor recreation may be attainable.

**Relationships between dust-like soil structure and urban forestry and city management in Moscow.** Makarova, O.V. (*Moscow State Forest University, Russia; Makarova@mgul.ac.ru*), Bondarenko, V.V. (*Moscow State Forest University, Russia*), Koolen, A.J. (*Wageningen University, The Netherlands; jos.koolen@wur.nl*), Shalaev, V.S. (*Moscow State Forest University, Russia*).

Soil texture refers to the particle size distribution that is determined after removing the bonds between individual solids. Micro-aggregate analysis usually refers to the determination of the particle size distribution after soaking and boiling the soil. Aggregate size distribution usually refers to the size distribution of soil particles and aggregates determined by dry sieving. Soil structure is optimal when the fractions of dust-like elements and coarse elements are minimal. Texture analysis of a range of soil samples showed that Moscow soils are, potentially, very productive, but also that they belong to a soil type with a structure that can be destroyed easily. Dry sieving of a range of soil samples showed that Moscow soils contain a very large amount of dust-like material, indicating a strong degradation of micro-aggregates. The relative amount of beneficial micro-aggregates is a balance between micro-aggregate forming factors and micro-aggregate degrading factors. Micro-aggregate forming factors include action of tree and grass roots, input of fresh organic material, frost, precipitation, drying, soil fauna, bacteria and mycorrhiza. Examples of micro-aggregate damaging factors are raindrop impact, input of de-icing salt, human traffic, vehicle movements, sedimentation of dust from the atmosphere. The paper discusses these factors for Moscow conditions.

**Measuring visitor and community benefits of recreation: A research handbook for managers.** Nickerson, R.G. (*Minnesota State University, USA; ronald.nickerson@mnsu.edu*), Anderson, D.H. (*University of Minnesota, USA; dha@umn.edu*), Davenport, M.A. (*Southern Illinois University, USA; mdaven@siu.edu*), Leahy, J.E. (*University of Minnesota, USA; leah0024@umn.edu*), Stein, T.V. (*University of Florida, USA; tstein@ufl.edu*).

Recreation managers are increasingly confronted with the need to demonstrate how and why the recreation areas they manage benefit visitors and society. Managers are being asked to 'do more with less,' compete with other government service providers for declining budgets, or demonstrate that the programs and services they offer produce positive outcomes. Similarly, public recreation managers are under greater pressure to involve stakeholders and local communities in decisions made about the management of public recreation areas. Documentation of the positive outcomes that visitors and communities attain from recreation areas in the form of positive experiences and benefits has become important. Managers and researchers have been working together for the last 25–30 years to develop research instruments and methodologies to measure the experiences and benefits that visitors attain from recreation areas. A handbook has recently been produced to provide recreation managers with step-by-step instructions for how to conduct basic experience and benefits research. The handbook includes basic methodologies, survey administration guidelines, sample questionnaires and data analysis guidelines so that managers can conduct basic research with minimal, if any, assistance from professional researchers. This paper discusses the basic methodology, survey administration and questionnaire design contained in the handbook.

**Feel blue? Touch green! Participation in forest/woodland management as a treatment for depression.** Townsend, M. (*Australia*).

Recent research by a team from Deakin University into the health and wellbeing benefits of civic environmentalism (typified by membership of a 'friends of parks' group), confirmed what was known intuitively: that belonging to such a group and undertaking the activities associated with the group exposes people not only to the benefits of the natural environment, but also to other people and to opportunities to make a contribution which is socially valued. On the basis of those findings, a pilot program of intentional engagement of people suffering depression and related disorders in supported nature-based activities in a woodland environment was implemented and evaluated. This paper reports on that program and discusses the implications of its findings both for forest managers and for the health sector.

## **Forest landscapes for locals and tourists**

Organizer: Tuija Sievänen *METLA, Finland; tuija.sievanen@metla.fi*

**FORVISITS: Modeling visitor flows to forests and other natural areas.** de Vries, S. (*Alterra, Green World Research, The Netherlands; sjerp.devries@wur.nl*).

The Netherlands Environmental Assessment Agency (MNP) desires a coherent set of indicators to monitor nature areas in the Netherlands. One of these indicators is the recreational use of nature areas. Besides indicating the social value of an area, recreational use may also be used as input for modeling habitat quality, another MNP-indicator. Since the MNP desires an overview of all Dutch nature areas, on-site monitoring is not feasible. Therefore, we are developing

a model (FORVISITS) to predict the number of recreational visits to natural areas based on readily available data. The model distributes visits based on the size and the attractiveness of the available destinations in the local choice set, as well as on their distance from the visitor's home (by road). In the first national application we looked only at visits originating from permanent residences. Based on these results we decided to enlarge the local choice set (action radius) and to segment the local population, with indigenous people making more visits than those with a non-western ethnic background. Furthermore, visits originating from holiday resorts will be included in the second version of the model. The outcomes of the national application of this second version will be presented and discussed.

**Visitor responses to national park designation.** Fredman, P. (*European Tourism Research Institute, Sweden; peter.fredman@etour.se*).

Many national parks around the world are significant tourist destinations. While increases in national park tourism provide business opportunities both in the parks and adjacent communities, there are several economic, social and ecological aspects that need to be monitored in order to sustain high quality visitor experiences. This presentation reports findings from two different studies of visitors to Fulufjället National Park in Sweden—one year before and one year after national park designation. Both studies used on-site counters, self-registration boxes and follow-up mailed questionnaires to collect visitor data. The purpose of the study was to monitor short-term changes in tourism as a consequence of the national park designation in 2002. Results from the study show some significant changes in visitor numbers, characteristics, use patterns and economic impact. The number of visitors increased by almost 40%, and approximately one in ten visitors come to the area because of the national park designation.

**Recreation and tourist pressures on forested areas in Asian countries: Japan as an example.** Ito, T. (*University of Tsukuba, Japan; taiichi@sakura.cc.tsukuba.ac.jp*), Tanaka, N. (*Forest and Forest Products Research Institute, Japan; tanakan@ffpri.affrc.go.jp*).

Increasing social demand for forested areas is causing overuse problems world wide—soil erosion/compaction, vegetation changes, litter and crowding. Researchers have been studying these issues, however, they often focus on a certain aspect of these problems within the boundaries of a forest or national park. They proposed solutions tailored to suit the issues in a limited area. On the other hand, to enhance sequential landscape experiences, which are becoming more important in corridor protection or greenway development, comprehensive planning beyond forests, to include urban areas, is indispensable. The ROS concept proposes diverse settings of forested areas to satisfy visitors with different expectations. However, from the sequential point of view, a management system including access from cities beyond each setting is required. Especially in Asian countries which do not have strict zoning systems, a consolidated approach is indispensable to protect forest resources. To realize such comprehensive management, public involvement, integrated with environmental education is important. Trail management often requires traditional community support. Thus, even in the field of recreational management of forests, social approaches including urbanities are required.

**National Danish forest recreation inventories in an international perspective: Towards a future monitoring system.** Jensen, F.S., Skov-Petersen, H. (*Danish Centre for Forest, Landscape and Planning, Denmark; fsj@kvl.dk; hsp@kvl.dk*).

In Denmark, two major national forest recreation surveys have been conducted: the Forest and Folk project in 1975 and the Outdoor Life 1995–1998 project. The latter was, in terms of overall objective and chosen methodology, a repetition of the first to be able to trace trends. Both surveys aimed at the collection of base-line information regarding the recreational life and preferences of the adult Danish population, and the use pattern of the Danish forests (and other nature areas). Both surveys used a combination of: 1) household questionnaires, including verbal-statement-cards and photographs for preference assessment, and 2) the counting of parked cars combined with a delivery of questionnaires at parking lots in the forests. Based on preliminary European data, the Danish experience is put into an international perspective as results from an assessment of European national forest recreation inventory projects and campaigns are compiled. With the Danish situation as point of reference, the paper looks forward by initiating a discussion outlining a future system for the collection of statistical information on recreational use of the forest and other nature areas.

**An assessment of skills and qualification of uniformed forest staff working in amenity forests of peninsular Malaysia.** Noor Azlin, Y. (*Forest Research Institute Malaysia (FRIM), Malaysia; azlin@frim.gov.my*), Manohar, M. (*Universiti Putra Malaysia, Malaysia*), Azman, A.R. (*Forestry Department of Peninsular Malaysia, Malaysia*), Azyyati, A.K. (*Forest Research Institute Malaysia (FRIM), Malaysia*), Lim, G. (*EduTrees Services, Malaysia*).

In Malaysia, the focus of forest management has shifted from timber production toward ecosystem or services functions. The Forest Rangers and Foresters, are those directly communicating with the public in amenity forests. Mostly trained and

experienced in timber production, the uniformed staff now need to be involved in ecotourism and public awareness. A study was conducted to assess the current skills and qualification of the staff. A group of 17 rangers and 19 foresters was randomly selected to fill a guided questionnaire. Prerequisites to their current positions are 2-years training at the Kepong Forestry School for rangers and 1-year for foresters. Results showed 70.6% of the rangers and 68.4% of the foresters had higher secondary school education compared to lower secondary. For involvement in handling visitor's programs, 52.0% of the rangers and 63.2% of the foresters had experiences. Half of the respondents—58.8% (rangers) and 42.1% (foresters)—had undergone interpretation-related courses such as nature guiding and interpretation for forest trails and caves. As for working experience, the ranges for both groups were 1–11 years (rangers) and 3–30 years (foresters). Modes of working years are 4, and age is 42 for both groups. All respondents were male and married.

**Forest landscapes: Opportunities and limitations for recreation and tourism in Europe.** Pröbstl, U. (*University of Natural Resources and Applied Life Sciences, Austria; ulrike.proebstl@boku.ac.at*).

Across Europe, forested landscapes constitute preferred areas for recreation and vacationing. Many of the exceptional recreational landscapes, such as nature parks and national parks and their surroundings, contain particularly large areas of forests. However, across Europe one can also observe changes to the proportion of forested landscapes and their spatial distribution, resulting from structural changes in the agricultural system. Particularly in the already intensively forested regions, the proportion of forested land is increasing further, as these areas are generally less suitable for agricultural production. Interestingly, this change is not necessarily perceived as a positive trend by the local population or visitors. Therefore, this presentation will focus on the recent dynamics of forested areas across Europe and its effects on that landscape's suitability for tourism use. The discussion will consider the recreational demands on the landscape in terms of structure, composition, diversity and other resource characteristics, and how these relate to the changing motives for visiting forests, as well as to the newest trends in tourism and recreation.

**Visitor attractions of nature conservation areas in Finland.** Sievänen, T., Pouta, E., Neuvonen, M. (*Finnish Forest Research Institute, Finland; tuija.sievanen@metla.fi*).

In this study, we focus on recreation use of state owned nature conservation areas in Finland. National parks, national hiking areas and other conservation sites provide opportunities and environments for those outdoor recreation activities that benefit from the ecological and aesthetic values of nature. The study focuses on those factors that attract nature tourists to these areas. When planning new nature conservation areas or services to the existing areas, it is important to be aware of those attributes that influence use. Methods and tools to model the use of the areas provide the basis for defining user benefits, and the regional economic impacts that are realized through commercial services. Study data include 40 observations (e.g., conservation areas), and the number of visitors was systematically counted. In addition, the data set includes information about natural and constructed attributes of these areas, and associated commercial services. Regression techniques are used to model the number of visitors. The most important nature attractions include the amount of old growth forests, topography of the area, amount of lakes and wilderness characteristics. The recreational services that relate to the amount of users in an area are: signed paths, rest sites, open huts and visitor information services.

**Opportunities of forest resources for ecotourism: An Indonesian case.** Sukandi, T. (*Research and Development Centre for Forest and Nature Conservation, Indonesia; taulana@forda.org*).

A new paradigm has evolved in Indonesian forest management from a timber product focus to a broad forest resources focus. As a result, services and non-timber products are being emphasized. Ecotourism is one of the services provided by the forest, and Indonesia has great ecotourism potential because of the extent of forests and beauty of the forested landscape. Since a main program of the Indonesian government is Social Forestry, it is suggested that ecotourism could be developed with the involvement of communities surrounding forest areas, to improve the local socio-economy and environment, including the sustainability of forests. This paper identifies the opportunities of forest resources for ecotourism related to the Social Forestry Program. New policies and strategies are presented.

**Sustainable recreation in threatened forest landscapes.** Visschedijk, P.A.M. (*Alterra Green World Research, Netherlands; peter.visschedijk@wur.nl*).

This cooperative research project between English, French and Dutch partners focuses on the relation between recreational use and the conservation of landscape values and wildlife habitats. During 2003 and 2004, data were gathered in the New Forest (UK) and Fontainebleau (F) on the recreational use, landscape values and wildlife habitats. Data collection involved the conventional methods of interviewing and counting visitors and inventorying flora and fauna, and also more sophisticated techniques—GPS tracking, remote sensing and GIS analysis. The main goals of the study were to reduce the recreational impacts on ecology and to implement a strategy of positive incentives to change the way people use sites with

high ecological quality. The data were analyzed using models, specially adapted for this study, that simulate recreational use and wildlife population dynamics. These models helped to optimize the balance between recreation and ecology, without the need of experimenting, and assisted forest managers in recreation and nature conservation decision making. Results of the analysis can also be used for communication with stakeholders—an important step in gaining their support.

**A field study on profiles and suggestions of tourists for sustainable mountain tourism in the Ukrainian Carpathians.** Yoshimura, T. (*Kyoto University, Japan; yoshimu@bre.soc.i.kyoto-u.ac.jp*), Styranivsky, O. (*Ukrainian State University of Forestry and Wood Technology, Ukraine; styran@forest.lviv.ua*), Potočnik, I. (*University of Ljubljana, Slovenia; igor.potocnik@Uni-Lj.si*), Bybljuk, N., Styranivsky, Y. (*Ukrainian State University of Forestry and Wood Technology, Ukraine*).

The Ukrainian Carpathians, located in southwestern Ukraine, attract many national and international tourists by providing opportunities of skiing and other outdoor activities. A questionnaire survey was conducted on the profiles and suggestions of summer tourists, visiting the top of Mt. Trostjan by ski lift facilities. The survey aimed to collect data on impressions and suggestions from tourists for the purpose of establishing sustainable mountain tourism. The results indicated that there were many visitors who came from eastern Ukraine (26%), and even from foreign countries (5%). The visitors brought economic benefits to the local people by spending typically 1–10 GRN on eating/drinking and horse riding. The most frequent response to questions regarding measures that should be taken for nature conservation in Mt. Trostjan was ‘cleaning.’ This comment reflected the current situation with considerable litter at the mountain top due to the lack of trash cans. In conclusion, it is essential for sustainable tourism to control the environmental impacts of visitors on nature. Measures to prevent littering should be taken because it damages not only the natural environment, but also tourists’ experience, which could result in the failure to encourage return visitors.

## **Forest policy research: New methodological and empirical developments in the last decade and priorities for the future**

Organizer: Birger Solberg *Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*

**Whither the United Nations Forum on Forests? Options for international forest policy in the future.** Corell, E. (*Swedish Institute of International Affairs, Sweden; ecorell@ui.se*), Persson, R. (*Swedish University of Agricultural Sciences, Sweden; Reidar.Persson@spm.slu.se*).

This paper explores the future development of international forest policy. Forest-related issues are addressed in several international agreements, but the negotiation process that currently focuses solely on forests is the United Nations Forum on Forests (UNFF). Over the past 10–15 years, political opinions have diverged on whether the multiple existing agreements on forests are enough, or whether there should be a binding convention on forests. This matter is to be determined at the fifth meeting of UNFF in 2005. This paper takes a fresh look at the international forest process. First, it explores the fact that there appears to be little consensus about why the international forest process is needed. Some argue that the international community needs: a global forum to discuss basic forestry issues, discussions between the Collaborate Partnership on Forests and different stakeholders, and reporting on developments in forest management. Second, the paper discusses how these needs can be met. The options are to: 1) close down the UNFF, 2) continue with the UNFF, 3) negotiate a forest convention, 4) negotiate a protocol under the biodiversity convention (CBD), or 5) combine the already existing binding and non-binding agreements. The paper finally discusses the outcome of UNFF–5.

**Forest policy research in developing countries.** Kaimowitz, D. (*CIFOR, Indonesia; d.kaimowitz@cgiar.org*).

Forest policies in developing countries have been a major focus of research in recent decades. However, the majority of the more rigorous work has been carried out by researchers from developed countries, often based in northern universities, NGOs and international organizations. Most developing country professionals working on forest policies in the tropics write mostly ‘grey literature’ (e.g. consultant reports, workshop proceedings). Few developing country journals focus on these issues. Most forestry research organizations in the developing world devote little attention to policy issues. The forest policy research agenda has evolved considerably over the last thirty years. The 1970s and 1980s saw a great deal of attention to fuelwood, which subsequently declined. Research on tropical deforestation has grown steadily since the early 1980s and become increasingly sophisticated in the models used. Forest concession reform, log export restrictions, forest valuation, integrating conservation and development, community forestry and common property, and non-timber forest products were major topics in the 1990s. Most recently there has been greater attention to illegal logging, payment for environmental services and forest certification, and to the links between



forests and poverty. Looking forward, southern professionals must play a greater role in setting the research agenda. For that to happen a new generation of southern leadership must emerge. International cooperation can facilitate that.

**Impact of the natural forest protection policy on the state forest enterprises and local communities: The case of Chang-bai Shan Forest Reserve, Ji Lin, China.** Cui, T.Y., Mochida, H., Masuda, M. (*University of Tsukuba, Japan; teiyan@sakura.cc.tsukuba.ac.jp*).

China has applied a nationwide forest conservation and rehabilitation program since 1998. Natural forest protection is a part of the program, which consists mainly of a logging ban based on a zoning system. Natural forest areas, however, had supported the most important timber producing centers, and the state owned logging enterprises had supported the local communities by providing all public services. Chang-bai Shan is one such timber producing center, and the logging ban and consequent decline of income has had a significant influence on local stakeholders. This report analyzes the economic impact of the natural forest protection policy by dividing stakeholders into three groups: management staff of the enterprise, forest workers and rural communities dependent on non-timber forest products. The circumstances that enabled the central government to impose this uncompromising measure will also be discussed.

**Futures research to support policy-decisions for the forest sector viability.** Niskanen, A. (*University of Joensuu, Finland; Anssi.Niskanen@joensuu.fi*).

Futures research was introduced in Finland in 2003 as a new instrument to identify the challenges and opportunities facing the forest sector in the next 10–20 years, and to identify the required political decision making for the sector to be successful. Scenario analyses were applied to five areas: forest industry, forest technology, silviculture, social sustainability and environment. Results indicate that the forest sector in Finland will face severe challenges in the next several decades due to globalization, constant increase in society's environmental values and aging of the baby-boom generation. Without doubt, globalization will increase the movement of investments of Finnish-based forest industries to countries with better comparative advantage—Asia, South America and Russia. Increases in environmental consciousness will challenge the wood production traditions in forestry, decreasing the supply of wood for the sector. The aging population will increase the pressure for the state to decrease publicly funded services for forestry. These trends call for radical changes in Finnish forest and industrial policies to keep the forest sector economically viable. The paper presents results of the scenario analyses, discusses the opportunities of foresight in policy research and draws conclusions on how current forest and industrial policies should be developed to better meet the future challenges.

**Legitimacy of Finnish forest and nature conservation policy: A mixed methodology approach.** Rantala, T., Rekola, M. (*University of Helsinki, Finland; tapio.rantala@helsinki.fi*).

This study focuses on describing and explaining the legitimacy of forest and nature conservation policy, which we suggest to be a theoretically and practically fruitful approach under the conditions that prevail in Finland and other Western countries today. With the concept of legitimacy, we refer to citizens' approval or rejection of different institutions of public policies. Despite the salience of legitimacy for forest policy making, very few empirically oriented studies existed until now. Our main goal is to reveal and understand differences, if any, between various citizen groups and public officials regarding the legitimacy of policy institutions. The empirical analysis focuses on four issues. First, what are Finnish citizens' perceptions of the legitimacy of current forest and nature conservation policy? Second, what are citizens' perceptions of the different institutions of public participation? Third, what are Finnish administrative officials' perceptions of the legitimacy of current policy institutions? Fourth, how do administrative officials perceive the relationships between themselves and the citizens? A mixed methodology approach is used to combine current theories of social and political science, including: macro-theories of legitimacy, qualitative interpretation theories and quantitative survey methodology with psychological measures. The survey data is modeled through confirmatory factor analyses and structural equations.

**Global forest ownership: Implications for forest production, management and protection.** Siry, J.P., Newman, D. (*University of Georgia, USA; jsiry@forestry.uga.edu; newman@forestry.uga.edu*), Cubbage, F.W. (*North Carolina State University, USA; fred\_cubbage@ncsu.edu*).

Many discussions in forest resource policy relate to the question of whether decisions regarding the production of forest outputs are more appropriately made by the public or private sector. At least in principle, public forests are managed primarily for public goods, including both productive and protective uses, while private forests are managed for private and toll goods. In addition, public forest management is often thought to be more responsive to social and environmental needs. We use forest ownership data to assess and quantify the impact of ownership on forest production, management and protection worldwide. Public ownership dominates both the global forest resource stock, and concurrently, much of the observed forest decline. This results from a presumed lack of resources, expertise, proper incentives and workable

regulatory approaches. It is also apparent that public policy failures are equally serious factors behind forest decline, as are market failures. In such cases, a greater reliance on private and communal property and free markets should be considered. We evaluate recent forest ownership changes and assess their strengths and weaknesses, focusing on forest tenure rights and their impact on management outcomes. We conclude by assessing the real impacts of ownership on forest management, and propose new approaches for using ownership policies to achieve management goals.

**Forest policy research in North America: New methodological and empirical results in the last decade.** Shannon, M.A. (*SUNY at Buffalo Law School, USA; mshannon@buffalo.edu*), Johnson, K.N. (*Oregon State University, USA*), Cashore, B. (*Yale University, USA*).

Forest policy research generally takes several forms. It can be aimed toward understanding how a policy was developed and implemented. It can be directed towards the dynamics of policy making processes in order to develop new policy frameworks in general terms. Or, it may undertake a focused analysis of specific policy proposals in order to inform policy makers. In this paper, we will survey the full range of research types in an effort to better understand how the field of forest policy analysis is changing. Certainly one factor that will be of special interest is the increasing involvement of social scientists and policy analysts within teams of scientists engaged in informing or developing integrated, ecosystem based policies. What kind of research characterizes the policy analysis component in these exercises? Our study will be based upon a survey of the literature informed by our experiences in analyzing policy processes and informing them. We plan to identify the kinds of methodologies used in policy research as well as to highlight their strengths and weaknesses within the frames of studying policy processes, creating general frameworks, or informing policy makers. Since our own research suggests that forest policy scientists are playing new roles as well as developing new methods, we are especially attentive to identifying new trends as we survey the literature. From this analysis, we expect to draw some conclusions regarding priorities for new methods, new frameworks of analysis and new theories of the policy process. We expect this paper to provide a coherent understanding of what is happening in North American forest policy research.

**Forest policy research in Europe: New methodological and empirical results in the last decade and priorities for the future.** Solberg, B. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*), Tikkanen, I. (*European Forest Institute, Finland; ilpo.tikkanen@efi.fi*).

The paper aims at identifying and classifying major methodological and empirical developments in forest policy research the last decade in Europe, based on literature review, and discuss promising future research areas. By forest policy research is meant research of the development and implementation of public policies that address the management of forests and rangelands. As such, forest policy research can be classified through its object of study, problem specification and scientific method used. Methodological development refers to a range of issues like the choice of behaviour theory for providing hypotheses, sampling procedures, statistical methods applied for testing hypotheses and type of models used for mapping interactions between nature and agents/institutions. It is argued that forest policy research should get stronger links to general policy research and the general disciplines like political science, sociology and economics, to assure that the most appropriate methods are applied. Forest policy research often involves considerations of rather complicated interactions over time between natural ecosystems and people, social systems and institutions, and a main challenge is to develop analysis tools that facilitate realistic analysis of such interactions.

## **Setting conservation targets in managed forest landscapes: Theory and practice**

Organizers: Marc-André Villard *Université de Moncton, Canada; villarm@umoncton.ca*, and Pierre Drapeau *Université du Québec à Montréal, Canada; drapeau.pierre@uqam.ca*

**Forest conservation targets for umbrella species: A systematic approach.** Angelstam, P., Roberge, J.-M. (*Swedish University of Agricultural Sciences, Sweden; per.angelstam@smk.slu.se; jean-michel.roberge@nsv.slu.se*).

To maintain viable populations of specialized species, knowledge is required about the necessary quantity and spatial configuration of different habitat elements at multiple scales. We present a systematic procedure for evaluating the idea of habitat loss thresholds, and discuss how such knowledge can be used for maintaining functional forest habitat networks. A systematic procedure for identifying thresholds involves five steps: 1) Stratify habitats as a function of their natural disturbance regimes. 2) Describe how anthropogenic impacts have affected the disturbances and habitat structures. 3) Identify a suite of specialized species. 4) For each vegetation type identified in step 1, combine steps 2 and 3 to look for the presence of threshold responses. 5) Communicate the results to stakeholders. The procedure can be employed, using different methods differing in resolution, accuracy and sample size. They include 1) geographical

comparisons using contemporary gradients in land use history; 2) comparisons of landscapes, which have radiated from their once common patterns of land use, and 3) historical retrospective methods. Using resident birds in the Baltic Sea region (northern Europe) as an example, we present how umbrella species can be identified and how conservation targets for the maintenance of forest biodiversity can be derived.

**Responses of birds and mammals to landscape forest cover: A test of the critical threshold hypothesis.** Bennett, A.F., Radford, J.Q. (*Deakin University, Australia; Andrew.Bennett@deakin.edu.au; Jim.Radford@deakin.edu.au*).

In regions where forests occur as extensive tracts, conservation strategies focus on measures to maintain habitat quality. However, in many regions, such as the dry forests of central Victoria, Australia, managed forests together with conservation reserves and other forest types are interspersed amongst cleared land. The extent of forest habitat in the landscape then becomes an important influence on conservation values, with theory suggesting disproportionate loss of species when habitat cover decreases to 10–30% of the landscape. To test whether there are critical ‘thresholds’ in forest cover, we systematically surveyed birds and mammals in 24 landscapes (each 100 km<sup>2</sup>) that sampled a gradient in cover from <2% to 60%. We examined the relationship between forest cover, forest configuration and species richness for bird and mammal assemblages, and for individual species in each group. There was strong evidence for a threshold response in richness of woodland birds below 12% forest cover, indicating concurrent loss of multiple species in landscapes below the threshold. However, individual species demonstrated a range of response types (e.g. linear, curvilinear, threshold) and threshold levels. The response of the native mammal assemblage is tempered by major decline or regional extinction of numerous species, now leaving mainly generalist species.

**Boreal bird responses to forestry and natural disturbances in fragmented landscapes of eastern Canada.**

Drapeau, P. (*Université du Québec à Montréal, Canada; drapeau.pierre@uqam.ca*).

We examined patterns in the response of forest birds in naturally disturbed (fire) and managed (clearcutting) boreal landscapes. We measured bird abundance in 430 stations across a gradient of regional forest cover that ranged from less than 15% to more than 65% of forest cover. We used logistic regressions and Akaike information criterion (AIC) to hierarchically select the models that best explain species-specific response to vegetation variables reflecting habitat alteration at stand and landscape scales. Separate analyses were conducted for sites altered by natural disturbances and forestry. For species showing significant responses to gradients in forest disturbance, we then used ROC (receiver-operating characteristic) analysis to determine habitat threshold values. To propose numerical targets for conservation planning that may reflect species tolerance to the range of habitat alteration generated by natural disturbances, we then compare these thresholds between types of habitat alteration (natural and anthropogenic). Finally, within the sites embedded in a managed landscape we compare habitat thresholds values determined for the presence/absence vs. the reproductive activity (fledgling broods) for a subset of target species. This will provide an empirical test on how presence/absence of habitat thresholds may or may not underestimate species habitat requirements for population persistence.

**Influences of stand and landscape structure on habitat use of wildlife in managed forests in southern Japan.** Ito, S., Masunaga, L. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp; as2146u@student.miyazaki-u.ac.jp*).

More than 40% of the forested land in Japan comprises plantations. These commercial plantations provide a considerable national resource of industrial wood such as Sugi (*Cryptomeria japonica* D. Don) and Hinoki (*Chamaecyparis obtusa* Endl.). However, the establishment of extensive areas of even-aged monocultures has resulted in a simplified forest and landscape structure of low biodiversity. In Japanese plantations, many studies have been reported for plant species diversity in relation to stand management and landscape design. However, much less information is available on wildlife habitat in the managed forest landscapes. In this study, we investigated wildlife habitat by using sensor cameras placed in mosaics comprised of conifer plantations and mixed evergreen-broadleaved semi-natural forest patches in order to detect the key wildlife species and the factors associated with the habitat. The results indicated the importance of both complexity of the stand structure of plantations and connectivity of semi-natural forest patches for richness and abundance of wildlife communities. Based on these results, we propose an optimal strategy of patch arrangement and stand manipulation for conservation of the detected key species in the managed forest landscapes.

**Setting conservation targets in managed landscapes.** Lindenmayer, D. (*Australian National University, Australia; davidl@cres.anu.edu.au*).

This paper synthesizes the topics covered by the presenters in this session. It will encompass a range of topics including reserve targets, ecological thresholds, legacy retention targets and other approaches for setting targets in managed forests.

**Influence of tree species for species composition of soil inhabiting mites (Acari) and nematodes (Nematoda).**

Skorupski, M., Dobies, T., Wierzbicka, A. (*August Cieszkowski Agricultural University, Poland; maskorup@owl.au.poznan.pl; tomDOB@owl.au.poznan.pl; wierzbaa@wp.pl*).

In the Forest Experimental Station in Siemianice, Poland, 14 selected species of forest trees were established in a 2.4 ha-plot approximately 30 years ago. Previously in these places, pine monocultures were growing and pH of the soil was 4.2. The experimental forest is unique; the environmental conditions within the forest are uniform and only the tree species are different. Differing types of ground cover were formed in the small plots (0.04 ha each) under individual tree species. The aim of the study was to determine whether there were any differences between mite and nematodes species compositions in the area depending on tree species. A total of over than 5000 mesostigmatid and oribatid mites representing 70 species, and over 5000 nematodes representing 25 species were collected from these experimental areas. The results indicated that the development of different soil environments under the canopy of the studied tree species are important for mites and nematodes.

**Thresholds in bird response to forestry as conservation targets in a hemiboreal forest of eastern Canada.** Villard, M.-A., Guénette, J.-S. (*Université de Moncton, Canada; villarm@umoncton.ca*).

Birds represent a large proportion of terrestrial vertebrate species in forest ecosystems and they can be surveyed efficiently over large spatial scales. To propose numerical targets for conservation planning, we examined patterns in the response of woodpecker and passerine species to gradients in harvesting intensity, both at stand and landscape scales. We surveyed birds at 650 stations in a managed hemiboreal forest landscape of northwest New Brunswick. Conifer stands were treated through clearcutting with retention patches followed by spruce plantation, whereas deciduous stands were treated using selection systems or patch cuts. We used logistic regression models to examine species-specific response to either PCA axes or individual variables reflecting habitat/landscape alterations associated with forestry. For species showing significant responses to habitat alteration, we used ROC analysis to determine threshold values. At the species level, we distinguished three types of thresholds corresponding to different degrees of saturation of suitable habitat. When compiled for a species assemblage, such thresholds provide empirical tradeoffs between conservation and fibre extraction. They are also very useful to map habitat suitability for species or assemblages. Future research should test the spatio-temporal consistency of these thresholds, as well as the underlying processes.

**Forest reserves as a reference for forest ecosystem management.** Wijdeven, S.M.J. (*Alterra – Centre for Ecosystem Studies, the Netherlands; Sander.Wijdeven@wur.nl*).

Forest ecosystem management depends on a sound understanding of natural dynamics and potential developments. Old growth (OG) is an important reference of natural dynamics, and forest reserves are an effective tool to study these long term dynamics. The Dutch Forest Reserves Network encompasses 60 reserves and includes research plots in OG such as Fontainebleau (FR). Fontainebleau is one of the least disturbed beech forests in northwest Europe. Monitoring indicates a long-term cyclic regeneration pattern is slowly leveling off due to historical influences. Nowadays, gap areas vary between 7–23%, and dead wood levels between 120–160 m<sup>3</sup>/ha. Recruitment occurs in all development phases, with many individuals showing flexible growth patterns. This may have negative consequences for stem form and possibly induces increased branch fall and more fine-scaled disturbance patterns. These developments offer key reference points. However, OG cannot cover the whole potential development spectrum. Present stands will develop from a different starting point than reference OG with an altered available species pool. These forests could thus be typified as ‘New Growth’. Forest Reserve Networks should include, next to OG, actively managed stands, covering sites of potential development to guide forest ecosystem management.

**Sustainable management of high-value timber species of the Meliaceae:  
A global perspective**

Organizer: Sheila Ward *Mahogany for the Future, Inc., Puerto Rico; seward@caribe.net*

**Genetic (AFLP) diversity in Peruvian populations of *Cedrela odorata*: Implications for conservation.** de la Torre, A., López, C. (*Universidad Nacional Agraria “La Molina”, Peru; amandadltc@hotmail.com; cflb@lamolina.edu.pe*), Cornelius, J.P. (*World Agroforestry Centre, Perú; j.cornelius@cgiar.org*).

*Cedrela odorata* L. is an economically important timber species native to Central and South America. Natural populations in Peru have been severely reduced due to increased selective logging, which it is thought has led to loss of genetic diversity. Nevertheless, no information is available regarding the genetic structure of *Cedrela odorata* in South

America, although the region harbours most of the unlogged populations of the valuable species. In the present study, amplified fragment length polymorphism (AFLP) variation within and between nine widely dispersed Peruvian populations of the species is reported, as well as the degree of genetic variation between riparian and upland ecotypes. The implications of these results for the in situ conservation and use of its genetic resources are discussed.

**Perspectives on the management of *Hypsipyla robusta* in the Asia Pacific region.** Griffiths, M.W. (*Department of Primary Industries and Fisheries, Queensland, Australia; manon.griffiths@dpi.qld.gov.au*), Cunningham, S.A. (*CSIRO Entomology, Australia; saul.cunningham@csiro.au*), Wylie, F.R. (*Department of Primary Industries and Fisheries, Queensland, Australia; ross.wylie@dpi.qld.gov.au*), Floyd, R.B. (*CSIRO Entomology, Australia; rob.floyd@csiro.au*).

Worldwide, shoot borers in the genus *Hypsipyla* are the greatest deterrent to growth of high-value trees of the Family Meliaceae, subfamily Swietenioideae. In the Asia Pacific region, damage from *H. robusta* has effectively prevented the commercial growing of the endemic *Toona* and *Chukrasia* spp., as well as a range of introduced species. In 1999 a series of genetic resource and mixed planting trials were established in several countries in the region (Australia, Thailand, Lao PDR, Philippines and Vietnam). During the trials, *H. robusta* damage was intense, and after five years few trees were free of attack. However there were differences between species, seedlots and individual trees in the frequency of damage, and in the growth performance of trees. We observed geographic variations in host preference between regions, in particular a preference for endemic hosts, and identified chemical differences between trees according to the level of damage sustained. The trials also provided important information on the seasonality and intensity of damage. Mixed planting trials have confirmed that damage levels are reduced and recovery enhanced on trees grown in the shade compared with those in open plantings. Results from these trials have provided important information relevant to the management of this species.

**Assessing the potential for genetic resource loss in *Swietenia macrophylla* and *Cedrela odorata* (Meliaceae): a review of range-wide and landscape-scale molecular marker studies.** Lowe, A. (*University of Queensland, Australia; a.lowe@uq.edu.au*), Cavers, S. (*Centre for Ecology and Hydrology, UK; scav@ceh.ac.uk*), Navarro, C. (*Centro Agrónomico Tropical de Investigación y Enseñanza (CATIE) Costa Rica; cnavarro@catie.ac.cr*).

Molecular marker surveys allow detailed description of genetic diversity and its partitioning within and between natural populations. In addition, combining information from surveys of variation at the range-wide and landscape scales allows assessment of both contemporary genetic diversity and gene flow dynamics set within the framework of the evolutionary history of the species. The Meliaceae species *Swietenia macrophylla* and *Cedrela odorata* are genetically some of the best studied tropical trees in the world, and have been subjected to extensive surveys of variation within natural and exploited populations. At a range-wide scale, chloroplast DNA variation and whole-genomic markers indicate significant genetic discontinuities across the ranges of both species. Pollen and seed dispersal mechanisms have established significant structuring of variation at the fine spatial scale, and extraction and habitat fragmentation pressure have the potential to reduce genetic diversity at the population level. The interpretation of these results, and their implications for provenance movement and for mitigation of genetic resource loss in reforestation programmes, are discussed within the context of a new European–Latin American collaborative project—SEEDSOURCE.

**Genetic trials for mahogany and Spanish cedar in Costa Rica and Mexico.** Navarro, C. (*Centro Agrónomico Tropical de Investigación y Enseñanza (CATIE), Costa Rica; cnavarro@catie.ac.cr*), Ward, S.E. (*Mahogany for the Future Inc., Puerto Rico; seward@caribe.net*), Wightman, K.E. (*Managua, Nicaragua; kevin\_wightman@hotmail.com*), Santiago, B.R. (*Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), México*), Hernández, G. (*Centro Agrónomico Tropical de Investigación y Enseñanza (CATIE), Costa Rica; ghermand@catie.ac.cr*).

Since mahogany and Spanish cedar are in high demand as fine cabinet woods, collections and trials have been implemented in Mesoamerica for conservation and genetic improvement. In 1996 and 1998, collections were made of 300 families of mahogany and 259 of Spanish cedar from the Yucatan in Mexico to Panama. Varying groups of progenies of both species were planted out in genetic trials at several sites in Costa Rica and the Yucatan peninsula using (usually) a randomized block design with 20–30 individuals total per family. The traits considered included height, diameter, shoot borer attack, form and branching. On a site-by-site basis, individual heritability for height ranged from 0.21–0.61 for Spanish cedar and from 0.31–0.55 for mahogany. Diameter heritabilities were usually somewhat less. Differences among progeny groups in amount of shootborer attack seemed to depend on the method of measurement. Heritabilities for branching and form were usually intermediate to those growth and attack. A unique genetic trial in Costa Rica demonstrating the potential of Spanish cedar as coffee shade has implications for mixed species plantings. The results from these trials should encourage attempts for genetic improvement in these species.

**Superior genotype selection in *Toona ciliata*: The green gold of Himalayas.** Rana, V., Atul (CSK Himachal Pradesh Agricultural University, India; [atul@hillagric.ernet.in](mailto:atul@hillagric.ernet.in); [atul1028@email.com](mailto:atul1028@email.com)).

*Toona ciliata* (Toon) is an important agroforestry species in Himachal Himalayas and is largely cultivated for farm-grown timber, occasionally lopped for fodder and fuel purposes. The annual requirement of wood is 280 million m<sup>3</sup> against the supply of 52 million m<sup>3</sup>. So, the work on alternate sources of timber has assumed special significance. Toon has great potential to meet the growing demand for small timber and other wood products. Dysgenic selection for superior genotypes is leading to the erosion of the valuable genes. Therefore, there is an urgent need to select superior genotypes from plantations as well as from scattered natural populations to select and conserve superior genotypes for sustaining productivity. This study was undertaken to determine the variability for different phenotypic characters among different altitudinal seed sources. The study indicated vast variation in seed colour, ranging from near black, mustard brown to cream. The weight of 100 seeds varied between 0.144 g for the Palampur seed source and 0.434 g for the Mandi (Dhelu) seed source. Leaf length varied between 27.72 and 36.69, while number of leaflets per leaf varied from 14.34 to 20.5. Seed source from the HP-V(b) zone was judged to be superior on the basis of these traits.

**Twenty years of advances toward sustainable silviculture of mahogany (*Swietenia macrophylla* King) in natural tropical forests: Synergies between communities and international researchers in Mesoamerica.** Snook, L.K. (CIFOR, Indonesia; current address International Plant Genetic Resources Institute, IPGRI, Italy; [l.snook@cgiar.org](mailto:l.snook@cgiar.org))

The most commercially important timber species in the neotropics, mahogany (*Swietenia macrophylla* King), is at the crux of debates about the feasibility of sustainable forest management in the tropics. CITES listing in 2003 requires that producing countries develop sustainable production systems. The most advanced efforts to produce mahogany timber sustainably from natural forests are those of communities that harvest multiple products from 800,000 ha of production forests on Mexico's Yucatan peninsula. Over the past 20 years, their foresters have developed inventories and management plans, and overseen enrichment planting efforts, while researchers have established experiments and studies to evaluate management alternatives. Seven years of research focused on mahogany regeneration have revealed that mahogany trees over 75 cm DBH are the most important seed producers, but are being depleted by selective harvesting with a minimum diameter limit of 55 cm. Establishment and survival of mahogany regeneration was favoured on clearings of 5000 m<sup>2</sup> produced by machinery or burning, which impeded resprouting by trees of other species, but seedlings did not survive under the forest canopy. Researchers, foresters, government agencies and communities are collaborating to integrate these new findings into revised management guidelines, and make corresponding modifications to forestry-related policies.

**Late growth of planted *Swietenia macrophylla* in Puerto Rico.** Wadsworth, F.H. (USDA Forest Service, Puerto Rico; [fwadsworth@hotmail.com](mailto:fwadsworth@hotmail.com)), Gonzalez, E. (Department of Natural Resources and Environment, Puerto Rico; [g\\_edgardo@hotmail.com](mailto:g_edgardo@hotmail.com)), Ward, S.E. (Mahogany for the Future, Inc., Puerto Rico; [seward@caribe.net](mailto:seward@caribe.net)).

Tropical climate is commonly associated with rapid tree growth. The case of 6-year clones of eucalyptus for fiber is an example. Promoters of teak have claimed cabinet wood rotations as short as 25 years. There are reasons to question such claims. Processors consider young wood to be no substitute for that from old trees. Traditional use and termite resistance of the principal species are limited to the heartwood, suggesting low yield of usable volume from small trees. There is a need for integration of reliable physical and economical data into decisions as to when to harvest. An example from a plantation of *Swietenia macrophylla* in Puerto Rico with some 60 trees from 40–65 years old is presented. Not only did 65-year-old trees withstand a hurricane, but the plantation has continued to increase the annual production of heartwood. It is well known that tree value increases with size. However, value per cubic meter increases faster than volume due to larger dimensions of useful wood. This example provides further argument for delaying harvest of healthy plantation trees.

## Environmental concerns of forest products utilization

Organizer: K. Mahabala Bhat Kerala Forest Research Institute, India; [kmbhat@kfri.org](mailto:kmbhat@kfri.org)

**Inventory analysis of adhesives used for wood-based materials.** Ando, K., Sawada, Y., Hattori, N. (Tokyo University of Agriculture and Technology, Japan; [andok@cc.tuat.ac.jp](mailto:andok@cc.tuat.ac.jp); [y-sawada@cc.tuat.ac.jp](mailto:y-sawada@cc.tuat.ac.jp); [hattori@cc.tuat.ac.jp](mailto:hattori@cc.tuat.ac.jp)), Tamura, Y. (Akita Prefectural University, Japan).

To assess the environmental loads of a wooden material, it is necessary to know the chemical loads of adhesives. However, we cannot find reliable data. Therefore, five popular adhesives for wooden materials—urea resin (UF), melamine-urea co-condensed resin (MUF), phenol resin (PF), phenol-resorcinol resin (PRF) and aqueous polymer isocyanate (API)—were analyzed in accordance with the inventory analysis. Energy consumption and emissions of

CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>x</sub> were calculated for each resin per 1 kg whose unit processes consist of production from raw materials. It became clear that PRF had the highest energy consumption and emission of SO<sub>x</sub>. Little difference was observed between UF and PF energy consumption and SO<sub>x</sub> emission. CO<sub>2</sub> and NO<sub>x</sub> emissions of PRF and API were remarkably high—more than twice as high as the other resins. It is highly recommended that environmental loads of adhesives be judged by functional unit rather than by weight.

**Dimensional movement of coffee residue based cement-bonded boards in response to moisture.** Babatunde, A. (*Federal University of Technology, Nigeria; babatundeajayi2000@yahoo.com*).

Cement-bonded ceiling boards, 6 mm thick, were produced from coffee waste at a cement/coffee waste ratio of 2.0:1, 2.5:1 and 3.0:1, with board densities of 950, 1050 and 1150 kg/m<sup>3</sup>. Ceiling boards were soaked in water for 24 hours in order to assess their responses to thickness swelling (TS), water absorption (WA) and linear expansion (LE) properties. Increases in the cement/coffee waste ratio and board density caused decreases in thickness swelling, water absorption and linear expansion. The average values obtained for these properties ranged from 0.32–0.76% for TS; 8.32–12.85% for WA and 0.13–0.27% for linear expansion. Generally, all the boards produced responded to changes in environmental condition but boards produced at the highest levels of cement/coffee ratio (3.0:1) and board density (1150 kg/m<sup>3</sup>) showed highest resistance to water intake and movement. This demonstrates that boards produced at these levels are more dimensionally stable and can be used under moist conditions without necessarily disintegrating into particles. The study also revealed that waste from coffee and other agricultural wastes can be used to produce ceiling boards after hot water pretreatments.

**ForestSAFE: demonstration of the use of satellite images, estimations and the www in forestry to protect nature and prevent environmental accidents.** Björk, L. (*Regional Forestry Board of Västerbotten, Sweden; lars.bjork@svsac.svo.se*), Donoghue, D.N.M. (*University of Durham, UK; danny.donoghue@durham.ac.uk*), Hagner, O., Olsson, H., Nilsson, M. (*Swedish University of Agricultural Sciences, Sweden; Olle.Hagner@resgeom.slu.se; Hakan.Olsson@resgeom.slu.se; Mats.Nilsson@resgeom.slu.se*).

ForestSAFE is an international project funded by the EU LIFE–Environment program which aims to demonstrate new remote sensing aided methods and technologies for environmentally friendly forest management. The project is carried out within an international partnership between nine institutions involving researchers and foresters from Sweden and the United Kingdom. The project aims to develop practical data acquisition methods that combine satellite imagery and ground survey data, and to demonstrate how public authorities, forest companies and private forest owners can access up-to-date forestry and landscape information. Satellite images from Landsat ETM+ and SPOT HRVIR were used in combination with field data to map forest parameters such as total stem volume, stand age and tree height. To improve the quality of the estimated parameters, new estimation methods have been developed that include ancillary data from old forest maps, lidar, radar and aerial photographs. Methods for monitoring changes in the forest landscape and for following the development of regeneration using satellite images from different years have also been developed. An important part of the project has been to demonstrate how up-to-date forest and protected area information can be provided to users through the internet.

**Challenges facing forest certification and eco-labeling of forest products in developing countries.** Durst, P.B., McKenzie, P., Appanah, S. (*FAO, Thailand; Patrick.Durst@fao.org; Philip.Mckenzie@fao.org*).

Certification was developed as an instrument for promoting sustainable forest management. Although the initial focus of certification was on tropical forests, it has gradually shifted to encompass all forest types. Ten years after the first certification schemes were developed, most (92.5 percent) of the 230 million ha of forest that have been certified are located in Europe and North America, while the rest is located in developing countries. This paper examines the causes for this divergence, and the principal challenges facing forest certification in developing countries. First, many developing countries have weak enforcement of national forest legislation and policies, often resulting in low forest management standards. Second, there is often insufficient capacity to implement sustainable forest management at the forest management unit level. Third, the cost of certification for these countries remains prohibitive. Finally, there is insufficient market demand for certified products on the global market. The paper further examines why many developing countries are interested in certification despite the difficulties. It concludes by looking at some promising opportunities for moving forward, such as the codes of forestry practice, stepwise approaches to certification, group certification for small holders and prospects for increasing demand for certified products in Asia.

**Forest residues: a global analysis for tropical forests.** Dykstra, D.P. (*USDA Forest Service, USA; ddykstra@fs.fed.us*).

Forest residues produced as a consequence of industrial timber harvesting operations represent both an environmental problem and an opportunity cost. Excessive production of residues reduces profitability and may inhibit the recovery of

the forest after logging. Recent studies of extensive fires in Indonesia suggested that heavy accumulations of forest residues from logging operations made the fires much worse than they would have been in undisturbed forests. Based on a comprehensive FAO study, estimated forest residues produced during 2000 in 84 tropical countries were 4.8 times higher per cubic meter of industrial roundwood produced than in the temperate forests of the United States. Although this is partially due to inherent differences between tropical and temperate forests, it suggests that there is considerable scope for reducing tropical forest residues through improved harvesting operations. The FAO study indicates that in tropical forests, an average of approximately 42% of the tree volume felled is eventually delivered to processing facilities or other destinations as industrial roundwood. A reasonable short-term goal might be to increase the recovery rate in tropical forests to around 60% by adopting improved harvesting practices such as those promoted through the FAO Model Code of Forest Harvesting Practice.

**Recovered wood: the environmental strategy.** Frühwald, A. (*University of Hamburg, Germany; a.fruehwald@holz.uni-hamburg.de*).

Solid wood products after-use are subject to either energetic use (burning), material recovery, or deposition in landfill sites. Many countries are preparing regulations for directing recovered wood, either towards recycling or energy. This study, in Germany, dealt with a comparative assertion of strategies bringing recovered wood toward the three alternatives. The LCA Life Cycle Assessment Methodology was applied. The results, independent from contamination of recovered wood, showed: energy uses are best, followed by recycling into particle boards and last, land filling. German and European legislators are presently considering these results.

**Paper trails: environmental regulation of the pulp and paper industry in a global economy.** Harrison, K. (*University of British Columbia, Canada; harrison@politics.ubc.ca*).

Approximately one quarter of the global roundwood harvest is used by the pulp and paper industry, one of the five most pollution intensive industries in the world. The shift of a growing fraction of production in this international industry to developing countries in Asia and South America, which have traditionally had weak environmental standards, raises the spectre of a 'race to the bottom' in environmental standards. This paper begins to fill the gap between the abundant theorizing that has taken place concerning the 'race to the bottom' and the scant empirical evidence, through examination of environmental regulation of the pulp and paper industry in five countries – Canada, the United States, Sweden, Australia and Indonesia. The case studies demonstrate that domestic standards have neither converged at the top nor the bottom. Rather, the unique political and institutional context within each country has ensured persistent differences. However, to the extent that global forces have influenced those standards, it is the upward pressures that have prevailed. First, international dissemination of research via trans-national networks of environmentalists and bureaucrats exerts upward pressure in each of the countries studied. Second, environmental groups generated consumer demand for 'chlorine-free' paper, which in turn created market pressure for improved environmental performance around the world.

**Recycling solid residues from paper pulp mills: Quantitative assessment of plant-nutrient recovery and heavy-metal contamination.** Rothpfeffer, C., Karlton, E. (*SLU, Sweden; caroline.rothpfeffer@sml.slu.se; erik.karlton@sml.slu.se*).

Increased recycling of nutrients may be achieved through the use of solid residues from paper-pulp mills as mineral fertilizers. We compared the amount of nutrients and heavy metals entering pulp-mills in wood chips with the amount of nutrients and heavy metals found in the residual products through a mass-balance analysis of input and output streams of three paper-pulp mills producing between 380 and 680 Mton of paper pulp/yr. If green-liquor sludge, lime-grit and discarded lime-mud are recycled to the forest, 163% of the Mg, 77% of the P and 5% of the K coming in with the wood-chips can be returned to the forest. The high figure for Mg is caused by additions of MgSO<sub>4</sub> in the pulp-making process. K is mainly lost through the waste water. Mixing the ash from the separately burnt bark with the other residual products will improve the nutrient balance in the recycled product. The amount of heavy metals returned to the forest through the recycling was 102% Pb, 120% Cr, 75% Cd and 53% of the Zn coming in with the wood chips, which means that the recycling will mean no or small net additions of heavy metals to the forest.

**Utilization of bark from industrial tree plantation species in the Philippines.** Tamayo, J.P. (*Forest Products Research and Development Institute (FPRDI), Philippines; jnytamayo@yahoo.com*), Flavier, M.E. (*University of the Philippines Los Baños, Philippines; meflavier@yahoo.com*).

The Philippines produce considerable waste bark from 653,000 ha of government and private industrial tree plantations. Comprising 10–20% of the trunk's total volume, bark remains an untapped resource. This paper reports on a study of the potential of bark to remove heavy metals in the wastewater of a galvanizing plant, using the bark of eight



tree species—*Acacia mangium*, *Eucalyptus deglupta*, *E. camaldulensis*, *Paraserianthes falcataria*, *Endospermum peltatum*, *Anthocephalus chinensis*, *Samanea saman* and *Gmelina arborea*. The adsorptive capacity of the bark of industrial tree plantation species (ITPS) in removing heavy metals in wastewater from a galvanizing plant followed the order: Pb > Cr > Cu > Zn. The bark of all the ITPS selectively removed Pb<sup>2+</sup> ions. The removal of metals ranged from 20–49% Zn (II), 61–81% Cu (II), 84–90% Cr (VI) and 96–100% Pb (II). This study indicates that waste bark from tree plantations can be used to clean toxic metals from polluted water.

**Economic compensation of forest watershed environmental benefits: Analyzing the effect on forest management and social welfare at different compensation levels.** Wu, S. (*Chinese Academy of Forestry, P.R. China; wushr2000@263.net*).

This paper examines the issue of economic compensation for environmental benefits arising from forest watershed resources of Muchuan County of Sichuan Province, Qilianshan national protected area and Miyun County of Beijing City, using the Faustmann-Hartman forest resource model. Based on literature review, field experiments, time series of ecological data, timber price, production cost and econometrics, forest resource evaluation methods were adopted to determine the environmental and timber benefit functions for different forest age classes. On the basis of these deduced functions, the changes in the quality of forest management and the degree of social welfare of relevant stakeholders at different compensation levels, with and without transaction costs, are analyzed. Results indicate that when the compensation level is between 2–10% of environmental benefits of forest resources there are significant improvements in environmental quality, managers' benefits and social welfare of the stakeholders, and higher compensation levels cause further enhancements. Compensation levels are selected on the basis of the stage of economic development of the area in question, with their enhancements undertaken in steps. When transaction costs are taken into consideration, the benefits of stakeholders are reduced. The effect of transaction costs on the benefits of stakeholders is considered acceptable within the range of 10–50% of the environmental benefits of forest resources.

## **Building synergies between institutions and conventions dealing with Non-Wood Forest Products**

Organizers: Jim Chamberlain *USDA Forest Service, USA; jachambe@vt.edu*, Brian Belcher *CIFOR, Indonesia; b.belcher@cgiar.org*, Paul Vantomme *FAO, Italy; Paul.Vantomme@fao.org*, and Maxim Lobovikov *International Network for Bamboo and Rattan (INBAR), China, and Common Fund for Commodities (ICB CFC), China; mlobovikov@inbar.int*

**A product approach for developing institutional capacity.** Lobovikov, M. (*International Network for Bamboo and Rattan (INBAR), China, and Common Fund for Commodities (ICB CFC), China; mlobovikov@inbar.int*).

International Network for Bamboo and Rattan (INBAR) is an international organization with the main mission to improve well-being of producers and traders of bamboo and rattan – the two major non-wood forest products (NWFP). History of INBAR is 25 years old. Originally it was established as a primarily research-based organization and gradually changed its focus to development issues. In 1997 INBAR was officially inaugurated as an international organization with the headquarters in Beijing (China) and currently it has 28 member countries. INBAR has built its program structure and institutional capacity using a product approach unlike 'process' approach used by many other development organizations and NGOs with broader missions. The same approach was successfully used to develop institutional capacities of the INBAR project partner institutions in the member countries. The product approach for developing institutional capacities is practiced directly (through developing the new products and supply chains) and indirectly (through improving the commodities' business environment). A qualitatively new phase in the product approach development started in October 2000 when INBAR became an International Commodity Body of the Common Fund for Commodities – a UN financial instrument. The product approach has been used to shape a new commodity strategy of the organization.

**Informing decision-making for successful NTFP commercialization: Research findings and policy implications from Mexican and Bolivian case studies.** Marshall, E. (*UNEP-WCMC, UK; Elaine.Marshall@unep-wcmc.org*), Newton, A. (*University of Bournemouth, UK; ANewton@bournemouth.ac.uk*).

Whilst interest in NTFP commercialization as a rural development option continues to grow, initial enthusiasm is increasingly being tempered by a growing realization that many attempts fail to deliver the expected benefits. There is therefore a growing need for information and tools to support the decisions being made by a wide range of

stakeholders, including local communities, development and conservation agencies, government agencies, NGOs and the private sector institutions involved in trading and marketing forest products. Objectives need to be set on what criteria constitute 'a success' and information is needed to guide the selection of NTFPs for development, and how and where investments should be targeted. Our multidisciplinary, multi-stakeholder research project has developed a decision support tool in the form of a Bayesian Belief Network that represents the different processes involved in commercialization of a typical NTFP. These include production, collection, processing, storage, transport, marketing and sale. The factors influencing the probability of success at each stage of the chain are represented in the model, enabling their relative impacts to be evaluated. Success in this context can be defined in a variety of ways, including positive impacts on poverty reduction, gender equity and access to and conservation of forest resources.

**Analysis of policies and regulations governing Non-Timber Forest Products (NTFPs).** Razal, R.A., Peralta, E.O. (UPLB College of Forestry and Natural Resources, Philippines; *cfnr@yahoo.com*; *eoperalta@yahoo.com*), Villanueva, M.M.B., Dolom, P.C., Camacho, S.C. (UPLB College of Forestry and Natural Resources, Philippines; *lyn\_bvillanueva@yahoo.com*; *bldolom@yahoo.com*).

This study assesses existing policies and regulations that govern the country's NTFPs. Problems, issues and conflicts of policies are solicited from the NTFP permit holders and key stakeholders. Lessons and experience learned about propagation, production, harvesting, processing and marketing are compiled by using structured questionnaires. Eighteen permit holders and 18 stakeholders from five regions of the country were interviewed. NTFPs studied were almaciga resin, pili resin, buri, rattan, bamboo, anahaw, hinggiw and honey. Study sites were selected based on the availability of permits in the area. The study found that: a) there is no comprehensive inventory of NTFPs, therefore locations of NTFPs and possible revenue to the government cannot be determined; b) lack of a program on insuring sustainable yield, like replanting and assisted natural regeneration may contribute to the loss of more NTFPs; c) too many checkpoints entails additional cost on the part of the licensees; d) existing policies on NTFPs need to be revised; e) there is lack of DENR personnel to man NTFP areas; and f) there are conflicts in the implementation of policies by DENR and LGUs.

**Challenges and constraints to building government-private sector partnerships in NTFP research.** Smith, R., Cameron, S. (Natural Resources Canada; *rosmith@nrcan.gc.ca*; *scameron@nrcan.gc.ca*).

Government and academic scientists are increasingly encouraged to seek private sector funding. The factors and potential conflicts that may constrain or limit the formation of effective partnerships, may include, but are not limited to: a) intellectual property (IP) rights – the industrial need for confidential IP for commercial advantage may be at odds with the government/academic mandate to publish the research; b) agency mandates – research for the public good may conflict with research which must demonstrate an immediate or short-term economic benefit to the industrial partner; c) markets – the time required to complete scientifically credible studies is typically too long to accommodate the partners' new needs that arise from changes in markets and or product lines; d) science and technology transfer – rapid, effective technology transfer to the industrial partner sometimes must be provided before complete answers are available; and e) commitment to the partnership – changes in the priorities and/or policies of government and academic institutions may make it difficult for the researchers to continue R&D efforts on a project and still stay within institutional mandates. This paper will discuss the above factors, citing examples from the CFS and others whereby logistical, policy and priority differences have been reconciled to produce successful NTFP partnerships.

**The impact of cross-sectoral policies and institutional aspects of NWFPs.** Vantomme, P. (FAO, Italy; *Paul.Vantomme@fao.org*).

Despite the reference to 'forest' in its term, Non-Wood Forest Products (NWFPs) are increasingly being (commercially) produced outside 'forests' and by people more linked to farms than to 'forests'. NWFP are traditionally considered to be a 'forestry' issue and are supposedly governed by 'forestry' institutions and regulations. This approach may have been more or less appropriate and technically feasible in the past from a silvicultural, environmental and socio-economic point of view. However, it becomes less and less applicable today and might become even counterproductive in the future. The growing cross-sectoral impacts on forests and NWFP in particular, such as the increasing globalization of production and liberalization of trade (in agriculture products, and which includes NWFP) on the one hand, combined with the rapidly growing awareness and initiatives to protect global (forest-based) biodiversity (and related indigenous knowledge/livelihoods) on the other hand, result in a conflicting 'development versus conservation' status-quo for many NWFP species. NWFPs do cover a wide range of different products for different uses, such as food, medicines, fibers or recreation and as such, their development and conservation agenda requires a wide range of inter-disciplinary skills and approaches much beyond the institutional capacity and mission of forest agencies in many countries.

**Ozone exposures and effects on forest vegetation: A global overview**Organizer: Marcus Schaub *WSL, Switzerland; marcus.schaub@wsl.ch***State-of-the-art of ozone exposures and effects on forest vegetation within the Asian region.** Aoki, M. (*Tokyo University of Agriculture and Technology, Japan; aoki.mas@cc.tuat.ac.jp*).

Natural forest decline of deciduous and coniferous trees is often found in mountainous areas in Japan. We monitored tropospheric ozone (O<sub>3</sub>) from spring through summer seasons for about five years on the ridge of the Tanzawa Mountains at approximately 1600 m above sea level, where beech forest decline is a serious threat and were measured O<sub>3</sub> concentrations often exceeding 100 ppb. During the five years of measurement, the data indicate that the growth of beech branches was decreasing proportionally to the average O<sub>3</sub> concentrations during spring–summer. Furthermore, we measured concentrations of peroxides along with O<sub>3</sub> during the summer period at a mountainous area in Oku-Nikko where birch trees are declining. We found that peroxides are always present at sub-ppb levels and proportional to the O<sub>3</sub> concentrations. We found through chamber fumigation experiments that the sub-ppb level peroxides seriously accelerated foliar injury of plants if sub-ppb peroxides were added to air with 50 ppb O<sub>3</sub>. Other forest declines related to tropospheric O<sub>3</sub> in Japan and Asian countries will be reported. Biomass burning effects on air pollution in Southeast Asia will also be reported.

**Physiological behaviours of woody species under high ozone exposure probed with the JIP-test.** Bussotti, F. (*University of Florence, Italy; filippo.bussotti@unifi.it*), Strasser, R.J. (*University of Geneva, Switzerland; Reto.Strasser@bioen.unige.ch*), Schaub, M. (*Swiss Federal Research Institute WSL, Switzerland; marcus.schaub@wsl.ch*).

Visible ozone symptoms on leaves are an expression of physiological mechanisms to cope with oxidative stresses. Often, the symptoms consist of stipples which correspond to localized cell death (hypersensitive response—HR), separated from healthy cells from a layer of callous. The HR strategy tends to protect healthy cells and in most cases chlorophyll efficiency is not affected. Thus, leaves are still able to produce antioxidative compounds which act as repair strategies. In other cases, the efficiency of leaves declines quickly and the plant loses the photosynthetic apparatus replacing it with a new more efficient one. Another strategy consists in the production of pigments (anthocyanins and phenolics) and leaves become reddish or brownish. These pigments reduce the oxidative pressure from ozone and high light radiations. In these cases, the most relevant physiological manifestation consists of the enhanced dissipation of the energy. These different behaviours are reflected in the initial events of the photosynthetic activity and can be monitored with techniques based on the direct fluorescence of chlorophyll A in the photosystem II (Kautsky effect)—applying the JIP-test. These results demonstrate evidence that the JIP-test is able to describe, in a fast and less expensive way, the overall physiological behaviour of different tree species.

**State-of-the art of ozone exposures and effects on forest vegetation within the Carpathian Mountain region.**Bytnerowicz, A. (*USDA Forest Service, USA; abytnerowicz@fs.fed.us*), Grodzinska, K., Godzik, B. (*Polish Academy of Sciences, Poland*), Manning, W. (*University of Massachusetts, USA*), Musselman, R. (*USDA Forest Service, USA*), Muzika, R.-M. (*University of Missouri, USA*), Fleischer, P. (*Slovak National Forests, Slovakia*), Badea, O., Tanase, M., Popescu, F. (*Forest Research and Management Institute, Romania*), Fraczek, W. (*Environmental Systems Research Institute, USA*).

Ambient ozone (O<sub>3</sub>) concentrations in some parts of the forested areas of the Carpathian Mountains, especially in Romania, are at the European background levels (summer season means ~30 ppb, 2-week long means <50 ppb). Other parts of the Carpathians, especially their western range (Slovakia, Czech Republic and Poland), have high O<sub>3</sub> seasonal means of ~50 ppb, 2-week long means >80 ppb, and occasional hourly peak concentrations >120 ppb. In large portions of the Carpathian Mountains, O<sub>3</sub> exposures are above levels recommended for protection of forest and natural vegetation. Consequently, some native plants experience O<sub>3</sub>-related injuries manifested by foliar changes and premature senescence of understorey vegetation and trees. Swiss stone pine (*Pinus cembra*), an important species because of its high ecological and forest management values, seems to be one of the most O<sub>3</sub>-sensitive trees. Ambient O<sub>3</sub> in combination with nitrogen dioxide and sulfur dioxide have also been responsible for growth reduction of Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*) in some Carpathian locations. Continuation of forest health monitoring and air chemistry with a combination of active monitors and passive samplers will help in developing risk assessment scenarios for forests and other natural areas of the Carpathian Mountains.

**Selected cases of ozone effects on the vegetation of central Mexico.** de Bauer, M. de L. (*Colegio de Postgraduados, México; libauer@colpos.mx*).

The first report on oxidant plant damage in the Valley of Mexico was presented over 30 years ago. Since then, it is common to find Mexico among the countries which have ozone problems severe enough to be mentioned at the international level.

Ozone is known to occur in the Mexico City area and elsewhere, causing chlorotic mottling on needles which are two years old or older, as observed in 1976 in the southern areas on *Pinus hartwegii* and *P. leiophylla*. Tropospheric ozone concentrations originate in urban areas and travel every day southward from the city into the mountains. Visible evidences for the negative effects of ozone on the vegetation of central Mexico are as follows: foliar injury, chlorotic mottling on pines, decline of sacred fir, visible symptoms on native forest plant species (e.g. Mexican black cherry), and species replacement. Investigations showed effects such as very limited root colonization by ectomycorrhiza fungi for ozone-damaged *P. hartwegii* trees and a negative influence on the germination of this species. The negative ozone effects on the vegetation will most likely continue to increase. Due to the socio-economic situation of Mexico in respect to poverty, air quality will not be seriously considered as a priority among the future development issues.

**State-of-the-art ozone flux modeling for forest vegetation.** Emberson, L.D., Büker, P., Ashmore, M.R. (*Stockholm Environment Institute at York, UK; l.emberson@york.ac.uk; pb25@york.ac.uk; ma512@york.ac.uk*).

Recent adoption by the UNECE CLRTAP convention of flux-based risk assessment methods for tropospheric ozone requires the development of models capable of estimating ozone deposition to forest canopies/stands. In addition to estimating fluxes for risk assessment, it is also imperative to accurately model deposition on forested areas to ensure appropriate mass balance calculations of ozone in chemical transformation models. To address both these needs, a 'big leaf' forest deposition model has been developed based on an existing scheme capable of differentiating between stomatal and non-stomatal ozone deposition. The model incorporates the heterogeneity that exists within tree canopies to enable calculation of whole-canopy stomatal flux. As such, the model incorporates not only morphological variation (e.g. leaf age, sun and shade leaf morphologies, leaf orientation and leaf area index) but also variations in environmental conditions with canopy depth (e.g. irradiance levels, temperature, VPD and ozone concentrations) and the influence of soil water balance and within-canopy phenology (leaf population dynamics) to estimate canopy/stand ozone deposition. Methods to simplify these rather complex canopy/stand model schemes are presented to enable their regional/global scale incorporation within photo-oxidant models for application under both current conditions and for future 'climate change' scenarios.

**Perspectives regarding 50 years of research on the effects of tropospheric ozone air pollution on North American forests.** Karnosky, D.F. (*Michigan Technological University, USA; karnosky@mtu.edu*), Skelly, J.M. (*The Pennsylvania State University, USA; jms34@psu.edu*), Percy, K.E. (*Natural Resources Canada; kpercy@nrcan.gc.ca*), Chappelka, A.H. (*Auburn University, USA; chappah@auburn.edu*).

Tropospheric ozone (O<sub>3</sub>) air pollution was first determined to be phytotoxic to grapes in southern California in the late 1950s. American investigations soon followed showing O<sub>3</sub> causing visible foliar symptoms in eastern white pine. In the early 1960s, the cause of 'X' disease of ponderosa pines in the San Bernardino Mountain National Forest was determined to be due to photochemical oxidants, primarily O<sub>3</sub>, contained within pollution plumes from Los Angeles. Nearly 50 years of research have followed with inputs of new findings recorded in US EPA Criteria Documents every five years. Investigations of O<sub>3</sub> effects on forest trees include descriptions of foliar symptoms on conifer and broadleaf tree species within forests exposed to elevated levels of ambient O<sub>3</sub>. Controlled exposure studies have demonstrated negative growth effects on forest tree seedlings due to season-long O<sub>3</sub> exposures, but due to complex interactions within natural forest stands, strong evidence of similar losses within mature tree canopies remains elusive. Recently, several investigators reported and verified additional forest tree and native understory species in the USA, Canada and Mexico to be symptomatic of O<sub>3</sub> exposures. In addition, investigations on whole tree growth, canopy O<sub>3</sub> uptake/flux and forest stand productivity are being conducted along natural O<sub>3</sub> gradients and in open-air exposure systems to better understand O<sub>3</sub> effects on forest ecosystem structure and function.

**The effect of ozone exposure on tree-ring growth and carbon stable isotopes in broadleaf species grown in open-top chambers.** Novak, K., Cherubini, P. (*Swiss Federal Research Institute WSL, Switzerland; kristopher.novak@wsl.ch; paolo.cherubini@wsl.ch*), Saurer, M. (*Paul Scherrer Institute PSI, Switzerland; matthias.saurer@psi.ch*), Fuhrer, J. (*Swiss Federal Research Station for Agroecology and Agriculture FAL, Switzerland; juerg.fuhrer@fal.admin.ch*), Skelly, J.M. (*The Pennsylvania State University, USA; jms34@psu.edu*), Kräuchi, N., Schaub, M. (*Swiss Federal Research Institute WSL, Switzerland; norbert.kraeuchi@wsl.ch; marcus.schaub@wsl.ch*).

This study aims to determine the effect of ozone exposure on leaf gas exchange, tree-ring growth and carbon stable isotopes of three broadleaved plant species grown in open-top chambers in southern Switzerland. At the conclusion of the 2002 growing season, stem cross sections were taken from plants of *Fraxinus excelsior*, *Populus nigra* and *Viburnum lantana* grown in non-filtered and charcoal filtered open-top chambers and open plots. Tree-ring widths and carbon stable isotopes were measured for each sample. Gas exchange measurements were also made during the 2001 and 2002 growing season on the sampled species. We show a reduced ring width growth, corresponding to reduced leaf gas exchange levels in response to ambient ozone exposures as compared to the charcoal-filtered air treatment. Furthermore, we show that the analysis of carbon-stable isotopes can provide a link between stomatal activity and tree-ring growth of these plants.

**Physiological responses to ozone in Mediterranean evergreen shrubs.** Paoletti, E. (IPP–CNR, Italy; [e.paoletti@ipp.cnr.it](mailto:e.paoletti@ipp.cnr.it)), Nali, C., Lorenzini, G. (University of Pisa, Italy).

Climatic conditions in Mediterranean-type ecosystems favor ozone (O<sub>3</sub>) production. Three Mediterranean shrubs—*Phillyrea latifolia*, *Arbutus unedo* and *Laurus nobilis*—differing in their morphological and ecological response to water shortage, were exposed for three months to 0 (control in charcoal-filtered air), 55 (ambient) or 110 (twice ambient) ppb O<sub>3</sub>. The treatments yielded 0, 15.8 and 31.5 ppm h AOT40, respectively. Ambient O<sub>3</sub> modified net photosynthesis in none of the species, while twice ambient O<sub>3</sub> concentration impaired assimilation in *A. unedo* and mainly in *L. nobilis*. The most tolerant species was *P. latifolia*, despite the highest stomatal conductance rates and thus the highest potential O<sub>3</sub> flux into the leaves. Chlorophyll *a* fluorescence was analyzed with the OJIP technique. Reduced density and increased activity of active reaction centres were recorded, mainly in *P. latifolia*. Ambient O<sub>3</sub> slightly depressed the energy dissipation in *A. unedo*, and increased performance index and maximum quantum yield of primary photochemistry in *L. nobilis* and *A. unedo*. These responses are interpreted as over-compensation due to counter-O<sub>3</sub>-reactions. It is suggested that these evergreen broadleaved shrubs are relatively tolerant to realistic O<sub>3</sub> levels, and that such tolerance overlaps with the inborn adaptability to drought—*P. latifolia* > *A. unedo* > *L. nobilis*.

**Ozone exposures and effects on forest vegetation: A global overview.** Schaub, M. (Swiss Federal Research Institute WSL, Switzerland; [marcus.schaub@wsl.ch](mailto:marcus.schaub@wsl.ch)).

Tropospheric ozone (tropO<sub>3</sub>) has been suggested to be one of the main air pollutants threatening forest health in heavily polluted parts of Europe, the United States of America, Asia and Latin America. In particular, in Asia and Africa biomass burning due to anthropogenic activities has a significant impact on the production of tropO<sub>3</sub>. Current levels of tropO<sub>3</sub> have been shown to cause damage to forest vegetation while climate models predict a global increase of tropO<sub>3</sub> concentrations. Furthermore, tropO<sub>3</sub> plays a key role in the atmospheric radiation transfer and its increase enhances the greenhouse effect. Numerous studies have demonstrated the role of trans-Atlantic and continental air masses transport and the impact of large-scale anthropogenic emissions on tropO<sub>3</sub> levels. While international cooperative programs provide a good understanding of origin and transport of tropO<sub>3</sub>, there is a lack of international cooperation investigating the assessment and monitoring of tropO<sub>3</sub> effects on forest vegetation. This session aims to address scientists from Asia, Latin America, the USA and Europe to give a state-of-the-art assessment for a better overview of the global threat by tropO<sub>3</sub> to forest health and to initiate an improvement in the use of international synergies.

**Ozone visible injury assessment across Europe.** Schaub, M. (Swiss Federal Research Institute WSL, Switzerland; [marcus.schaub@wsl.ch](mailto:marcus.schaub@wsl.ch)), Sanz, M.J. (Fundacion CEAM, Spain; [mjose@ceam.es](mailto:mjose@ceam.es)).

Ozone air pollution leaves no elemental residue that can be detected by analytical techniques. Therefore, visible injury on leaves and needles is the only easily detectable evidence in the field. Even though visible injury does not include all the possible forms of injury to trees and natural vegetation (i.e., pre-visible physiological changes, reduction in growth, etc.), observation of typical symptoms on above ground plant parts in the field has turned out to be a valuable tool for the assessment of the impact of ambient ozone on sensitive plant species. Until now, experiments have concentrated on explaining the mechanisms leading to the injury observed in the experimental studies, rather than to identify and characterize the symptoms observed in the field. The pilot phase of a program has been initiated that includes the assessment, validation and mapping of visible ozone injury and the implementation of tropospheric ozone concentration data on 860 permanent observation plots across Europe. During the assessments to date, 180 sensitive species have been assessed, developing ozone-induced visible injury across 10 European countries. This review provides a list of ozone sensitive species and their distribution, and presents the methods applied for assessment of ozone visible injury and quality assurance criteria developed by the program after the test phase.

**Decline of *Betula ermanii* with special reference to ozone concentrations at Mt. Mae-Shirane, Oku-Nikko, Japan.** Shimizu, H. (National Institute for Environmental Studies NIES, Japan; [hshimizu@nies.go.jp](mailto:hshimizu@nies.go.jp)), Feng, Y. (Japan Society for the Promotion of Science, Japan; [ab-feng@criepi.denken.or.jp](mailto:ab-feng@criepi.denken.or.jp)).

The decline of *Betula ermanii* has been observed around Mt. Mae-Shirane, Oku-Nikko, Japan, without any definite cause defined yet. We established a research plot on the south-east slope (SE-slope) of Mt. Mae-Shirane within a forest-decline area and in the north-west slope (NW-slope) within a non-decline (healthy) area. The field survey showed that the degree of decline, the calculated trunk volume and the tree stand density were severely depressed on the SE-slope as compared to the NW-slope. Ozone concentrations measured with passive samplers, and meteorological and soil environmental factors for each slope indicated that ozone concentrations could be one of the main factors causing the decline of *B. ermanii*, with and without water stress. We examined the effects of ozone exposures and/or

water stress on the tree growth of *B. Ermanii* by using environment-controlled cabinets. Ozone and/or water stress affected the dry weight growth significantly. Both factors suppressed the rates of net photosynthesis and transpiration which should cause a decrease in dry weight growth of *B. ermanii*. Based on the results of these field surveys and the environment-controlled experiments, we suggest that ozone and/or water stress is the potential cause of the decline in *B. ermanii* observed on Mt. Mae-Shirane.

## **Remote sensing in forestry: Modern technology supporting sustainable development**

Organizer: Tomasz Zawila-Niedzwiecki *University of Applied Sciences, Germany; tzawila@fh-egerswalde.de*

**Inventory systems in Australia using remotely sensed data to improve precision and scale of estimation.** Brack, C.L. (*Australian National University, Australia; Cris.Brack@anu.edu.au*).

Remotely sensed data, including aerial photography, have been collected over Australian forests since the late 1930s. To a large extent, these data have been used to stratify the forest into relatively homogenous units to support ground-based inventory in the calculation of relatively precise average characteristics for large units. Recently, several major projects in Australia have used remotely sensed data across extensive regions and empirical or process-based models to predict the quantity of biomass or even merchantable products on units that are often less than one hectare. This presentation will examine the use of remotely sensed data for the estimation of commercial products on heterogeneous privately managed forests of Tasmania and over 6.2 million ha of south-east Queensland. Empirical models, using data input from the satellite or aerial photography allowed an improvement in the precision of the total volume estimates (confidence limits half the length when compared to equivalent stratified random samples) as well as unbiased estimates of volume in *ad hoc* selections of stands.

**A spectral index for detection of candidate areas for pre-commercial thinning in Landsat ETM+ imagery.** Hagner, O. (*Swedish University of Agricultural Sciences, Sweden; Olle.hagner@resgeom.slu.se*).

An index that estimates the ratio between actual and recommended stem density in young (less than 30 years) forest stands, based on spectral reflectance in the six reflective Landsat bands supplemented with age- and site quality information has been developed for Boreal forests in Sweden. The index is based on 20,000 National forest inventory-plots matched with spectral reflectance data derived from Landsat ETM+ scenes covering large parts of central and northern Sweden. The index is implemented in the form of a trained artificial neural network which also outputs an estimate of coniferous vs. broadleaf proportions. An important feature of the index is the capability to quantify relative stem density in both coniferous and broadleaf stands simultaneously and to account for stand age and site quality. Also, the ability to discriminate between closed young broadleaf canopy and grass-dominated areas was given high priority. There are plans to develop a similar index for the SPOT satellite sensors and also to incorporate information from multitemporal imagery into the analysis. The main motive for development was to improve the accuracy, compared to the current practice of using a subjective threshold for a normalized difference vegetation index (NDVI) that is calculated from radiometrically uncalibrated imagery.

**The effect of sensor resolution and image acquisition gaps on forest change detection errors.** Sader, S.A., Jin, S., Metzler, J. (*University of Maine, USA*), Hoppus, M. (*USDA Forest Service, USA*).

Forest change detection is one of the most successful and operational uses of moderate to coarse resolution satellite imagery in forest monitoring. MODIS and Landsat are both popular and important sensors for monitoring forest change at the regional and landscape scale, respectively. The difference in spectral, spatial and temporal resolution of these two sensors can have a major effect on their capability to detect and monitor forest change. Recent research indicates that simple vegetation indices computed from time-series Landsat imagery can detect both light and heavy forest canopy disturbances. Clearcuts and heavy partial harvests were detected with relatively lower errors over longer (>5 years) image acquisition gaps. Softwood forests were detected with lower error compared to hardwoods when image acquisition gaps were shorter. In this paper, we compare two vegetation indices and the effect of Landsat image acquisition gaps on forest change detection errors by forest type (evergreen, deciduous) and harvest intensity class (clearcut, heavy partial, light partial) in a northern Maine forest. Also we compare MODIS (250 and 500 m) to Landsat (30 m) capabilities to detect forest changes using time-series images. Finally, the implications of these results for statewide forest inventory conducted by the US Forest Service are discussed.

**Linking between policies and land use/cover change as detected by Landsat TM in Malaysia.** Suratman, M.N. (*Universiti Teknologi MARA, Malaysia; nazip@salam.uitm.edu.my*), Bull, G. (*University of British Columbia, Canada; gary.bull@ubc.ca*), Leckie, D. (*Natural Resources Canada, Canada; dleckie@pfc.cfs.nrcan.gc.ca*), LeMay, V., Marshall, P. (*University of British Columbia, Canada; Valerie.LeMay@ubc.ca; Peter.Marshall@ubc.ca*).

Quantification and characterization of change patterns in land use/cover is necessary to understand land cover dynamics. Despite the number of studies which recognized the loss of land use/cover as a national problem, very little is understood about the relationships between the primary drivers and policies that induce changes in any given resource type. In order to gain a better understanding of the complex policy environment driving land-use change, we attempted to identify the primary drivers affecting policies that relate to land use/cover change in south Selangor, Malaysia. The primary focus was change in rubber acreage, and examination of linkages between policies and this change, recorded from Landsat TM between 1989 and 1999. Evidence from this case study suggested that some linkages between policies and the change in area of rubber plantations exist. The relatively poor price of natural rubber was one of the primary drivers that determined the formation and implementation of rubber policy instruments, thus affecting subsequent changes in rubber acreage. Federal government policies and state policies operating within the federal context explained the rapid urbanization and development of infrastructure. These activities, driven by demographic expansion, subsequently determined the change in rubber acreage in the study site.

**High resolution remote sensed imagery as input data for individual tree growth model: The case of cork oak.**

Surovy, P., Ribeiro, N.A., Scheer, L., Ferreira, A. (*Universidade de Évora, Portugal; psurovy@uevora.pt*).

In recent years, several models to estimate and predict cork production have been developed in Portugal. A set of models (tree growth, cork growth, mortality, etc.) is available in a software environment called CORKFITS 2.1. Aerial imagery has been used in this work to extract input data for the model, with minimum cost and labour. 'Open' forest stands in southern Portugal require an additional step when they are being compared with 'closed' forests. This step is to distinguish between vegetation and background; vegetation indices to handle this task are presented and compared. Tree positions and dimensions are necessary as input for the models. Two different techniques: 'tree top detection' and 'template matching' are presented and compared.

## **Silviculture and management of rare, threatened and endangered tree species**

Organizer: Margaret Devall *USDA Forest Service, USA; mdevall@fs.fed.us*

**Maturation and chemical composition of *Lindera melissifolia* [Walt.] seeds.** Connor, K.F., Lindstrom, G.M., Donahoo, J., Devall, M.S., Gardiner, E.S., Leininger, T.D., Wilson, D., Schiff, N.M., Hamel, P.B., Echt, C., Hawkins, T. (*USDA Forest Service, USA; kconnor@fs.fed.us; glindstrom@fs.fed.us; jdonahoo@fs.fed.us; mdevall@fs.fed.us; egardiner@fs.fed.us; tleininger@fs.fed.us; dwilson02@fs.fed.us; nschiff@fs.fed.us; phamel@fs.fed.us; thawkins@fs.fed.us; cecht@fs.fed.us*).

Pondberry (*Lindera melissifolia* [Walt.]) is an endangered, dioecious, clonal shrub that grows in forested wetlands, in seasonally flooded areas, or along the margins of sinks and ponds in the south-eastern USA. With the emphasis placed on the clonal nature of this species, little has been published about the early physical and biochemical characteristics of the fruit as they mature. Fruits were collected every 30 days after flower anthesis and examined for cellular structure and chemical composition of the fruit and/or seed. Sixty days after anthesis (DAA), fruits had not formed an organized embryo/cotyledon, weighed 0.081 g and measured 7.063 mm x 4.313 mm. Ninety DAA, a complete seed had formed within the fruit. Of the total fruit weight (average 0.228 g), seeds accounted for 33% of the mass gained from 60 DAA. Overall composition of the seed and fruit lipids changed significantly over the course of development. Preliminary lipid analysis revealed the presence of myristic, palmitic, steric, oleic, linoleic and lenolenic fatty acids; lauric acid was not found in any of the early lipid samples but did form later in fruit pulp development.

**Silviculture of rare, threatened and endangered tree species in the USA.** Devall, M.S. (*USDA Forest Service, USA; mdevall@fs.fed.us*).

During the last two centuries, populations of rare, threatened and endangered tree and shrub species in the USA have been exposed to several human-related threats, including land use changes, exotic species invasions, harvesting and fire. Future predicted climate change could have severe effects on the growth, reproduction and survival of these species. Qualities of rare tree populations, especially southern populations, may become increasingly important as the predicted climate change proceeds and species migrate north. Approximately 35 conifers in the USA are rare or

confined to limited geographic areas. There are approximately 25 rare minor eastern hardwoods, excluding many border species which are uncommon within the United States but are more numerous elsewhere. Although much silvicultural information is available for common tree species, information for many rare species is extremely scarce or lacking. Progress in maintaining and restoring these species depends on our ability to fill in the gaps in our knowledge of silviculture. Restoration of degraded land is occurring in various parts of the country, such as the Lower Mississippi Alluvial Valley, and provides an opportunity to restore rare trees and shrubs and increase biodiversity of the area provided silvicultural information is available. Several examples of restoration efforts will be presented.

**Development of silvical guidelines for restoration of blight-resistant American chestnut (*Castanea dentata*) to eastern forests of the USA.** Jacobs, D.F., Selig, M.F. (Purdue University, USA; [djacobs@purdue.edu](mailto:djacobs@purdue.edu); [mselig@purdue.edu](mailto:mselig@purdue.edu)), Severeid, L.R. (Walnut Council, USA; [bwtree@aol.com](mailto:bwtree@aol.com)).

American chestnut (*Castanea dentata*) once dominated the eastern deciduous forests of the USA, comprising over one-third of species in many locales. However, the introduced chestnut blight (*Cryphonectria parasitica*) was discovered in 1904 and within several decades, the blight killed nearly every tree throughout the range. A dedicated breeding program has made tremendous progress toward producing a blight-resistant form of chestnut by backcrossing with resistant Chinese chestnut (*C. mollissima*) and a hybrid chestnut tree (~94% American chestnut) should be available for reintroduction within the next decade. Due to the early introduction and continued presence of chestnut blight, little modern information is available concerning ecological and silvical attributes of the species. This knowledge is needed to develop effective silvicultural guidelines for reintroduction. We studied early growth and competitive ability of American chestnut on a site isolated from blight in Wisconsin, USA relative to interplanted species. American chestnut outperformed all associated species, growing an average of nearly 1 cm in diameter and 1 m in height annually. High competitive ability of American chestnut was attributed to branching habit, biomass allocation and photosynthetic ability. Silvical guidelines for reintroduction must account for this rapid early growth when selecting planting densities and corresponding species for interplanting.

**Trees and shrubs at risk in Canada.** Loo, J.A., Beardmore, T., Simpson, D. (Natural Resources Canada, Canada; [jlou@nrcan.gc.ca](mailto:jlou@nrcan.gc.ca)).

By comparison with more temperate and tropical areas of the world, Canada has relatively low biodiversity, particularly in numbers of tree and shrub species, and few species are endemic. As a result, Canada's biodiversity is less threatened than that of many other parts of the world. Nevertheless, a recent preliminary assessment found 200 species of trees and shrubs to be in need of gene conservation in at least some part of their range. Gene conservation initiatives have been undertaken for several of the species, and recovery plans are mandatory for species having official endangered status. Four tree and shrub species are officially designated endangered. Four other species have threatened status and six are of special concern. Most of these species are located in the Carolinian region of southern Ontario, with ranges just entering a small densely populated area of Canada. The threats to Canada's tree and shrub species are likely to increase in coming years because of the effects of climate change and invasive alien species. Proactive work to conserve potentially valuable genetic resources should be initiated now. A national initiative has been undertaken to coordinate research related to gene conservation and ex situ conservation efforts across provincial boundaries.

**Improving germination and vigour of three endangered medicinal herbs inhabiting difficult to access slopes of the Indian Himalayas.** Thakur, A., Mehta, R. (University of Horticulture and Forestry, India; [thakuranju2004@yahoo.com](mailto:thakuranju2004@yahoo.com)).

India is one of the few countries bestowed with a large number of rare and endangered medicinal herbs widely used both in alleopathic and Ayurvedic systems of medicine. Among these; *Podophyllum hexandrum* Royle, *Dioscorea deltoidea* Wall and *Gentiana kurroo* Royle have great medicinal potential, so these herbal species are in high demand. These species inhabit far-flung upland forests making seed collection difficult. Further, these species exhibit late, poor and erratic germination with rapid loss of viability and germinability, hampering commercial cultivation. Present studies were, therefore, undertaken to investigate the methods to improve germination, viability and seedling vigour through various pre-sowing seed treatments. Seeds of these herbal species were collected from their natural population, cleaned, air dried, sorted and used for further experimentation. Seeds were subjected to pre-chilling at different temperatures and duration, pre-soaking with a combination of wetting and drying, thermal shock, scarification and stratification, and seed coat puncturing with H<sub>2</sub>SO<sub>4</sub> and GA<sub>3</sub> giberellic acid. The findings of the present investigation indicate that presowing seed treatments for different duration at different temperatures may be used for substantial improvement in germination, early emergence and seedling vigour of these endangered medicinal herbs.



**Tree-ring response of *Pinus eldreichii* to climate and anthropogenic activity in the National Park of Pollino (Basilicata, Southern Italy).** Todaro, L., Saracino, A., D'Alessandro, C.M. (*Università degli Studi della Basilicata, Italy; todaro@unibas.it; saracino@unibas.it; dalessandro@unibas.it*), Cherubini, P. (*Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland; paolo.cherubini@wsl.ch*).

*Pinus eldreichii* is widespread in the Balkan Peninsula and in its western area, in southern Italy, is present as a post-glacial relict species. The main Italian populations are located at the tree-line in the National Park of Pollino. For many centuries, grazing and logging endangered the survival of pine populations at the tree-line, so that during 1990s the National Park was founded and anthropogenic activities were partly forbidden and partly prescribed to preserve *P. eldreichii*. We used tree ring-width patterns as indicators of environmental changes and to interpret the impact of anthropogenic activities (deduced from historical records) on *P. eldreichii* stands. An increase in ring width since 1980s to date was detected. Possible causes for this observed trend include increases in nitrogen deposition, atmospheric CO<sub>2</sub> concentration and air temperature, or a decrease in anthropogenic pressure. A positive effect of thinning, logging or nitrogen fertilization on tree-ring width can be excluded, because *P. eldreichii* trees are scattered and atmospheric nitrogen deposition is scarce on Monte Pollino. We also found that ring-width is not strongly influenced by monthly precipitation and mean monthly temperatures, suggesting that at this site tree rings reflect land-use changes caused by socio-economic reasons than by climatic changes.

**Structure of diebacked *Juniperus procera* forests in the Asir Mountains, Saudi Arabia.** Yoshikawa, K. (*Okayama University, Japan; kenchan@cc.okayama-u.ac.jp*), Yamamoto, F. (*Tottori University, Japan; forester@mud.biglobe.ne.jp*).

In the Asir mountainous in the southern semiarid region of Saudi Arabia, a large number of *Juniperus procera*, evergreen conifer, are growing and form nearly pure juniper forests because of high amounts of precipitation and moderate temperatures. However, a number of junipers suffered damage of dieback on the tops of their crowns. To clarify the structure of the juniper forests and the causes of dieback, eight experimental plots were established. The existence of the forests is due to the periodic cover of dense fog derived from ascending air currents along the steep slope of the mountains throughout the year. However, the tree density of these forests ranged from 20 to 150 trees/ha depending mainly on the topographic conditions. Because the experimental area was a common forest, most of the junipers showed signs of stem harvest. Judging from the spatial distribution of trees, the junipers harvested by inhabitants were selected carefully to avoid the destruction of canopy structure. High correlation between tree height and stem length of dead crowns implied the dieback occurred recently and extended from the apex to an almost equal height. Such symptom might be the result of environmental stresses.

## **Social and cultural values of forests: Benefits-based management**

Organizer: Elizabeth Johann *University of Applied Life Sciences Vienna, Austria; elis.johann@utanet.at*

**Problems and prospects of the last remaining natural forests of Bangladesh: The case of the Sundarbans mangroves.** Misbahuzzaman, K. (*Chittagong University, Bangladesh; kmzaman\_for@yahoo.com*).

The Sundarbans, covering 571,500 ha, are the largest single tract of mangrove forest in the world. Located in the estuary of the river Ganges in southwest Bangladesh, it has been declared a World Heritage Site by UNESCO in 1997. Research was conducted between 1999 and 2003 to study a) the effects of introduced tree species in the raised areas, and b) the ecology of the disease of top-dying of the dominant tree species, Sundri (*Heritiera fomes*). Although the introduced tree species showed promising growth, profuse natural regeneration by *Albizia procera* and *Leucaena leucocephala* in places indicated that they were capable of replacing the mangrove species. Top-dying prevailed mostly in the higher diameter trees of Sundri, was profuse in affected areas, and was found to be associated with burial of pneumatophores, the breathing organs, through increased sedimentation. It is recommended that a) physical facilities for eco-tourism be built, instead of introducing inland tree species in places where mangrove species have disappeared, and b) Sundri trees affected by top-dying be removed through salvage felling. This would ensure regeneration of Sundri species, while maintaining sanitation for the remaining growing stock.

**Benefits-based management as a research and planning framework for nature-based tourism and recreation.** Stein, T.V. (*University of Florida, USA; tstein@ufl.edu*), Anderson, D.H. (*University of Minnesota, USA; dha@umn.edu*), Pierskalla, C.D. (*West Virginia University, USA; cpierska@wvu.edu*), Nickerson, R.G. (*Minnesota State University at Mankato, USA; ronald.nickerson@mnsu.edu*), Clark, J.K. (*Mecklenburg County, North Carolina, USA; juliekateclark@yahoo.com*).

Nature-based tourism and recreation managers struggle to plan and manage for the outputs of recreation. Unlike many natural resource industries that have tangible products (e.g., timber, livestock, and minerals), tourism and recreation

professionals help provide a diversity of concrete and abstract outputs: environmental education, physical fitness, economic development, ecosystem protection and many others. In the early 1990s, a benefits-based management (BBM) framework was developed to identify, plan and manage for the diversity of leisure's economic and non-economic benefits. This paper discusses BBM's evolution and its role in nature-based tourism and recreation research and planning. In particular, it describes key studies that examined the link between recreationists' desired personal benefits (i.e., motivations for recreation) and specific recreation activities and setting characteristics. It also addresses recent research that goes beyond visitor benefits to include tourism and non-recreation benefits (e.g., community pride and improved quality of life) accruing to communities as a result of their proximity to and association with public recreation areas. Finally, expanding the BBM framework to include the concept of place attachment is examined. Examples are provided to illustrate how inclusion of these concepts enhances the management of recreational lands.

#### **Analysis of national cultural background of Russian labour and management cultures in the forest industry.**

Vinokurova, N. (*Moscow State Forest University, Russian Federation; vinokurova@mgul.ac.ru*).

An analysis of the national cultural background of Russian labour and management cultures in the forest industry will enable the improvement of the effectiveness of capital investments made by donor countries. The national characteristics of the personnel within an organization affect their behaviour, which in turn impacts on the competitive abilities of the organization. The best way to analyze the national features of personnel behaviour in Russia is to study the national cultural background of Russian labour and management cultures through such factors as ethnocultural factors, civilization and economic factors, geoclimatic factors, ethnoecological factors and ethnoconfession factors. The main goal of this analysis is to structure the different component of national cultural backgrounds into organizational behaviours and to systematize the forms of organizational behaviour within a framework of national cultural backgrounds. This will lead to improvements in the ability of the managers within Russian forest enterprises to understand the problem of Russian forest policy.

#### **Mangroves and the protection of coastal areas**

Organizer: Brad B. Walters *Mount Allison University, Canada; bwalters@mta.ca*

**Changing climate changing mangroves.** Duke, N.C. (*Centre for Marine Studies, University of Queensland, Australia; n.duke@uq.edu.au*).

Climates around the world are changing. And, these changes are taking place at an increasing rate brought on by the growing demands and pressures of human population. Like other natural habitats, mangroves and tidal wetlands, must accommodate if they are to survive. Although there is nothing new in the processes taking place, it is the high rates of change that threaten, especially in combination with human disturbances preventing life-saving, natural shifts. Case studies from Australia and the Western Pacific provide important new insights into the key responses taking place in tidal wetlands. In one example, changing rainfall patterns drive shifts in mangrove-saltmarsh ecotones. In another, human-damaged mangroves leave coastlines more exposed to more severe storms and tidal surges. In an effort to build a sustainable future, such indicators are tools in the development of new ecological models for better prediction and management of expected effects and consequences.

**What we do and don't know about the role of waves in mangrove ecosystems.** Lugo, A.E. (*USDA Forest Service International Institute of Tropical Forestry, USA; hanael@caribe.net*).

Mangroves are ecosystems that flourish in low energy coastlines and are usually incompatible with high energy conditions. In high energy coastal conditions, mangroves occur behind sand dunes, protected from direct wave action. High tidal surges also limit mangrove establishment. Therefore, mangroves will not survive chronic high wave activity because the capacity of their extensive root systems to absorb tides and wave action is limited. A tsunami is an acute disturbance event similar to a hurricane, and both can cause extensive short-term mangrove mortality, but allow for mangrove recovery if coastal conditions (substrate and hydrology) return to pre-disturbance states. Long-term effects of these disturbances on mangroves will depend on the degree that coastal geomorphology, hydrology and soil change after the acute events.

**Principles for a Code of Conduct for the sustainable management of mangrove ecosystems: A work in progress for public discussion.** Macintosh, D., Neilson, T., McEwin, G. (*University of Aarhus, Denmark; Donald macintosh@hotmail.com*), Zweig, R. (*The World Bank, Washington, DC; rzweig@worldbank.org*).

The Principles for a Code of Conduct for Sustainable Management of Mangrove Ecosystems is a guide to assist states, local and national non-governmental organizations and other stakeholders to develop cooperatively local codes, laws

and/or regulations to protect mangroves and the critical functions they serve with regard to contributions to local livelihood, biodiversity conservation and coastal protection through sustainable management. The objective is to help bring attention to the importance of mangrove ecosystems, particularly to policy makers, to help arrest and reverse their loss. The Principles, being a work in progress, are being discussed in a range of forums that involve representatives from governments, NGOs, multilateral organizations, research institutions, grassroots organizations and other interested individuals and groups. The Principles were formulated based on a review of global mangrove management experience, about fifteen country case studies from all regions where mangroves exist, and seven regional workshops to date. The purpose of the presentation at this IUFRO forum is to gain additional feedback from researchers and other experts, in particular, to provide input on the content of the Principles. The Principles and many of the background documents and summaries of the feedback from workshops conducted to date can be found on the following website: <[http://www.biology.au.dk/cenTER/MCB\\_Ph2\\_ToR.htm](http://www.biology.au.dk/cenTER/MCB_Ph2_ToR.htm)>.

**Mangrove forests and environmental security.** Walters, B.B. (*Department of Geography, Mount Allison University, Canada; bwalters@mta.ca*).

Scientists and decision-makers are increasingly interested in the relationship between environmental change and human security, i.e., 'environmental security'. Research from the Philippines and elsewhere suggests that mangrove forests illustrate this relationship particularly well. Mangroves and the diverse resources they provide – wood, food, fuel – are critical to the livelihood security of highly vulnerable coastal populations throughout the tropics. At the same time, their restricted coastal distribution, which is often proximate to population concentrations, makes them the frequent loci of conflict between competing human interests. Studies of mangrove planting and human settlement along the coast demonstrate the value of mangroves for protecting property and livelihood from storm impacts. Preliminary observations of the Asian tsunami of 2004 further highlight this protective role and provide a stark reminder that environmental sustainability and human security are inseparable.

## **Forests, trees, and human health and well-being (B)**

Organizer: Kjell Nilsson *The Royal Veterinary and Agricultural University, Denmark; kjni@kvl.dk*

**Ergonomics challenges in forest harvesting in Brazil.** Souza, A.P., Minette, L.J. (*Federal University of Viçosa, Brazil; amaurysouza@ufv.br; minetti@ufv.br*).

This work presents ergonomic challenges to protect the health of forest harvesting workers. Several forest harvesting operations are still being carried out manually, semi-mechanized, or using adapted machines. Work conditions are unsatisfactory in many cases, leading to fatigue, accidents and occupational illnesses. During the last decade, the forest sector has searched for new, highly mechanized, harvesting systems as a means of achieving greater productivity. This resulted in: improved systems with highly skilled workers, enhancing productivity, reducing the impacts to the environment, improving processed wood quality, reducing accidents and providing workers safer and more comfortable working conditions. However, challenges remain to be overcome, such as: introducing ergonomics into the integrated management system (health, quality and environment), stimulating ergonomic cooperation between employers and employees, encouraging extension of ergonomic practices in communities, searching for improved registration and analysis of accidents and occupational illnesses caused by ergonomic problems, enhancing the quality and reach of work-related public services, increasing application of ergonomics in small and medium size enterprises, intensifying research on ergonomics and introducing ergonomics in all education levels.

**The effects of trees on pollutant transport and fate: modeling of the benefits to the urban and periurban environment.** Freer-Smith, P. (*Forest Research, UK; peter.freer-smith@forestry.gsi.gov.uk*), Taylor, G. (*University of Southampton, UK; g.taylor@soton.ac.uk*).

Particulates, oxidants and other pollutants are a serious problem in industrial, urban and periurban areas. For example, a correlation between hospital admissions from chronic respiratory diseases and particulates in the air of Seattle has been identified. A recent World Health Organization report suggested that more people are killed prematurely by the effects of pollutants than through car accidents. As a result of their large leaf area and the turbulent air movements created by trees, woods, and shelterbelts, trees capture more pollution from the atmosphere than shorter vegetation or other land uses. The ability of trees to capture gaseous pollutants and particles has been characterized through measurement of deposition velocities and capture efficiencies in wind tunnels, and through micro-meteorological measurement in the field with good comparability of data from different approaches. There is now sufficient understanding to produce an integrated model of

how urban and periurban trees can improve air quality. In this paper we review the models currently available for describing the flux of different pollutants from the atmosphere to vegetation, and the atmospheric chemistry models which describe their key interactions. We describe our progress in the development of an integrated model on which to base policy advice/recommendations for planners, regulators and local authorities.

**Research on therapeutic benefits of technical, recreational tree climbing in Japan.** Gathright, J., Yamada, Y., Morita, M. (*Nagoya University, Japan; John@johnsan.net*).

Tree Climbing Japan (TCJ) was established in 1998 as an organization to help people of all ages and abilities, safely climb trees for rehabilitation, recreation and nature education throughout Japan. Tree climbers often reported therapeutic benefits from tree climbing and the numbers of participants reached over 13,000 by June 2004. Our research team collected over 1000 questionnaires from Japanese tree climbers. Both disabled and able bodied tree climbers expressed benefits such as decreased depression, less anger, easing of chronic pain, less fear of heights, increased physical strength, better mobility, as well as greater self worth and vitality. In order to scientifically investigate the physiological and psychological effects through tree climbing, we further selected a control group of 11 healthy able-bodied adults, 21–51-years-of-age, to perform tree climbing in a controlled environment using progressively larger trees. Finally, a comparison between climbing a tree and a concrete tower were performed. Our research methods included heart rate RR intervals, pain sensitivity monitoring, saliva cortisol content and state of mood and self-worth psychological testing. Our results indicate that there are physiological and psychological effects experienced by tree climbers.

**Nature's impact on health and well-being.** Hansen, K.B., Nilsson, K. (*Forest & Landscape, Denmark; kabh@kvl.dk*).

A comprehensive questionnaire has shown the Danish population's assessment of the role of nature for health and well-being. Central questions were whether, and how, the public experienced nature and green areas as restorative for mental and physical health. These results will be presented. Health planners, physical planners and public authorities in Denmark have not been aware of the impact green areas have on health and well-being. But occurrence of 'welfare deaths', such as stress and overweight, have, however, created a broad interest among planners and authorities in how to use the natural environment for health promoting activities. Physical diseases together with mental stress, depression and burn-out syndrome have become a major economic challenge to the Danish health system. Building on experience from the United States and Sweden, a number of health projects has been started in order to assess if, how, and why the natural environment is a positive factor in promoting public health.

**Ergonomic analysis of *Eucalyptus* seedling production in nursery.** Minette, L.J., Souza, A.P., Gomes, J.M. (*Federal University of Viçosa, Brazil; minetti@ufv.br; amaury Souza@ufv.br; jmgomes@ufv.br*), Alves, J.U. (*RIMA industrial S.A., Brazil*).

Ergonomic factors in eucalyptus seedling production in nursery were evaluated. The operation demanding the heaviest physical work load was seedling transportation with a cardiovascular load value of 30.8%, and none of the activities evaluated had values above the maximum limit of 40%. Most activities were classified as light, except preparation of substrate, tube covering with vermiculite, seedling transportation and first selection, which were classified as moderately heavy. Seedling transportation was the only activity presenting spine-disc strain above the recommended superior limit load. All the activities evaluated, except for first selection, were classified as high risk of repetitive strain disorders. The noise levels and the wet-bulb globe thermometer values did not surpass the limits of 85 dBA and 26.7 °C, respectively, recommended by the Brazilian Association of Technical Norms. The amount of light available at the workplaces was found insufficient for the activity tube arrangement and stake cutting.

**Citizens and urban forests in Italy: Environmental perception and psychosocial implications.** Sanesi, G., Laforteza, R. (*University of Bari, Italy; sanesi@agr.uniba.it*), Bonnes, M., (*University of Rome "La Sapienza," Italy*), Carrus, G. (*University of "Roma Tre", Italy*).

Urban forests, trees and natural spaces are thought to contribute significantly to certain psychophysical, social and cultural needs of urban dwellers. Recent studies on citizens' perceptions and behaviours toward urban green areas have shown the complexity and the multidimensional character of the man-nature relationship in the city: the inhabitants' use of green spaces appears to be motivated by the need for psycho-physical restoration with relevant social implications. In this paper we provide a critical review of research findings coming from two major studies promoted in selected Italian cities: Rome (central Italy) and Bari (southern Italy), two cities displaying different characteristics in terms of urban forestry cover. We combine urban forestry and environmental psychology sciences in a unique and holistic framework (i.e., fully ecological), thus illustrating how the presence of green areas within settlements affects the inhabitants' perception of urban environmental quality, as well as the psychological health of citizens. We conclude

by outlining a series of guiding principles for enhancing the environmental and social benefits of urban forests through collaborative projects and scientific co-operation between ‘Green’ (i.e., urban foresters and social scientists) and ‘White’ (i.e., environmental psychologists and clinicians) researchers.

**Evaluation of proficiency of forest machine operators through questionnaires: Efficient operating, safety work and maintenance.** Yamada, Y. (*Nagoya University, Japan; yozo@nuagr1.agr.nagoya-u.ac.jp*).

Proficiency of machine operators is difficult to evaluate after they can operate their machines efficiently. However, beyond efficiency, there are many significant aspects of proficiency to evaluate—work quality, cost performance, safety, environmental impact, work planning and machine maintenance. We investigated more than one hundred operators of harvesters, processors, tower yarders, skidders and forwarders from throughout Japan, using specially developed questionnaires. Although most of the novices have rich knowledge regarding safety, they do not have much experience regarding cost, environment, quality and planning. Compared to experts, who know what and where they should pay attention because of their rich experience, the number of questionnaire answers from novices was expected to be limited. It can be evaluated that they understand points of operation, however, we must be aware that there is safety hazard due to their lack of experience. In respect of safety, many experts pay less attention than novices. In this paper we present the results of an inventory of operational, safety and environmental responses from forest machine operators, with experience ranging from novice to expert.

**Forest planning in terms of soundscape for recreational and therapeutic activities.** Yamada, Y. (*Nagoya University, Japan; yozo@nuagr1.agr.nagoya-u.ac.jp*).

In Japan, there are 1267 recreational forests and with 16 million visitors per year. People go to these forests to seek transient contentment and countenance, apart from their stressful urban life. Importance of the recreational use of forests has been increasing daily. Moreover, therapeutic effects of forests are becoming recognized for rehabilitation and therapy. In forests, there are: cool and fresh air, agreeable smells, brilliant green scenery and sounds of wind and streams. According to sound wave frequency analysis, the sounds of wind are different between conifer and hardwood forests. Although the former has  $1/f^2$  fluctuation tendency, the latter has  $1/f$  fluctuation. Similarly the sound of streams has near  $1/f^2$  fluctuation, and that of waterfalls has  $1/f$  fluctuation. We implemented sound exposure tests for 30 healthy university students, aged 21–35, to investigate the different physiological and psychological responses between sounds of  $1/f$  and  $1/f^2$  fluctuation. According to these results, the soundscape of recreational forests is of prime importance. Moreover, layout of trails and facilities in the forest can maximize the soundscape to increase enjoyment and healing.

## Sub-theme: Realizing the Environmental Benefits of Forests

### Realizing the environmental benefits of forests

Organizer: Niels Elers Koch *Danish Centre for Forest, Landscape and Planning, KVL, Denmark; nek@kvl.dk*

**Influence of globalization on forests, forestry and environment.** Andrian, G. (*UNESCO-ROSTE, Italy; g.andrian@unesco.org*), Essmann, H.-F. (*University of Freiburg, Germany; hans.essmann@ifp.uni-freiburg.de*), Pettenella, D. (*University of Padova, Italy; davide.pettenella@unipd.it*), Vantomme, P. (*ITTO, Japan; vantomme@itto.org.jp*).

The most recent years of worldwide socio-economic development have been characterized by accelerated phenomena with clear supranational features, all of which have been identified with the term globalization. Until now, the most evident feature of the globalization process has been the intensive interweaving of the financial centres in worldwide operating markets. In this process, the links to national economies, particularly within the forestry sector, are declining rapidly, and the largest enterprises (namely the multinationals) are operating exclusively on a global scale. As forest management is still traditionally oriented on local, regional and, at most, national levels, timber markets and wood processing industries have already been strongly affected by the globalization process. The same seems true to the non-timber produce, as far as it is following the development of wood production, reciprocally. The paper discusses the impacts of globalization on forests and forestry by looking closer to the territorial value of forestry, the non-wood forest production and the role of civil society on forest policy exemplarily. The findings are being discussed in the (tentative) conclusions.

**The right forest for the right city: Decision-support through assessment of multiple benefits.** Konijnendijk, C.C. (*woodSCAPE consult, Denmark; cecil@woodscape-consult.com*), Jellesmark Thorsen, B. (*Danish Centre for Forest, Landscape and Planning (KVL), Denmark; bjt@kvl.dk*), Tyrväinen, L. (*University of Helsinki, Finland; liisa.tyrvainen@helsinki.fi*), Anthon, S. (*Danish Centre for Forest, Landscape and Planning (KVL), Denmark; sia@kvl.dk*), Rahim Nik, A. (*Forest Research Institute Malaysia, Malaysia; rahimnik@frim.gov.my*).

Although the multiple values of woodland in and near urban areas are generally recognized, forestry often plays only a minor role within overall urban development and land use planning discussions. Many environmental and social services provided by urban and peri-urban forests are difficult to assess and quantify, for example, in monetary terms. Therefore, there is a need to develop assessment approaches that can strengthen the policy–science interface by acting as decision-support tools within wider urban and regional policy-making contexts. Examples of recently developed tools for assessing the multiple benefits of existing and new urban woodland include, among others, a study mapping social meanings and values of urban forests in Helsinki, Finland, and a hedonic pricing study of peri-urban afforestation in Denmark. In Malaysia, various assessment tools have been combined to assess the multiple values of a woodland park near the capital of Kuala Lumpur. These and other assessments show that the services provided by urban forests can be considerable and that opportunities exist for generating alternative income for forestry.

**Forests in balance? Forests under the spell of economic, ecological and recreational requirements.**

**Considerations about the European Model.** Pröbstl, U. (*BOKU – University of Natural Resources and Applied Life Sciences, Austria; ulrike.proebstl@boku.ac.at*).

The discussions surrounding forestry in Europe are more heterogeneous and controversial than ever, due to the ever increasing and increasingly conflicting demands towards European forests. The first part of this contribution will present the changing conditions with respect to the economic, conservation and recreational demands being put on the forest. So far, European forestry focused predominantly on multiple use, which is integrating economic interests with those of recreation and conservation in the same areas. Is this concept now questioned, and which solutions do science and research offer to society, politics and management? The second part of the presentation will emphasize that research can offer a multitude of answers and solutions to these questions. However, it seems that the tradition of multiple use of European forests is scrutinized for several reasons. It will therefore depend on science, the application of forest management and society at large to maintain the multi-functionality of the forest *vis-à-vis* short-term and shortsighted changes and re-structuring.

**Forests and water and biodiversity.** Rasmussen, K.R. (*Danish Centre for Forest, Landscape and Planning (KVL), Denmark; krr@kvl.dk*), Carnus, J.-M. (*INRA, France; carnus@pierroton.inra.fr*), Sennerby Forsse, L. (*Formas, Sweden; lisa.sennerbyforsse@formas.se*).

Forestry and forest-based operations are of increasing importance to societies all over the world. There are great demands on forests to provide environmental benefits such as biodiversity, as well as water and industrial products. In

addition, there are pressures on forest ecosystems, e.g. climate change, air pollution, market demands and subsequent exploitation. Ideally, through fine-tuned management, forests could provide the raw material for industry, improve the living conditions for people in forested areas and, at the same time, sustain or restore environmental benefits. However, there are conflicts that pertain to maximal fibre production, biodiversity conservation, security of water supply and enhancement of the livelihood of people in tropical forests. Further complexity is presented by the fact that a sustained supply of clean water may conflict with biodiversity conservation. This presentation will address the question of how forest management strategies may influence i) quantity and quality of water ii) biodiversity conservation, and iii) living conditions for people. Focus will be on how to balance forest production while maintaining water and biodiversity, and to look at management options as a means of optimizing the effects of changing environmental- and socioeconomic conditions.

## **The role of forests in carbon sequestration: Considerations for the carbon market**

Organizer: Robert Jandl *Austrian Federal Office and Research Centre for Forests, Austria;*  
*robert.jandl@bfw.gv.at*

**Carbon storage in managed *Pinus patula* forests in central Mexico.** Angeles-Pérez, G., Valdez-Lazalde, R., de los Santos-Posadas, H., Hernández-de la Rosa, P., Gómez-Guerrero, A., Velázquez-Martínez, A. (*Colegio de Postgraduados-Programa Forestal, Mexico; gangeles@colpos.mx; valdez@colpos.mx; hmsantos@colpos.mx; pathr@colpos.mx; agomezg@colpos.mx; alejvela@colpos.mx*).

Despite the importance of carbon reservoir estimates in terrestrial ecosystems, this information is generally lacking in Mexico. There is evidence that while undisturbed old-growth forests store significantly greater quantities of organic carbon than younger managed stands, the net annual carbon fixation rates in the latter are consistently higher. However, after harvesting natural forests, a reduction is expected in the amount of carbon sequestered in the living biomass due to the extraction of forest products. This study investigates the effect of complete harvest on the carbon pools of *Pinus patula* forests in central Mexico. Results show a reduction in the carbon stored in living biomass after the harvest, but the high growth rate of this species promotes a prompt recovery, reaching 90 Mg C/ha 20 years after cutting. In addition, preliminary results indicate an increase of carbon in the organic matter on the forest floor soon after cutting.

**Carbon mitigation potential of farm forestry in Punjab state of India.** Gera, M. (*Indira Gandhi National Forest Academy, India; mohitgera@yahoo.co.in*), Mohan, G., Bisht, N.S. (*Forest Research Institute, India; deoban@sify.com; bishtnsifs@yahoo.com*).

Carbon mitigation potential and cost effectiveness of tree growing activities on farmlands in the agrarian state of Punjab was assessed. This state has an area of 50,362 sq km with 85.94% under agriculture. The analysis is based on data collected from the three most popular plantation models using a stratified sample of sixty villages: poplar block, poplar bund and eucalyptus bund plantations. A project-based comprehensive mitigation analysis process (PRO-COMAP) was used, taking into account five carbon pools: above ground biomass, below ground biomass, woody litter, soil carbon and harvested wood products. A mitigation potential of 24.49 Mt C was determined, with an average of 72 tC per ha for the period 2005 to 2030 at a unit cost of \$5.67 per tC. This potential could be achieved at a negative cost where non-carbon revenue is sufficient to off-set direct costs. Agroforestry options appear to be quite attractive for carbon mitigation in India because of the extensive land area (approximately 140 m ha) and because approximately 60% of population is dedicated to agriculture. The associated issues of non-permanence, additionality and leakage, along with implementation strategies and barriers to implementation, are discussed.

**Soil carbon change and carbon storage in litter on the forest floor after land use change from native pasture to pine plantation.** Guo, L.B. (*CSIRO Plant Industry and CRC for Greenhouse Accounting, Australia; lanbin.guo@csiro.au*), Cowie, A.L. (*NSW Department of Primary Industries, CRC for Greenhouse Accounting, Australia*), Gifford, R.M. (*CSIRO Plant Industry and CRC for Greenhouse Accounting, Australia*).

From our meta-analysis of worldwide data, soil carbon content decreased following land use change from pasture to conifer plantation. However, carbon stored in litter on the forest floor may balance the carbon lost from mineral soil. A paired study (a native pasture with *Themeda triandra* dominant, and a 16-year-old *Pinus radiata* plantation) at Kowen Forests, ACT, Australia, assessed the soil carbon change, carbon accumulation in litter on the forest floor and annual carbon return to soil surface via litterfall after land use change from native pasture to pine plantation. Results

show that carbon stocks in the top 1 m mineral soil had decreased by 18% from 75 to 61 t/ha, 16 years after the land use change. However, approximately 10 t C/ha in litter had accumulated on the forest floor (including 3.2 t/ha in woody debris mostly from pruning/thinning). In the last two (local drought) years (July 2002–June 2004) approximately 2 t C/ha/yr returned to the soil surface via litterfall. Hence, C in the litter pool could substantially compensate the C loss from soil. Thus, considering the significant amount of carbon likely to be stored in plant biomass, a pine ecosystem planted onto prior pasture should be a net sink for C despite possible losses in soil C.

**Estimation of biomass and sequestered carbon of a young teak plantation with participatory forest management in East Java, Indonesia.** Kato, T. (*JICA–FORDA, Indonesia; ktsuyoshi@mtj.biglobe.ne.jp*), Rohman, Oktalina, S.N., Supryo, H., Simon, H. (*Gadjah Mada University, Indonesia*).

One of the major concerns in CDM projects is the beneficial contribution to local people as well as the efficient sequestration of carbon. In Madiun, East Java, cooperative teak (*Tectona grandis*) forest management with local people has been conducted by the State Forest Enterprise for the past decade. To achieve the balance between the agriculture and forest management, Management Regimes (MR) were introduced. MR consists of five types that differ in the proportion of area in agricultural and teak plantation, and the manner of thinning. The allocation of each type was decided based on the distance of a plantation from a village and geographic conditions, including topography and soil. The objective of this paper is to compare the biomass in young teak plantations under different MR systems, and estimate overall biomass of the Madiun forest district. Individual above and below ground allometric equations were developed from destructive sampling of 45 trees. A detailed inventory was carried out in the area and the biomass was estimated with inventory data inserted in the developed equations. Also, soil carbon (including litter) was assessed in sample plots. The potential of participatory forest management in relation to carbon segregation in teak plantation is discussed.

**Overestimating forest biomass and underestimating expansion of biomass have contributed to the problem “missing sink”.** Kauppi, P. (*Finland; pekauppi@mappi.helsinki.fi*).

Some forest facts have been ignored in carbon budget research, prompting problems in analyzing the atmospheric carbon dioxide trend by creating the ‘missing sink’. The change in atmospheric carbon dioxide over the past 50 years is approximately 64 ppm—smaller than can be estimated by deducting the output from the atmosphere into oceans from the input of emissions from fossil fuels and deforestation. The difference must have entered land ecosystems, but many models have failed to detect where. Forest carbon stocks (i.e., biomass) have been much smaller than often has been proposed in literature and the estimated sink into tree biomass has often been too small. In the 1970s, the perception of the world’s forest was dual—the tropical forests were over-exploited while non-tropical forests were in balance. This was correct regarding tropical forests, but incorrect regarding non-tropical forests. Northern forests have been expanding substantially in terms of biomass, due to improved forest protection, silviculture, legislation and practices. Successful forest policy in the tropics to revert the current trend would improve the global carbon budget, plus create socio-economic opportunities and preserve genetic heritage. The effort to control the concentration of atmospheric carbon dioxide is a good example of where progress in environmental and forest policy is hindered by the still insufficient quality of scientific information.

**Comparison of aboveground biomass and carbon in *Araucaria cunninghamii* plantations and dry rainforest sites in southeast Queensland.** Koeckemann, B., Bauhus, J., Rennenberg, H. (*University of Freiburg, Germany; benjamin.koeckemann@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de; heinz.rennenberg@ctp.uni-freiburg.de*), Schmidt, S., Richards, A. (*University of Queensland, Australia; s.schmidt@botany.uq.edu.au; a.richards@botany.uq.edu.au*).

Aboveground biomass and carbon contents in different biomass layers (canopy trees, understorey trees, undergrowth and litter) of four *Araucaria cunninghamii* plantations (26, 35, 51 and 64 years old) and four paired, natural rainforest sites in Yarraman State Forest, southeast Queensland were measured or estimated. Biomass in *A. cunninghamii* plantations was on average 365 t/ha and more than three times the biomass of the rainforest (104 t/ha). The average biomass in the tree layer (canopy and understorey) was 301 t/ha in the *A. cunninghamii*-stands, compared to only 63 t/ha in the rainforest. Also the litter biomass in *A. cunninghamii* plantations (61 t/ha) was significantly higher than in the rainforest (39 t/ha). Rainforest contained more biomass in undergrowth (3.2 t/ha) than the plantations (2.6 t/ha). Biomass of understorey trees increased with plantation age from 0.4–4.7 t/ha. The much higher biomass of the *A. cunninghamii* plantations when compared to native rainforest underpins the potential of these plantations for C sequestration through afforestation in the subtropical region of Australia. The investigated plantations belong to the few examples worldwide, where plantations contain more aboveground biomass and carbon than the native forest they replaced.



**Carbon budget of forest soil and vegetation with uncertainty estimation: Nation-wide inventory in Finland from 1922 to 2002.** Lehtonen, A., Mäkipää, R., Liski, J., Eggers, T., Muukkonen, P., Palosuo, T., Peltoniemi, M. (*Finnish Forest Research Institute; aleksi.lehtonen@metla.fi*).

We integrated national forest inventory (NFI) data with a soil carbon model to estimate the carbon sink in forests. Stem volumes estimates of the NFI were converted to whole tree biomass by species, age and compartment specific whole tree biomass expansion factors. Growing stock estimates were calibrated with growth index and drain statistics. The carbon budget of soil used the dynamic soil carbon model Yasso, which requires litter production and basic climate variables. Litter production was estimated by multiplying the biomass estimates by compartment-specific turnover rates. From 1922–2002: carbon stocks in Finnish forests increased 49% from 510–757 Tg, carbon stock of mineral soils increased 8% from 907–982 Tg, the annual carbon sink of the trees and mineral soils averaged 16.5 g C/m<sup>2</sup> and 6.4 g C/m<sup>2</sup> respectively, intensified harvesting increased soil C stock but reduced tree C stock, and high temperatures increased growth of trees and consequently tree C stock, but soil C stock was reduced due to faster decomposition. Uncertainty of vegetation carbon stock was mostly dependent on biomass estimation of trees and understory, while the uncertainty of soil carbon stock was dependent on uncertainty of litterfall. Uncertainties of carbon stock changes of vegetation and soil were dependent on reliability of temporal variables (e.g., temperature, growth index and drain).

**Simulated biomass and soil carbon of cottonwood and loblolly pine plantations across a thermal gradient in southeastern USA.** Luxmoore, R.J., Tharp, M.L., Post III, W.M. (*Oak Ridge National Laboratory, USA; luxmoorerj@ornl.gov*).

Changes in biomass and soil carbon with nitrogen fertilization were simulated for a 25-year-old loblolly pine (*Pinus taeda*) plantation and for three consecutive 7-year-old short-rotation cottonwood (*Populus deltoides*) stands. Simulations were conducted for 17 locations in southeastern United States with mean annual temperatures ranging from 13.1 to 19.4 °C. The LINKAGES stand growth model, modified to include the 'RothC' soil C and N model, simulated tree growth and soil C status. Nitrogen fertilization increased cottonwood aboveground biomass for the three stands significantly from 106 to 272 Mg/ha in 21 years, whereas loblolly pine showed a non-significant change with fertilization from 176 to 184 Mg/ha in 25 years. Location results, compared on the annual sum of daily mean air temperatures above 5.5 °C (growing-degree-days), showed contrasts. Loblolly pine biomass increased whereas cottonwood decreased with increasing growing-degree-days particularly in cottonwood stands receiving N fertilization. Average soil C in loblolly pine increased from 24.3 to 40.4 Mg/ha in 25 years and in cottonwood soil C decreased from 14.7 to 13.7 Mg/ha after 21 years. Soil C did not decrease with increasing growing-degree-days in either plantation type suggesting that global warming may not initially affect soil C. Nitrogen fertilizer effects on soil C were small or negligible.

**Organic carbon in pasture lands and natural forests – BOTUCATU/SP – Brazil.** Rufino, A.M.M., Engel, V.L., Guerrini, I.A. (UNESP/FCA, *Department of Natural Resources, Brazil; anafloresta00@yahoo.com.br; veralex@fca.unesp.br; iguerrini@fca.unesp.br*).

Forests have a positive effect on the global carbon cycle due to their carbon stocking capacity. The objective of this study is to compare the contents of organic carbon in the forest soil and in abandoned pasture lands with different soil types. The samples were taken at depths of 0–5; 5–10; 10–20; 20–30; 30–40; 40–50; 50–70 and 70–90 centimeters. The results indicate that carbon level (g/dm<sup>3</sup>) gradually decreased with increasing soil depth in the profile. Site 1 showed higher contents of carbon in the forest soil, while Site 2 presented the largest amounts in the pasture starting from a depth of 10–20 cm, which can be explained by the highest degree of successional development of the forest fragment in this site, in comparison to the others. In Site 3, the highest carbon contents have been observed inside the forest, where degradation is especially high on the neighboring pasture.

**A simulation model of the activities described by Article 3.4 of the Kyoto Protocol.** Nakajima, T. (*The Tokyo University, Japan; nakajima@fr.a.u-tokyo.ac.jp*).

The objective of this study was to develop a model of forest management using forestry statistics. It was based on the forest management (FM) activities described by Article 3.4 of the Kyoto Protocol and used to simulate the total area of FM forests. The study areas were in Gifu and Hokkaido prefectures in Japan. Only private plantation forests were selected in the study. Plantation forests which have implemented silvicultural practices since 1990 were considered as FM plantation forests. We present multiple regression models for the simulation of FM plantation forests. In this model, the independent variable is the subsidies. The dependent variable is the stand area implemented silvicultural practices. We attempted to calculate the total area of FM plantation forests in Japan.

**Role of forests and forest soils in the carbon sequestration.** Podrazsky, V., Ulbrichova, I. (Czech University of Agriculture Prague, Czech Republic; [podrazsky@fle.czu.cz](mailto:podrazsky@fle.czu.cz); [ulbrichova@fle.czu.cz](mailto:ulbrichova@fle.czu.cz)).

Sequestration of carbon dioxide in forest biomass is a broadly studied topic worldwide. Forest ecosystems are represented also by other potential carbon sink—forest soils including the most prominent upper part, humus forms. In the soil ecosystem compartment, there considerably more carbon could be fixed, compared to the above and below ground biomass. This poster summarizes results of the surface humus quantification on a forest site degraded by bulldozing (800 m above sea level in a *Fageto-Abietum* forest type with kryptopodzols). Not only the humus accumulation, but also its dynamics is evaluated during the period 1994–2004. Sustainable forest ecosystems should contain 10–200 t/ha of carbon in holorganic layers. The soil compartment can fix 1–3 t/ha of carbon annually, depending on the species composition in the stand, site conditions, and also on the ameliorative treatments. With some exceptions, conifers generally fix more carbon dioxide than broad-leaved species. Alder stands, in appropriate site conditions, supported by liming and fertilizing, sequester more carbon in humus form than conifer tree species in the same locality. We found that net carbon output occurred with inappropriate forest management practices that liberated CO<sub>2</sub> through accelerated humus mineralization.

**Carbon balance implications of wood substitution in building construction.** Sathre, R., Gustavsson, L. (Mid Sweden University, Sweden; [Roger.Sathre@miun.se](mailto:Roger.Sathre@miun.se), [Leif.Gustavsson@miun.se](mailto:Leif.Gustavsson@miun.se)), Pingoud, K. (Finnish Forest Research Institute, Finland; [Kim.Pingoud@metla.fi](mailto:Kim.Pingoud@metla.fi)).

Use of wood instead of other building materials such as concrete and steel generally lowers net carbon dioxide emission for three reasons: manufacture of most wood products uses less fossil energy than manufacturing other materials, byproducts of wood processing can be used as biofuel, and carbon is stored in wooden materials. We explore these issues by comparing two wooden frame apartment buildings constructed in Sweden and Finland to functionally equivalent reinforced concrete buildings. We compare results based on three different northern European process analyses of specific energy use for material production, and discuss alternative methods of determining specific energy use. We calculate the potential biofuel available from byproducts of the entire wood processing chain, and the impact on net carbon balance if these biofuels replace coal or natural gas. We explore the relative importance of material production parameters, biofuel recovery and carbon storage, and calculate best- and worst-case carbon balances for the wood and concrete buildings. We express the net carbon emission reduction per unit of building area, forestland area and biomass used, and discuss alternate indices describing the emission reduction effectiveness of material substitution. We find the primary energy used and net lifecycle carbon emission to be substantially lower for the wood frame buildings. The impact of carbon stored in wood building materials is minor compared to other factors.

**Effects of alternative management schedules on stand level carbon stocks: a simulation study.** Sievänen, R., Pohjola, J., Siipilehto, J., Hynynen, J. (Finnish Forest Research Institute, Finland; [risto.sievanen@metla.fi](mailto:risto.sievanen@metla.fi)), Liski, J. (Finnish Environment Institute, Finland).

We have augmented the MOTTI stand simulator with the dynamical soil carbon model Yasso. MOTTI employs an empirical growth model that has been devised to apply to all commercial tree species in Finland. Yasso simulates the decomposition of litter and soil organic matter, and calculates the amount of soil carbon and heterotrophic soil respiration. We estimated the litter production of living trees for input to Yasso on the basis of tree biomasses by applying coefficients that turn part of the biomasses of the tree compartments into litter. Harvest residues and natural mortality produce also litter. We have applied this system to study the effects of management regimes on carbon stocks. We studied the effects of intensity and timing of thinnings and rotation period, and observed that they have pronounced effects on carbon stocks. We indicate how these observations extend from the stand to the regional level. We also studied possible strategies to achieve carbon sequestration goals during Kyoto commitment periods. They include specific management regimes and thinning schedules to reach the sequestration target from the current state.

### **Innovations in forestry accounting: Integration of forest assets and non-market environmental benefits into management and national accounting and reporting**

Organizer: Hans Jöbstl BOKU—University of Natural Resources and Applied Life Sciences, Vienna; [hans.joebstl@boku.ac.at](mailto:hans.joebstl@boku.ac.at)

**Can we use non-market valuation techniques in green national accounting for forests?** Campos, P., Caparrós, A. (Spanish Council for Scientific Research (CSIC), Spain; [pcampos@ieg.csic.es](mailto:pcampos@ieg.csic.es); [acaparros@ieg.csic.es](mailto:acaparros@ieg.csic.es)).

Theory on green national accounting has been an important research topic in recent years. Nevertheless, little effort has been put into the practical measurement of exchange values for environmental goods and services to be integrated with

commercial ones in applied green national accounting. While market values are measured in national accounts using market exchange prices times quantity, environmental valuation techniques yield consumer surplus and other non-exchange market values, so an homogeneous aggregation of those values is required. This paper proposes to simulate markets, demand and cost functions, for forest environmental goods and services, at the micro-level, to obtain imputed exchange values that can be aggregated to commercial values in a homogeneous manner. The methodology is illustrated by applications to Mediterranean forest using contingent valuation data for free access recreation and landowner's self-consumption services. In addition, self-employment and grazing resources are estimated as a joint accounting residual value from market data for livestock production.

**The development of forest accounting in the province of Trento.** Goio, I. (*IVALSA – CNR, Italy; ilaria.goio@ivalsa.cnr.it; ilaria.goio@libero.it*), Gios, G. (*University of Trento, Italy; geremia.gios@economia.unitn.it*), Pollini, C. (*IVALSA – CNR, Italy; claudio.pollini@ivalsa.cnr.it*), Notaro, S. (*University of Trento, Italy; sandra.notaro@economia.unitn.it*).

In the increasing scientific debate about sustainable forest management, a crucial role is played by the development of adequate instruments of evaluation and survey. The proposed system of national account (SNA) underestimates the full value of forest resources and does not permit a correct evaluation of the total contribution of forests to economic welfare. The SNA reflects, partially, the consumption of forest natural capital or the costs of loss of forest quality. This is due to the fact that it registers only the value of produced outputs that are traded in the marketplace. The non-market functions provided by forests (recreational, aesthetic, ecological and protective) are definite 'non-SNA functions' and are not taken into account. As many study have demonstrated, forests have a higher value than that connected to production aspects. This paper focuses on results of a tentative accounting system in order to estimate and integrate the benefits of non traded-goods and services provided by forests located in the Province of Trento (north-east Italy). The forests, which cover about 50% of the whole surface, have to be valued.

**International accounting standards: How adequately are forest assets reported in the balance sheet and income statement?** Herbohn, K. (*University of Queensland, Australia*).

Australia was the first country to develop a financial accounting standard on self-generating and regenerating assets (SGARAs). The standard AASB 1037 Self-generating and regenerating assets mandates reporting requirements for all non-human living assets, and so its scope includes forests. Companies and state governments that have material holdings of forests must comply with the standard. It has been operative for financial reporting periods ending on or after 30 June 2001 and so presents a unique opportunity to investigate the impact of reporting forests on a balance sheet. A particularly interesting feature of AASB 1037 is that it requires the net market value of forests to be estimated at the end of each reporting period. Changes in the net market values of forest assets are to be recognized as either revenues or expenses in the income statement. An investigation of the impact of AASB 1037 also provides valuable insights into the potential impact of IAS 141 Agriculture that must be complied with as part of international harmonization by Australia and all countries of the European Union from 1 January 2005. This is because the Australian standard and the international standard share many similar requirements.

**Forest assets and environmental benefits in management accounting.** Jöbstl, H.A. (*BOKU–University of Natural Resources and Applied Life Sciences, Vienna; hans.joebstl@boku.ac.at*), Peyron, J.-L. (*ECOFOR, France; peyron@gip-ecofor.org*).

Management of forests takes place in the institutional framework of forest enterprises and requires a variety of information. The core instrument of information supply is the accounting system. It provides the basis for decisions and internal controlling, and it is needed for reporting to external stakeholders on economic and social aspects of the forestry operation. Forestry accounting also has major deficiencies; periodic changes in forest assets are insufficiently recorded, and other achievements, especially with respect to the environment, are not shown adequately. Many approaches have been proposed over time to consider changes in forest assets, but none of them have been accepted in practice. Whereas there are hardly any legal regulations concerning forest asset records in external accounting, it is indispensable for internal accounting to have correct records and examine if targets have been reached. With regard to the environmental benefits that cannot actually be assessed with a monetary system, so-called performance reports and sustainability reports that show primarily physical factors are being examined. On a higher level these performance reports are partially complemented by monetary factors. An overview on new developments and related topics with a focus on performance measurement and management control shall be presented and discussed in this paper.

**Environmental, social and economic accounting for forestry at national and international levels.** Lange, G.-M. (Columbia University, USA), Peyron, J.-L. (ENGREF/INRA and ECOFOR, France; [peyron@gip-ecofor.org](mailto:peyron@gip-ecofor.org); [peyron@nancy-engref.inra.fr](mailto:peyron@nancy-engref.inra.fr)).

National accounts are widely used as information sources for political decision-making. However, their central framework often fails in correctly representing forestry. Forest production is not fully represented either regarding wood products or non-wood goods and services. The relationship between the forest sector and the national economy or between the forest sector and the society is not really described, and there is also inconsistency between current accounts and balance sheets. For several years, this situation has been improving through the formalizing of forest accounting in the United Nation's System of Integrated Environmental and Economic Accounting (SEEA). The concept of production is being extended, new efforts have been made in practical implementation of theoretical approaches, and satellite accounting in forestry has been developed to provide valuation of natural growth and non-wood goods and services. FAO, EUROSTAT and other agencies have initiated programs to implement forest accounting. Methodology, results and policy application of forest accounts will be discussed, based on these experiences.

**Valuing ecosystem services from forests: A multidisciplinary, field-based approach.** Maraseni, T.N., Cockfield, G., Apan, A. (University of Southern Queensland, Australia; [w0007649@mail.connect.usq.edu.au](mailto:w0007649@mail.connect.usq.edu.au)).

There are a number of land-use regimes in the world. Within forest land-use there are different management strategies. There are diverse views about the superiority of one regime or strategy over the others. The resulting debates cannot be solved from the current body of literature as there need to be net economic values of both marketed and non-marketed good and services in order to compare the outcomes from different management regimes. Because of the uncertainty of methodology and the difficulty in calculations, researchers are often limited to the valuation of marketed goods of forest and non-marketed values are not taken into account. Consequently, total goods and services from forests are undervalued and their contribution to the national output has been underestimated. As a result, decisions on forest land-use have been biased in favour of other land-use options. This paper reports on the development and testing of a method for evaluating the net benefits from forest that incorporates primary data on carbon sequestration rates and biodiversity and soil conservation values. This data can then be used to develop optimal production regimes.

**Economic accounts for forestry: Results for the Federal Republic of Germany.** Thoroe, C., Dieter, M., Rosin, A. (Federal Research Centre for Forestry and Forest Products, Germany; [c.thoroe@holz.uni-hamburg.de](mailto:c.thoroe@holz.uni-hamburg.de)).

With the implementation of the European System of Integrated Economic Accounts (ESA) in 1995, the national accounting systems of the member states have been harmonized and based on a standard framework. As part of the ESA, the Economic Accounts for Forestry (EAF) has become a common format as well. The EAF is a satellite account for the purpose of analyzing the production process and the entrepreneurial income in the forestry sector. The EAF is focused on typical forest-related activities and hence does not take into account activities like consulting and mandatory activities by state forest agencies or forest management services, hunting, recreation services etc. For Germany and the years 1991 to 2002, the Economic Accounts for Forestry have been calculated. The production value ranges between \$2,445,000,000 and \$3,301,000,000, more than the half accounting for compensation of employees. Due to methodological concerns and lack of data, the value of timber growth and harvested volume are not included. Arising partly from this, the net operating surplus is negative for most of the investigated years. It indicates that potentially higher revenues due to changes in forest management must be continuously paid with interest on outside capital.

**Economic accounting of carbon sequestration by forests.** Thoroe, C., Elsasser, P., Dieter, M. (Federal Research Centre for Forestry and Forest Products, Germany; [c.thoroe@holz.uni-hamburg.de](mailto:c.thoroe@holz.uni-hamburg.de)).

Forests play a significant role in the global carbon cycle. Until the beginning of the first commitment period of the Kyoto protocol, air was a free good and the removal of carbon from the atmosphere was a non-value service by forests. For the purpose of investigating the possibilities of a monetary valuation of this service within the national accounting system, a pilot study was conducted in Germany. Three different approaches have been identified and the results of a comprehensive literature survey have been applied to physical sequestration. Basically, valuation of carbon sequestration by market prices would be the most adequate valuation approach. However, carbon markets are still in a nascent stage, so the monetary valuation has to be assisted by other approaches that consider costs due to damage, damage avoidance, emission avoidance and carbon sequestration. The monetary value of carbon sequestration by forests in Germany is estimated to be between \$61 million and \$611 million annually. Different assumptions concerning the international climate policy account for the greatest variation and a very restrictive policy can cause much higher calculative results.

**Forestry accounting in German state and community forest-enterprises: Recent innovations.** Tzschupke, W. (*University of Applied Sciences (Fachhochschule) Rottenburg a.N., Germany; tzschupke@fh-rottenburg.de*).

Forestry accounting in nearly all German state and community owned forest-enterprises was, until now, a rather simple single-entry book-keeping based on an accounting of revenues and expenditures according to the respective budget-plans. For internal purposes, budget-oriented cash accounting was partially transformed into a widely used cost accounting system, whereas a valuation of forest-assets (soils and stands) and of non-market-benefits was not practiced. However the recent implementation of the so-called new public management-techniques within German states and communities initiated remarkable alterations in forestry accounting. The changes are characterized by introduction of double-entry bookkeeping, and differentiation between the financial and cost accounting systems, according to five product lines. These are timber production, environmental protection and rehabilitation; environment-oriented education; services for others and political and administrative tasks. The necessity of a valuation of forest-assets is still a controversial issue. However, it is inevitable for those forest-services that will be transformed into so-called public companies or into companies with a private legal status. This is why the actual discussion is focussed on the search for the most appropriate valuation method.

### **Decisions with long-term effects in forest management: how to deal with uncertainty?**

Organizers: Peter Deegen *Research Institute for Forest Ecology and Forestry, Germany; deegen@frsws10.forst.tu-dresden.de*, and Axel Roeder *Research Institute for Forest Ecology and Forestry, Germany; roeder@hrk.uni*

**ENFORS 3: the care of an inheritance—improved access to and management of SFM information.** Mårell, A. (*GIP ECOFOR, France; marell@gip-ecofor.org*), Andersson, F. (*Swedish University of Agricultural Sciences, Sweden; folke.andersson@eom.slu.se*).

Forestry has a long tradition of experimentation and data collection in the field. The earliest European forest experiments date back to the second half of the 19<sup>th</sup> century and many national forest inventories have 100 years of data collection. A survey by the European Network for long-term Forest Ecosystem and Landscape Research (ENFORS – COST Action E25) has revealed a rich asset of experiments, case studies, research projects, watershed studies and monitoring activities in Europe (accessible as a web-based meta-database at [www.enfors.org](http://www.enfors.org)). During the survey it also became evident that this asset is being jeopardized because of the lack of: 1) financial resources for its maintenance, and 2) proper documentation and (meta-)data management. The loss of data because of poor transfer of information between younger and older generations of researchers is a recognized problem. Its accessibility is also a problem due: to unpublished data becoming dust collectors over time, computer breakdowns, data being published in internal reports that are not always accessible to the general scientific community and language barriers. Guidelines for proper documentation in terms of meta-data as well as the development of information systems for data management and exchange need to be communicated and implemented at the large scale by the forest scientific community.

**Driving forces in forest resources utilization: Consequences of globalization and uncertainty.** Paschalis-Jakubowicz, P. (*Warsaw Agricultural University, Poland; paschalis@delta.sggw.waw.pl*).

The widespread conviction that forestry has come upon a ‘philosopher’s stone’ in the shape of the sustainable forestry model is being shown to be ever more illusory. The changes ongoing in forest ecosystems and around forestry—of whose genesis and course we still know very little—combine with irrational behaviour on the part of society and unpredictable changes globally to ensure the extreme difficulty of decision-making in forestry management (whose effects only emerge after many years). This is particularly true of the chances of foreseeing and assessing the final consequences of a decision concerning the use of forest resources that simultaneously encompasses productive, social and environmental functions. In consequence, this paper has sought to select and offer a preliminary analysis of, some 10–20 driving forces capable of determining the future development of forest resource utilization on the world scale, as well as evaluating the significance of different factors concerned *inter alia* with the forest environment, as well as the technological, economic, social, demographic and institutional solutions. The results obtained offer a basis upon which long-term decisions regarding resource-use may be made, with a view to a minimizing and spreading of the risk that errors will arise due to unpredictable events.

**Flexibility: A heuristic approach to deal with uncertainty in long term strategic planning.** Roeder, A. (*Research Institute for Forest Ecology and Forestry, Germany; axel.roeder@wald-rlp.de*).

Long-term management of sustainable forestry in central Europe faces considerable difficulties when trying to get reliable information necessary for rational and responsible strategic management decisions with long-term effects.

Long-term in our context means more than at least one human generation. For further analysis it is useful to classify these information deficits as risk, uncertainty and ignorance. In view of some methods generally used to overcome the lack of information on the far future, it becomes clear that information deficits especially in the class 'ignorance' (e.g. information on future markets) may not be bridged by any standard method. To reach still some guidance when deciding in a long-term context 'flexibility' is proposed as a useful decision criterion. Flexibility in this context is characterized by the existence of polyvalent management options and by the lack of long-term binding commitments. A heuristic decision tool is proposed and illustrated to make the criterion 'flexibility' operational.

**The change of forest investment decisions by fuzziness.** Setzer, F. (*Dresden University of Technology, Germany; frank.setzer@epost.de*).

Forestry investments are often characterized by being long-term with a lack of knowledge. However, there is a significant difference between uncertainty and fuzziness. An example of this difference can be seen in a forest investment 'mixed stand': generally, uncertainty describes the probability to achieve the financial optimal rotation, while fuzziness deals with the vague definition of the economic criteria of this investment (e.g., cash flows). The fuzzy set theory has been used as a model for many forest investment decisions by several authors. However, the extension of the Faustmann-formula to include fuzziness is still missing. Do we have really all information for defining the crisp interest rate or cash flows? The objective of this presentation is to demonstrate, how fuzzy information is modeled with membership functions for a substitution in the Faustmann-formula. In this way fuzzy information such as 'low interest rate' or 'high cash flows' can be recognized in the Faustmann-formula. Finally it will be shown that investment decisions which are based on the fuzzy Faustmann-formula can be quite different from the same decisions made by using the crisp Faustmann-formula. One example is that the lack of knowledge for an investment doesn't produce a rise of interest rate.

## **Forestry for urban development: Urban forestry as a tool for industrializing countries**

Organizers: Cecil Konijnendijk *woodSCAPE Consult, Denmark; cecil@woodscape-consult.com*, and Abdul Rahim Nik *Forest Research Institute of Malaysia (FRIM), Malaysia; rahimnik@frim.gov.my*

**Urban forestry for sustainable urban development in Eastern Europe.** Bell, S. (*Edinburgh College of Art/Heriot Watt University, United Kingdom; sbell@easynet.co.uk*), Donis, J. (*Latvian Forestry Research Institute 'Silava', Latvia; donis@silava.lv*).

In many cities of Eastern Europe and the Former Soviet Union, forests and urban fringe woodlands were designated as protected zones under the soviet or similar planning systems. Many of these cities, such as St Petersburg, Riga, Vilnius or Minsk are expanding rapidly and the urban planning constraints have been loosened in order to enable development to take place. In some cases, this is causing western-style urban sprawl. The authors have made preliminary studies in these cities and identified three needs. Firstly, core areas of urban forest should be preserved, even if they become surrounded, eventually. Secondly, existing forests should be better managed, using new information and participatory planning tools. Thirdly, new urban fringe woodlands should be developed as a framework for the control of urban sprawl. Riga, as the biggest city of the Baltic states newly incorporated into the EU, embodies many of the challenges and opportunities and will be used as a case study to demonstrate these.

**GIS analysis of drought damages in the park forests of the City of Helsinki.** Leino, O., Talvitie, M., Holopainen, M. (*University of Helsinki, Finland; olli.leino@helsinki.fi; mervi.talvitie@helsinki.fi; markus.holopainen@helsinki.fi*).

An urban environment is subjected to environmental stress. As a result of outdoor activities and recreation the areas nearest housing districts show greatest soil erosion and damage to the roots of trees. Additionally, the effects of traffic and air pollutants on trees are at their most intense in an urban environment. Consequently, the forests are more susceptible to drought damage, fungi, insects and storms than elsewhere. During spring and summer of 2003, severe drought damage was observed in the park forests of the city of Helsinki, especially in barren site pine and spruce stands. The city commissioned a study to assess these damages by an inventory carried out in autumn 2003. The objective of this study was to assess reasons for, and consequences of, drought damage in park forests. Methodology included GIS analyses of geographical data such as digital aerial photographs, rainfall statistics and the compartment-wise GIS-database of the park forests. Modern forest measurement methods facilitate the construction of a forest health monitoring system. In the case of monitoring drought damage in the City of Helsinki this would necessitate repetition of aerial photography every two years.

**Building up research capacities in urban forestry: The China experience.** Li, Z. (*Chinese Academy of Forestry, P.R. China; lzy263@263.net.cn*), Wang, C. (*Chinese Academy of Forestry, P.R. China; wangcheng@forestry.ac.cn*).

With the rapid development of the economy and the urbanization progress in China during past ten years, capacities of urban forestry research have greatly increased. At the policy level, the study of urban forestry has prompted preparation of a development strategy of China urban forestry. At the practice level, urban forestry is being developed in many large and middle-sized cities. At the academic level, a branch of urban forestry research has been founded within the Chinese Forestry Society. A study team has been formed and the magazine 'China Urban Forestry' has been launched. At the level of academic study, urban forestry research has been developed in cooperation with the central and local governments. With regards to the level of international cooperation, the Chinese Academy of Forestry has been a main player in the development of an ASEM forestry platform. In cooperation with Denmark and Finland, this platform has been used for convening an ASEM Urban Forestry Symposium and for developing other networking activities.

**Relationships between dust-like soil structure, urban forestry and city management in Moscow.** Makarova, O.V., Bondarenko, V.V. (*Moscow State Forest University, Russia; makarova@mgul.ac.ru; bondaren@mgul.ac.ru*), Koolen, A.J. (*Wageningen University, Netherlands*), Shalaev, V.S. (*Moscow State Forest University, Russia; shalaev@mgul.ac.ru*).

Soil texture refers to the particle size distribution that is determined after removing the organic material that holds the particles together. Micro-aggregate analysis concerns the determination of the particle size distribution after soaking and boiling the soil. Aggregate size distribution refers to the size distribution of soil particles and aggregates are determined by dry sieving of the soil. Soil structure is optimal when the fractions of dust-like elements and coarse elements are minimal. Textural analysis of a range of soil samples around Moscow showed that the soils are, potentially, very productive, but they belong to a soil type with a vulnerable structure that can be destroyed easily. Dry sieving of a range of soil samples showed that Moscow soils contain large amounts of dust-like material, indicating degradation of micro-aggregates. Micro-aggregation is promoted by the action of roots of vegetation, input of fresh organic material, frost, precipitation, drying, soil fauna, bacteria and mycorrhizae. Degradation of micro-aggregates is due to soil surface impacts from raindrops, application of de-icing salt, human traffic, vehicle movements and sedimentation of dust from the atmosphere. The paper discusses these factors for Moscow conditions.

**Studies on the relationships between flora of secondary *Quercus serrata* stands, area of stands and surrounding land use in a suburban district of Tokyo, Japan.** Nemoto, J., Nakashima, A. (*Wakayama University, Japan; UGN75508@nifty.com; nakat@sys.wakayama-u.ac.jp*).

We studied the relationships between flora of seven secondary stands of *Quercus serrata*, the area of stands and surrounding land use in a suburban district of Tokyo, Japan from autumn of 2003 to summer of 2004. The results indicated that the numbers of species were significantly correlated with stand area. In addition, as the number of species increased, the percentage of immigrant species from surrounding plantations also increased. The percentage of alien plant species was significantly correlated with the human population within 250 m from the studied stands. As urbanization around the stands increased, the percentage of species characterizing woodlands decreased. Formerly, the flora of fragmented woodlands in cities was thought to be isolated from the surrounding environment, similar to 'islands in the ocean'. However, the results show that the qualitative parameters of flora of fragmented woodlands are related to surrounding land use. Thus, to conserve the flora of fragmented woodlands qualitatively, both the areas of stands and land use around the stands should be considered.

**Urban forestry as a means to improve environmental quality: The US experience.** Nowak, D.J., Walton, J.T., Crane, D.E. (*USDA Forest Service, USA; dnowak@fs.fed.us; jeffreywalton@fs.fed.us; dcrane@fs.fed.us*).

Urban forestry research in the USA is detailing urban forest structure and its effect on environmental quality (e.g., air and water pollution, greenhouse gases, air temperatures, building energy use). This research is leading to new tools and policies that can be used to improve environmental quality in cities across the world. This presentation will detail the latest research findings, tools and policies for incorporating urban forests within designs and plans to improve environmental quality.

**Planning strategy for the enhancement and rehabilitation of green spaces in Metro Manila, Philippines.** Palijon, A.M., Bantayan, N.C., Aquino-Ong, S.C., Gordoncillo, P., Fernando, E.S., Lidasan, H. (*University of the Philippines Los Banos, Philippines; armpalijon@yahoo.com*).

The state of the Metro Manila's green spaces warrants the search for a holistic and sustainable enhancement and rehabilitation strategy. To appraise and analyze the interacting biophysical, social, economic, political and institutional conditions that directly and indirectly influence the health of the green spaces, a system approach is introduced. This approach can provide the mechanisms necessary to conscientiously determine the real issues and concerns. In this paper, we present a framework for this type of analysis using the case of the major thoroughfares in Philippines. The framework is helpful in

generating information to characterize the existing situation of the green spaces, and in identifying issues and concerns. On the basis of the results of the analysis, the paper recommends another framework necessary to achieve an ideal level of sustainable green space management. It includes, among others, various institutional, social, political and bio-physical programs designed to address these issues and concerns which would need multi-disciplinary and multi-sectoral involvement.

**Management of forests in the Prague capital area with respect to their forms of use and function.** Podrazsky, V., Karas, J. (*Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz; karas@fle.czu.cz*), Matejka, K. (*IDS, Czech Republic; ids@infodatasys.cz; ids@infodatasys.cz*), Vyskot, I. (*Mendel University of Agriculture and Forestry, Czech Republic; vyskot@mendelu.cz*).

The basic aim and primary approach of this project are the quantification of social needs of urban forests surrounding Prague, by optimization of their functional use and by defining the target management. Owing to social needs, data such as spatial distribution, socioeconomic importance and functional-multipurpose use in the defined area were collected and analyzed. Next, optimization of the spatial distribution, structure and equipment were developed for functional usage. Data analysis serves to define the management of present and future forests, to quantify the economic requirements and effects, and to compare the costs and benefits of optimized versus classical management. Finally, one of the main outputs is the area categorization from the point of view of social needs.

**Twinning for urban forestry research and development: the Malaysia–Denmark experience.** Rahim Nik, A. (*Forest Research Institute Malaysia; rahimnik@frim.gov.my*), Schipperijn, J. (*Danish Centre for Forest, Landscape and Planning, KVL; jsc@kvl.dk*), Haron, N. (*Forest Research Institute Malaysia; norini@frim.gov.my*), Konijnendijk, C.C. (*woodSCAPE consult, Denmark; cecil@woodscape-consult.com*).

Urban forestry is a relatively new, interdisciplinary approach, focusing on the planning and management of forests and trees in and around urban areas. Recent years have shown the high potential of urban forestry in contributing, globally, to sustainable urban development. As with any new approach involving different disciplines, however, urban forestry research, development and educational capacities need to be improved and enhanced. Both Denmark and Malaysia have recognized the potential of urban forestry and are developing their R&D and educational capacities. In order to learn more from each other and to develop joint initiatives, urban forestry is one of the priority areas of an ongoing twinning program between the leading forestry R&D institutions in both countries. The program assists in development of special third-level education on urban forestry in both countries, as well as improvement of training of urban forest managers. Guidelines for urban forest management are being assessed and developed and a joint pilot project is being undertaken within ongoing green structure planning and development in Kuala Lumpur. Experience has shown that many of the challenges faced by urban forestry are similar in both countries, and that bilateral R&D cooperation can be highly beneficial and rewarding.

**Forest disease: Urban disaster?** Ramsden, M., Pegg, G.S. (*Department of Primary Industries and Fisheries, Queensland, Australia; Michael.Ramsden@dpi.qld.gov.au*), McIlwain, J.-J. (*Brisbane City Council, Queensland, Australia*), Francis, L.P. (*Department of Primary Industries and Fisheries, Queensland, Australia*).

The basidiomycete root and butt rot disease *Phellinus noxius* (Corner) G.Cunn. is a pantropical fungal pathogen with a wide host range, affecting both angiosperms and gymnosperms. This pathogen is endemic in many of the wetter native forests, usually below an altitude of 500 m. Clearing of these forests for plantations of inadvertently susceptible species has resulted in economic loss and unforeseen management issues. Harvesting of these plantations exposes an unnatural number of stumps, which are capable of acting as new entry points, and reservoirs of the disease for following plantations. This pathogen is also present in the urban environment and was recently identified in an important coastal dune area in northern New South Wales, Australia. In the Brisbane urban area, this pathogen affects a number of exotic and native tree species. Of concern is its widespread association with the decline of a number of significant heritage-listed *Ficus* spp. This paper will discuss the research currently being undertaken by forest pathologists within Horticulture and Forestry Science in association with Arboricultural Consultants from the Brisbane City Council. This research addresses the significance of this disease, control methods (chemical and physical), mode of dissemination and disease/decay initiation and progression.

**Is urban forestry a tool to improve the quality of life and development in Latin America? Needs, actions and perspectives through networking and a case-study approach.** Salbitano, F. (*University of Firenze, Italy; fabio.salbitano@unifi.it*), Russo, I. (*City of Havana, Cuba*), Leon, B. (*NGO TECNIDES, Peru*).

The quality of life in urban settlements depends greatly on the quantity and quality of green space in and around towns. Latin America is the world's most urbanized region. In the year 2000, 80% of the people were living in towns and suburbs, and this share was forecasted to be over 85 % by 2020. Urbanization and poverty have gone hand in



hand; in the last 20 years the population living under the level of poverty in urban areas increased from 47 to 64%. Generally, urbanization takes over the best cultivated lands, causing a decrease in agricultural and forestry production. Other threats are pollution of natural and semi-natural ecosystems, such as woodland, and the increasing pressures on these due to human use and abuse. The quality of water and its catchments are heavily modified. Major problems also concern the relationships between human health and environment, and the limited amount of green spaces versus the high need for their benefits, such as mitigation for dust/pollution. The need for networking to develop urban forestry's contributions to sustainable development and combating poverty is described, based on an initiative launched in Lima in 2004. Selected case studies, highlighting strategies developed in Latin American countries, are presented.

**Towards greening and conservation efforts in the new federal government administrative capital: Putrajaya, Malaysia.** Sreetheran, M., Noor Azlin, Y. (*Forest Research Institute Malaysia (FRIM), Malaysia; sreetheran@frim.gov.my; azlin@frim.gov.my*), Raja Yusoff (*Perbadanan Putrajaya, Malaysia*).

Urban forests foster the green fabric of the urban landscape; harmonize the built-up environment that often dominates the scene. High quality buildings and urban forests, blended well, create special 'gems' of townscape. Green spaces such as parks and green corridors well integrated in the planning of a township can be seen in the example of the new Federal Government Administrative Capital of Malaysia, Putrajaya. Putrajaya has natural lush greenery with botanical gardens and large bodies of wetland spread across the landscape. The constructed wetlands were engineered to emulate the functions of natural ecosystems. The wetlands also serve as a bird sanctuary and provide habitats for other wildlife. Having a high biodiversity content, the wetlands serve as venues for public activities in wetland education. Putrajaya also hold great potentials for research in ecological and social functions of urban forestry, as will be discussed in this paper. The plan to develop Putrajaya as a Garden City is a very worthy effort. The aim of Putrajaya to become a model for other major cities in Malaysia is highly achievable.

**Inventory of drought damage by means of digital aerial photographs and adaptive cluster sampling.** Talvitie, M., Leino, O., Holopainen, M. (*University of Helsinki, Finland; mervi.talvitie@helsinki.fi; olli.leino@helsinki.fi; markus.holopainen@helsinki.fi*).

During spring and summer of 2003, severe drought damage was observed in park forests of Helsinki. The city commissioned an assessment of the damage by an inventory carried out in autumn 2003. The primary objective of the inventory was to map and document the extent of the damage by existing geographical information, digital aerial photography and field surveys. A secondary objective was to study the possibility of assessing drought damage by visual and numerical interpretation of digital aerial photography. Visual and numerical photo interpretation of digital aerial photographs was used to locate potential drought damage. Adaptive cluster sampling was utilized in field measurements and accuracy assessment. Study results showed that the area of serious damage was approximately 25 ha and most of these areas were located on rocky sites with low productivity. The proportion of damaged stock volume was 3.3% of total stock volume in the study area. Digital aerial photos proved to be an excellent tool for assessing drought damages. In further studies, alternative field sample and measurement methods for assess sparse forest phenomena will be tested. Data acquisition based on combination digital aerial photographs and modern field measurement technology will also be developed.

## **An overview of national forest greenhouse gas accounting systems: Progress and scientific challenges**

Organizers: Werner Kurz and Kevin Percy *Natural Resources Canada, Canada; wkurz@nrcan-rncan.gc.ca; Kevin.Percy@nrcan-rncan.gc.ca*

**The Kyoto perspective: Optimal use of wood.** Frühwald, A. (*University of Hamburg, Germany; a.fruehwald@holz.uni-hamburg.de*).

The poster deals with the optimal use of wood under aspects of the Kyoto Protocol. Carbon sequestration in the forest is honoured, especially in physical terms, by COP decisions. Sequestration in wood products is not fully acknowledged. The use of wood products contributes in several ways. Carbon sequestration occurs in wood products and amounts to 20–30% of that of forests above ground. There is low energy consumption in the production of wood products compared to others based on non-wood materials. Wood-based products are manufactured with up to 80% of renewable energy (wood residues) and this is superior to almost all other non-wood raw materials. The poster presents examples and proposals for comparative assertions.

**Canada's national forest carbon monitoring, accounting and reporting system: Progress and challenges.** Kurz, W.A., Apps, M.J., Stinson, G., White, T., Rampley, G., Banfield, E., Gillis, M., Paradine, D., Leckie, D. (*Natural Resources Canada; Canada; wkurz@cfs.nrcan.gc.ca*).

Canada contains about 10% of the world's forests. To estimate forest carbon stocks, stock changes and non-CO<sub>2</sub> greenhouse gas emissions, Canada is developing a comprehensive system that integrates information from several forest inventory sources with data on forest management activities, natural disturbances and land-use changes. Remote sensing programs contribute information on forest cover and the area affected by wildfire and other forest disturbances. Time series analysis of satellite images and ancillary data are used to identify where forest cover loss represents direct human-induced deforestation. Afforestation data are obtained through an internet-based voluntary reporting system. The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS) provides the framework to integrate this information in space and time. The model simulates living biomass, dead organic matter and soil carbon pools by accounting for carbon uptake from growth, transfers due to litterfall, mortality and disturbances, and carbon losses from decomposition and disturbances. A national system of forest inventory plots will provide data to refine model parameterization. Representation of carbon dynamics in the moss and deep organic layers of forested wetlands remains a major scientific challenge. Sensitivity and uncertainty analyses are planned to address the source and magnitude of uncertainties associated with greenhouse gas balance.

**National forest carbon accounting systems: A synthesis of national solutions to a global challenge.** Kurz, W.A. (*Natural Resources Canada; Canada; wkurz@cfs.nrcan.gc.ca*), Gytarsky, M.L. (*Institute of Global Climate and Ecology; Russian Federation; mike.gytarsky@g23.relcom.ru*), Matsumoto, M. (*Forestry and Forest Products Research Institute; Japan; machan@ffpri.affrc.go.jp*), Richards, G. (*Australian Greenhouse Office; Australia; gary.richards@greenhouse.gov.au*), Schlamadinger, B. (*Joanneum Research, Austria; Bernhard.schlamadinger@joanneum.at*), Ståhl, G. (*Swedish University of Agricultural Sciences, Sweden; goran.stahl@resgeom.slu.se*).

To meet the international reporting requirements on activities aimed at reducing greenhouse gas sources and enhancing sinks, many countries are developing national forest carbon accounting systems. The reporting rules, elaborated in the IPCC Good Practice Guidance report, cannot be met with existing forest inventory and monitoring programs alone. Enhancements to national land information systems focus on development of inventories that include dead organic matter and soil carbon information, systems for the conversion of stem volume data to information on all biomass components, and enhanced programs to monitor natural disturbances, management activities and land-use changes. Remote sensing is making increasingly valuable contributions to accounting systems but challenges remain because forest cover changes observed in satellite data must be attributed to causes, in particular when estimating deforestation rates. To account for rare events, such as land-use changes, forest inventories need to be augmented with monitoring programs aimed at increasing sampling intensity. Major scientific challenges remain in the estimation of the contribution to the greenhouse gas balance of forested wetlands, forest areas with permafrost, and the impacts of disturbances and management activities. Significant national efforts will also need to be expended to meet the requirements for documentation, archiving, transparency and uncertainty analysis.

**Developing a Japanese forest greenhouse gas accounting system to meet Kyoto requirements.** Matsumoto, M. (*Forestry and Forest Products Research Institute; Japan; machan@ffpri.affrc.go.jp*).

The Japanese forest greenhouse gas accounting system is designed to integrate attribute information including forest registers and a national forest inventory, and geographical information including forest maps, orthophotos and Landsat TM images. Japanese forest resources have been evaluated based on forest registers under a forest planning system for more than thirty years. The forest registers store stand information such as area, species, age, diameter at breast height and volume on every sub-compartment, and these are referenced to boundaries on forest maps. The forest registers might be available to identify forest management lands under Article 3.4 by linking them to forest practice records and forest maps. A national forest inventory based on systematic sampling has been taken since 1999, and it is available not only to estimate national forest GHG balances but also to verify information of the forest registers. Plans call for storing the TM images with 30 meter resolution and the orthophotos with 1 meter resolution for the base year. A combination of these images would be available to detect land-use changes and afforestation, reforestation and deforestation activities by analyzing differences from images at the end of the 5-year commitment period.

**Avoided greenhouse gas emissions when forest products substitute competing materials – effect on carbon account and optimal forest management. A case study of Hedmark County in Norway.** Petersen Raymer, A.K., Gobakken, T., Hoen, H.F., Solberg, B. (*Agricultural University of Norway, Norway; annpe@umb.no*).

The research presented in this poster focuses on how wood products contribute to reduction of greenhouse gas emissions on a regional level. Previous research has, in general, focused on sequestration of CO<sub>2</sub> in forests and not on the additional impact of wood-based products that are substituted for other materials or energy. There are two main objectives. The first

is to find how optimal forest management will change with various prices on CO<sub>2</sub>, and also study how optimal forest management changes when substitution effects are included. The second objective is to find the frontier between net present value in monetary terms and net present value of carbon benefit, and see how it will change when substitution is included. The case study is of Hedmark County in Norway, and it uses the dynamic forest management optimization model, GAYA-J/C. The model incorporates all main carbon flows and benefits in forests, including living and dead trees, litter, harvest residues, soil, end-use wood products and avoided emissions due to substitution.

**Australia's national carbon accounting system.** Richards, G. (*Australian Greenhouse Office; Australia; gary.richards@greenhouse.gov.au*).

Greenhouse gas emissions from forestry and agriculture form a large part of Australia's national emissions profile. The Australian Government took early action to develop a National Carbon Accounting System (NCAS). The NCAS objectives are to construct a comprehensive and integrated accounting system that takes into account all relevant activities, carbon pools and greenhouse gases. This is done in a spatially explicit manner so that accounting at all scales is achieved by aggregating from a single fine spatial grid (25 m) to the required reporting scale. The modelling used to simulate carbon and nitrogen cycles is implemented within a geographic information system and draws upon grid-based data layers to describe climate variables and resource conditions such as soil type and carbon content. A comprehensive and integrated framework was developed as an initial priority for the NCAS. However, generation of reporting capability has been sequential, according to policy priority. The general sequence of these priorities has been (i) deforestation (ii) reforestation (iii) cropland and grazing management (iv) revegetation and revegetation and (v) native forest management. Having an integrated design focus as the initial activity provided a capacity to collect information specific to need, and to develop fully integrated verification and continuous improvement programs.

**IPCC Good Practice Guidance: Reporting requirement for Kyoto Protocol LULUC and forestry activities.** Schlamadinger, B. (*Joanneum Research; Austria; bernhard.schlamadinger@joanneum.at*).

The Kyoto Protocol mandates that Annex I Parties that ratify the Protocol report carbon stock changes and non-CO<sub>2</sub> emissions/removals in five forest pools on lands subject to afforestation, reforestation and deforestation activities carried out since 1990. It also allows countries, to elect forest management as a further activity to be included in the accounting. The IPCC has elaborate guidelines for monitoring, estimating and reporting of the lands that fall into these categories, and the carbon stock changes and emissions of other greenhouse gases on these lands. This presentation will provide an overview of what countries should report, when and how the information should be reported, and how the information will be used for Kyoto Protocol greenhouse-gas accounting. It will also provide some insight into different methods that countries could use to identify lands subject to a certain activity, and to estimate GHG emissions and removals on these lands. Issues of definitional differences between LULUCF and UNFCCC requirements, inclusion of carbon pools, sources of information for estimating carbon stock changes in forests, avoidance of double counting, and the relationship with Joint Implementation project activities will be discussed.

**Key components of the forest greenhouse gas reporting system in Sweden.** Ståhl, G., Karlton, E. (*Swedish University of Agricultural Sciences, Sweden; Goran.Stahl@resgeom.slu.se; Erik.Karlton@sml.slu.se*), Lundblad, M. (*Swedish Environmental Protection Agency, Sweden; Mattias.Lundblad@naturvardsverket.se*), Petersson, H. (*Swedish University of Agricultural Sciences, Sweden; Hans.Petersson@resgeom.slu.se*).

As in many other countries, a new reporting system has been developed in Sweden in order to fulfill the new LULUCF sector reporting requirements of the United Nations Framework Convention of Climate Change and its Kyoto Protocol. In Sweden, the information from about 40,000 permanent sample plots of the National Forest Inventory will form the basis for estimating area transfers as well as changes in the different carbon pools. The plots cover all types of land and will be remeasured with a five-year interval (or 10 years for soils). An advantage with the plots is that they were established during the 1980s and thus the state in 1990 is known. Most carbon pool changes will be estimated from repeated measurements, although models will also be applied, based on the basic plot descriptions available. The presentation will describe key components of the system, problems of precision estimates of deforestation and the need for plot-level forecasts to fulfill international reporting requirements.

**Key elements in the development of New Zealand's carbon monitoring, accounting and reporting system to meet Kyoto Protocol LULUCF good practice guidance.** Stephens, P. (*Ministry for the Environment, New Zealand; peter.stephens@mfe.govt.nz*), Trotter, C. (*Landcare Research, New Zealand; trotterc@landcareresearch.co.nz*), Barton, J. (*Ministry for the Environment, New Zealand; james.barton@mfe.govt.nz*), Beets, P.N. (*Forest Research, New Zealand; peter.beets@forestresearch.co.nz*), Goulding, C.J., Moore, J. (*Forest Research, NZ; chris.goulding@forestresearch.co.nz*;

*john.moore@forestresearch.co.nz*), Lane, P. (Ministry of Agriculture and Forestry, New Zealand; *paul.lane@maf.govt.nz*), Payton, I. (Landcare Research, New Zealand; *paytoni@landcareresearch.co.nz*).

New Zealand (NZ) is developing a carbon accounting system to meet Good Practice Guidance for LULUCF. The system will apply to sustainably managed natural, and planted forests. Particular emphasis is being placed on a inventory of planted forests, since these will provide half of NZ's agreed emissions reductions. The system will comprise a network of permanent sample plots, with live and dead biomass estimated using allometric equations adjusted for both management regime and variation in wood density due to temperature, soil fertility and decay state. Biomass modelling will be developed for verification and forecasting purposes. Temporal changes in land use will be determined by mapping areas of afforestation and deforestation, using optical and radar satellite imagery and aerial photography. Stratification of the landscape, with grid-based sampling of areas of detected change, will be used to improve mapping accuracy. This combined mapping and sampling approach is considered to provide the most cost-effective methodology. The proposed approaches to carbon inventory under the Kyoto Protocol, including determination of land-use changes, are being finalized in a regional-scale trial. It is anticipated that full-scale national inventory of planted forests will begin in mid-late 2005.

**Carbon dioxide emission from log production process: Evaluation using the life cycle assessment method.** Suzuki, H., Yamaguchi, S., Umeda, S. (*Forestry and Forest Products Research Institute, Japan; hidesuzu@ffpri.affrc.go.jp*).

Wood is regarded as a zero emission material for carbon dioxide (CO<sub>2</sub>) because, when it is discarded, it releases the same amount of CO<sub>2</sub> as it absorbed in growth. However, machines such as excavators, chain saws and trucks are used for forest road construction, felling and transporting, and much CO<sub>2</sub> is released during log production. This study calculated the amount of CO<sub>2</sub> emission from log production, using the life-cycle assessment method. One of the CO<sub>2</sub> emission sources is the manufacturing activity of products and machines for forestry and this was defined as embodied emission. The operating time for each activity is a small fraction of the total for an individual machine, and we calculated the embodied emission of machines from the rate of depreciation by those operations. The other main emission source is fuel consumption by the machines. As a result, it was found that much CO<sub>2</sub> is emitted from road construction and the emission from a road of 5m width is 72 kg C per 1m length.

**Carbon stock estimates for red spruce (*Picea rubens*) forest in central Nova Scotia.** Taylor, A.R., Wang, J.R. (*Lakehead University, Canada; jwang1@lakeheadu.ca*).

Part of the challenge in utilizing forest management (FM) activities in order to receive green house gas credits in Canada is to quantify forests as potential carbon sinks. Computer models such as the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS) III are presently being developed in order that scientists and forest managers will be able to predict and measure changes in carbon stocks at the stand and landscape levels. Increased intensive FM in Nova Scotia (NS) required by new regulations will lead to increased wood supply, and carbon sequestration and storage. There were three objectives of this study. Firstly, measure carbon storage over a chronosequence of natural red spruce dominated stands. Secondly, compare these carbon storage measurements with simulation results predicted by a CBM-CFS III model. Thirdly, use the calibrated model to create and compare several forest management scenarios and their potential to enhance carbon sequestration. Carbon pools in above-and below ground biomass, dead organic matter (DOM) and the upper (0–0.1 m) mineral soil were determined in 24 plots over a 140-year chronosequence. Overall, carbon storage increased throughout stand development and peaked in the 81–100 year age class at 247 Mg C/ha.

## **Improving the functional benefits and ecological services from forest rehabilitation**

Organizers: David Lamb *University of Queensland, Australia; d.lamb@botany.uq.edu.au*, Alex Mosseler *Natural Resources Canada, Canada; amossele@nrcan.gc.ca*, and Thomas Crow *USDA Forest Service, USA; tcrow@fs.fed.us*

**To plant or not to plant: Perceived hydrological benefits of tropical reforestation programs under increased scrutiny.** Bruijnzeel, L.A., (*Vrije Universiteit, The Netherlands; sampurno.Bruijnzeel@geo.falw.vu.nl*) van Dijk, A.I.J.M. (*CSIRO Land and Water, Australia*).

There has been growing disparity between public and scientific perceptions of the hydrological role of forests in general and of forest plantations in particular. An increasing number of people emphasize the negative effect of forests on annual water yields, while a minority stresses the potential for enhanced flows during the dry season due to improved infiltration conditions. These contrasting views are pronounced with respect to degraded tropical regions.

The expected hydrological benefits of reforestation are often not realized, and in many cases forest plantations have aggravated the situation, particularly in sub-humid areas where a further reduction in dry season flows has occurred as trees matured. However, tree planting has been demonstrated to significantly reduce overland flow (and thus increase infiltration) that should compensate the extra losses induced by evapotranspiration. However, experimental evidence for increased low flows following forestation is still lacking. This paper seeks to give a balanced account of the impacts of forestation on total and seasonal catchment water yield, infiltration and stormflow production. Initiation of catchment experiments (backed up by hydrological process research) representing various stages of soil degradation to evaluate the hydrological effects of different land rehabilitation strategies is considered a prime research need.

**Reforestation for biodiversity recovery: Opportunities and limitations.** Catterall, C.P., Kanowski, P., Lamb, D. (*University of Queensland, Australia; d.lamb@botany.uq.edu.au*), Wardell-Johnson, G., Erskine, P.

Deforestation clearly leads to a loss in biodiversity, defined as the variety of indigenous species (including flora, fauna and microbes) and ecological processes. However, the pathways of recovery that could follow reforestation are not so obvious. A wide range of plantation styles is possible, and in the past the preferred form of design and management has often been driven by the goal of maximizing production, coupled with a tradition of mono-species planting. Whether reforestation is accompanied by a restoration of biological diversity depends on a many site and landscape factors: tree species selection, plant functional variety, complexity of physical vegetation structure, configuration and spatial complexity of the planted area, harvest regimes, size of a forest patch, and nature of adjacent and surrounding land cover/land use. Furthermore, important effects of reforestation on biodiversity may occur on-site or off-site. We review these issues and illustrate with information from case studies. While current knowledge enables recommendations and predictions to be formulated, there is also a need to obtain real-world performance data from a greater range of plantation designs. This requires their establishment at suitable spatial scales, together with quantitative long-term assessment of biodiversity indicators.

**Multi-functional plantations: resolving trade-offs and conflicts.** Sayer, J.A., Elliot, C., Pollard, D. (*WWF International, Switzerland; jsayer@wwfint.org*).

Plantations are established for a great diversity of reasons, and programs that are sensible and rational for one set of stakeholders are often viewed as perverse by others. When plantations are established to protect the environment or to produce industrial fibre, they can deprive local people of land for agriculture and grazing, and may threaten local biodiversity. This paper examines applying 'ecosystem approaches' to plantations to provide for multiple productive and environmental functions. Achieving multiple objectives for plantations requires processes for balancing trade-offs and resolving conflicts. The extent to which these desirable goals can be achieved without reducing the economic profitability of plantation programs is discussed. Methods being developed by Worldwide Fund for Nature and the Center for International Forestry Research for assessing the performance of multi-objective plantation schemes are presented. We conclude that the broad social and environmental principles currently considered to be central to sustainable forest management should also be applied to plantation forestry. However, we note that economic sustainability is a common principle of sustainable forest management and that this must also apply to multi-functional plantations. The attainment of these broad management objectives requires measures at scales larger than the plantation management unit.

**Restoration of *Eucalyptus-Paspalum* plantations for native biodiversity conservation in Bongil Bongil National Park, New South Wales, Australia.** Villa-Castillo, B., Reid, N., Cummings, J., (*University of New England, Australia; bvillaca@pobox.une.edu.au*), Corral-Rivas, J.J. (*Georg-August-University Göttingen, Germany*), Smith, M., Storrie, G. (*NSW National Parks and Wildlife Service, Australia*).

Sixty hectares of 30-year-old *Eucalyptus* plantations with exotic pasture understory were included in recent expansion of Bongil Bongil National Park on the New South Wales north coast. These plantations are dissimilar to nearby native forests and require restoration. We compared the plantations with nearby forest reference areas in terms of topsoil chemistry, litter and ground layer plant biomass, ground cover, canopy density and tree composition and structure. We then identified the ecological barriers that likely restrict succession towards more natural communities. Soil chemistry in the plantation and reference areas was similar, suggesting that abiotic limitations to restoration are unlikely. The plantations were homogeneous in structure, low in plant diversity, with a dense cover of paspalum and litter. We hypothesised that regeneration of natural forest is prevented by: 1) competition and suppression by the dense paspalum sward and litter, 2) competition from the unthinned eucalypts, 3) the absence of a native seed bank, and 4) wallaby browsing of woody seedlings, should revegetation occur. Subsequently, we implemented a restoration experiment focusing on vegetation management to overcome these biotic barriers. The treatments include canopy reduction of plantation trees and understory manipulations (i.e., burning, rotary hoeing, weed control, wallaby-exclusion fencing, planting native woody species).

## **Stem and shoot fungal pathogens and parasitic plants: The values of biological diversity**

Organizer: Simon Shamoun *Natural Resources Canada, Canada*; [Simon.Shamoun@nrca-nrcan.gc.ca](mailto:Simon.Shamoun@nrca-nrcan.gc.ca)

**Mistletoe ecophysiology: Diverse host–parasite interactions and effects.** Glatzel, G. (*BOKU Vienna, Austria*; [Gerhard.glatzel@boku.ac.at](mailto:Gerhard.glatzel@boku.ac.at)), Geils, B. (*USDA Forest Service, USA*; [bgeils@fs.fed.us](mailto:bgeils@fs.fed.us)).

Mistletoes—as perennial flowering plants and aerial parasites of trees—face several interesting, physiological challenges. Mistletoe seeds must be firmly fixed to the host branch, usually by sticky glue. The germinant must overcome host defenses and form a haustorium for access to organic and inorganic resources of the host. Mistletoes must be able to out-compete their hosts for water. In order to avoid mineral deficiencies, mistletoe growth must not exceed the growth of the host. Many mistletoe species tolerate a wide range of xylem sap composition for a range of hosts growing on different soils. The size of mistletoes varies considerably, from cryptic to fairly large. Many dwarf mistletoes cause distinctive witches' brooms. Mistletoes display a variety of reproductive and dispersal mechanisms. Examples include unusual modes of pollination, seed dissemination and reaction to light. Protracted flowering and fruiting of many mistletoes provides food for forest fauna, and mistletoe bushes provide special habitats. Although some mistletoes are generalists, many are host specific. By reducing their host's vigor, as well as by specific dispersal patterns, mistletoes may directly affect forest community composition. Thus, even though mistletoes are often seen as pests, they are integral and indispensable components of many forest ecosystems.

**Fungi and diseases: Natural components of healthy forests.** Ostry, M.E. (*USDA Forest Service, USA*; [mostry@fs.fed.us](mailto:mostry@fs.fed.us)), Laflamme, G. (*Natural Resources Canada, Canada*; [glafamme@exchange.cfl.forestry.ca](mailto:glafamme@exchange.cfl.forestry.ca)).

Forest health is described and viewed in many ways by the general public, land owners, managers, politicians and scientists, depending on their values and objectives. Tree pathogens are often associated with their negative impacts even when damage is limited or not widespread. Too often, concepts of tree health and forest health are used interchangeably and are not evaluated on a spatial or temporal scale. Pathogens often exist in equilibrium with natural forest communities so their critical ecological roles are not easily discernible. *Scleroderris* canker caused by *Gremmeniella abietina*, for example, is widely known for its damage in jack pine (*Pinus banksiana*) and red pine (*P. resinosa*) plantations. However, in a study of the disease in regenerating natural stands of jack pine, endemic levels of the disease did not cause excessive seedling mortality nor did it have large negative effects on tree growth. Disease impact in this case was similar to natural selection and provided a health benefit to the developing stand. Examined holistically, native fungi and disease, dead and dying trees and the many complex ecological interactions among them provide many valuable benefits that ultimately contribute positively to sustainable, healthy forest ecosystems.

**Impact and management of mistletoes in planted forests and wooded pastures.** Reid, N. (*University of New England, Australia*; [nrei3@une.edu.au](mailto:nrei3@une.edu.au)), Shamoun, S.F. (*Natural Resources Canada, Canada*; [Simon.Shamoun@nrca-nrcan.gc.ca](mailto:Simon.Shamoun@nrca-nrcan.gc.ca)).

Many mistletoe species are pests in agricultural and forest ecosystems throughout the world. Mistletoes are unusual 'weeds' as they are generally endemic to areas where they achieve pest status and therefore classical biological control and broad-scale herbicidal control are usually impractical. In North American coniferous forests, dwarf mistletoe (*Arceuthobium* spp) infection results in major commercial losses and poses a public liability issue in recreation settings. Hyperparasitic fungi have potential as biological control agents of dwarf mistletoe, including species which attack shoots, berries and the endophytic systems of dwarf mistletoe. The development of a mycobiotic control strategy will be useful in situations where traditional silvicultural control is impractical or undesirable. In southern Australia, farm eucalypts are often attacked and killed by mistletoes (*Amyema* spp) in grazed landscapes where tree decline is a major form of land degradation. Although long-term strategies to achieve a balance between mistletoe and host abundance are promoted, many graziers want short-term options to treat severely infected trees. Recent research has revisited the efficiency and efficacy of silvicultural treatments and various herbicides for aerial application in appropriate situations. The results of our recent research on these diverse management strategies in North America and Australia will be summarized.

**The influence of mistletoe on diversity: Patterns, mechanisms and consequences.** Watson, D.M. (*Charles Sturt University, Australia*).

Distributional surveys of particular species and descriptive community-level studies support the generalized pattern that mistletoe has a positive effect on diversity, and a growing body of experimental data indicates that mistletoe abundance has a direct, positive effect on species richness of some animal groups. To date, little attention has been given to the underlying mechanisms driving this widespread pattern. Mistletoe plants provide a suite of resources, considered

limiting in many habitats: secure nesting sites, and nutrient-rich fruit, nectar, leaves and litter. Mistletoe infection can also accelerate hollow formation in the host and lead to greater amounts of fallen timber, which in turn influences fire frequency and intensity which alters stand-scale successional dynamics. To evaluate the relative contribution of these resources to the overall influence on biodiversity, I conducted patch-scale removals of mistletoe across a catchment, removing all mistletoe plants from 20 remnants of eucalypt woodland with an additional set of 20 remnants used as controls. Explicit comparisons between treatment and control woodlands allow quantification of the mechanistic basis of mistletoe's influence on biodiversity. Longer-term monitoring will reveal the interplay between mistletoe density and species richness with time, suggesting optimal mistletoe densities that maximize biodiversity over the longer term.

## **Protection forests: Recognizing and maintaining the forest influence with regards to hydrogeomorphic processes**

Organizer: David Wilford *BC Ministry of Forests, Canada; dave.wilford@gems3.gov.bc.ca*

**The management of protection forests: An overview.** Brang, P., Schönenberger, W. (*WSL Swiss Federal Institute of Forest, Snow and Landscape Research, Switzerland; peter.brang@wsl.ch; walter.schoenenberger@wsl.ch*).

Our paper will give a short account of the ecology and management of forests that serve as protection against natural hazards. Consistent with our expertise, we focus on natural hazards in mountain areas, especially in the European Alps. We explain the basic concept of protection forests and provide the necessary terminology for protection and natural hazards. Then we give a historical account of protection forests and outline their geographic distribution. Next we address forest dynamics in subalpine and montane protection forests, including disturbance regimes, successional cycles, resistance and resilience. In general, we advocate mimicking natural forest dynamics when managing protection forests because this means relying on ecosystem processes that have ensured a permanent forest cover over centuries and millennia. When natural forest dynamics do not ensure sufficient protection, they should be modified slightly. Silvicultural operations such as planting and thinning can help to avoid undesirable forest conditions. If forest cover is still insufficient to ensure effective protection, artificial constructions should be built. Finally, we propose a general procedure for managing protection forests, consisting of four steps: collecting all information required to take informed decisions, designing interventions, carrying out interventions and monitoring outcomes.

**Evaluating management options in protection forests using a Markov chain model.** Brang, P., Schönenberger, W., Zingg, A., Bachofen, H., Wehrli, A. (*WSL Swiss Federal Institute of Forest, Snow and Landscape Research, Switzerland; peter.brang@wsl.ch; walter.schoenenberger@wsl.ch*).

The cost-effective management of protection forests requires integrating biological, technical and economic knowledge, which has only been partly achieved to date. It is therefore not possible to comparatively evaluate different management strategies, i.e. combinations of preventive operations (thinning, planting) and curative treatments after disturbances (clearing, again planting, artificial constructions). We have developed a new protection forest model that enables, in a long-term perspective, such evaluations in terms of protective effect and management costs. The model depicts relevant traits of the development of protection forests at a regional level. It is based on a modified Markov chain approach and contains three modules: stand dynamics, protective effect and management costs. In the stand dynamics module, the development of eight stand types (e.g., pole stage forest) is modeled under consideration of stand growth, disturbances and silvicultural operations. In the protective effect module, the share of stands with insufficient protection is estimated. The costs module summarizes management costs. The model runs over 150 years in steps of 10 years. By modifying the assumptions of various parameters, the model can be used to identify the drivers of the protection forest system. Furthermore, the model can be applied to evaluate the chances of reducing uncertainty in judging management strategies by investing research in different areas.

**Balancing tradition and technology to sustain protection forests in the European Alps.** Dorren, L.K.A., Berger, F. (*Cemagref Grenoble, France; luuk.dorren@cemagref.fr; frederic.berger@cemagref.fr*), Lievois, J. (*ONF-RTM, France; jerome.lievois@onf.fr*).

Protection against natural hazards is indispensable in the European Alps. Forests in the European Alps and the protection they provide have a long and distinguished history, especially with regards to reducing the runout zones of rockfalls and the prevention of snow avalanches and debris flows. However, investments are needed to sustain or optimize this service. Unfortunately, society has supported technical protective constructions, because there is a lack of quantitative data on the efficacy of protection forests. At the same time, many protective constructions cannot sustain the lifetime originally planned,

resulting in unforeseen costs. Recently, a paradigm shift towards ecological engineering has occurred. In addition, with the knowledge and tools obtained during the last ten years, we can now assess in quantitative terms how different mountain forests perform their protective function. Given these facts, the potential for protection forests as an alternative for civil engineering constructions has increased. In our presentation we explain this by a case of a forest which has the potential to provide sustainable protection against rockfall. We show how new research tools assess the silvicultural actions required to optimize the protective function and subsequently how the costs to carry out the required actions could be covered by an existing environmental tax. This is a perfect example of how the benefits of protection forests can be realized.

**The role of forests and forest harvest on floods: myths and realities.** Grant, G.E. (*USDA Forest Service, USA; Gordon.grant@oregonstate.edu*).

The idea that forests protect landscapes against floods and, conversely, that cutting forests increases flood risk, is widely held by the scientific community, governments in both developing and developed countries, environmental organizations and popular wisdom. References to the linkage between forests and floods extend back to the writings of Plato, and is a guiding principle for watershed management on rivers as large as the Yangtze in China and Brahmaputra in India. From this one might surmise that the evidence linking forests, deforestation and floods is incontrovertible. Yet a closer look reveals that the scientific evidence for such a linkage is problematic. In particular, literature and public perception do not clearly distinguish the hydrologic impacts of forests and deforestation from their geomorphic effects, nor the importance of watershed scale and storm size. Drawing on field evidence and modeling studies from both tropical and temperate regions, I develop a framework for evaluating the relationship among forests, deforestation and floods, and distinguish among various process-based mechanisms driving both hydrologic and geomorphic responses. While there are many examples of hydro-geomorphic coupling between forest dynamics and streamflow in small watersheds for moderate-sized storms, there are few documented examples of deforestation leading to widespread flooding.

**Assessing climate influence on the hydrologic response of forested watershed in Korea.** Im, S., Lee, S.-H. (*Seoul National University, Republic of Korea; junie@snu.ac.kr; shleeguy@snu.ac.kr*).

Water balance is one of the most limiting factors in forest ecosystems, and is closely related to the vegetation and climate conditions. The hydrologic response of a forested watershed to future climate change was investigated with a calibrated hydrological model and climate scenarios. A computer simulation model was first calibrated and validated against stream flow data measured at a small forested watershed in Korea. The simulated stream flow at two surface water monitoring stations, the sub-watershed outlet and the outlet of the watershed, were close to the observations with respect to low flow and monthly runoff volume, and reasonably close to the peak flows for the simulation period. Analyzing the impact of climate change on stream flow indicated that both high and low flows were characterized by strong changes, due to increases in evapotranspiration in the dry season and larger storms in the summer.

**The influence of various silvicultural concepts on the stability of single trees and the effectiveness of a protection forest against rockfall.** Kalberer, M., Mayer, A.C. (*Eidgenössisches Institut für Schnee- und Lawinenforschung SLF, Switzerland; kalberer@slf.ch*), Spiecker, H. (*University of Freiburg, Germany; instww@iww.uni-freiburg.de*).

The protective function of forests against rockfall, landslides, floods and avalanches has long been recognized. The capacity of forests to withstand these natural hazards is only limited. Moreover, the protective function of forests strongly depends on the forest structure. While practitioners agree that stand tending improves protection performance, there is no validated knowledge to support tending. The aim of the project was to quantify the effects of various silvicultural strategies on individual tree growth and mechanical stability of trees and forest stands. Key stability parameters are: maximum anchorage moment by means of the tree draught method, and the maximum energy uptake potential of a tree in the rockfall process with impact tests. Regressions are frequently used to analyze the context between the identified stability parameters and tree parameters such as: crown length, crown percentage, crown projection surface, diameter and stem form. The effects of various silvicultural concepts (e.g., extensive/intensive forest management) on individual trees have been simulated by means of an individual tree-oriented forest growth model. The protective effect of forests under different management regimes is assessed using an individual tree-oriented rockfall model. Cost and benefit of forest tending measures in protection forests may be quantified by means of the model. It can be used as a basis for effect-oriented management of protection forests.

**Multiaged forest stands: Imparting resistance and resilience to disturbances.** O'Hara, K.L. (*University of California – Berkeley, USA; Ohara@nature.berkeley.edu*).

Multiaged stands have two or more age classes that are the result of partial disturbances that do not destroy all trees in a stand. Multiaged stands represent a more static structure than comparable even-aged stands because there is less total



structural variation over time. For Protection Forests, potential benefits of multiaged stands are their resistance and resiliency to disturbances. Resistance comes from the capacity to withstand or avoid disturbance effects. Large trees provide greater resistance to hydrogeomorphic processes: the maintenance of large trees in multiaged stands improves resistance to removal as compared to smaller trees in even-aged stands. Resiliency is the capacity to maintain or regain normal function after disturbance. Resiliency may be higher in multiaged stands because of a smaller range of variation in structure over time that imparts a greater ability to quickly return to a pre-disturbance state. For example, for stands influenced by hydrogeomorphic events, a multiaged stand will have large trees adjacent to an impacted area that will, for example provide large woody debris sooner than if the area was surrounded by smaller even-aged trees. In the case of Protection Forests, the challenge is to establish a series of age classes of trees without reducing the resistance or resilience of a stand.

**The role of forests in reducing hydrogeomorphic hazards.** Sakals, M.E. (*University of British Columbia, Canada; msakals@interchg.ubc.ca*), Sidle, R.C. (*Disaster Prevention Research Institute, Japan; sidle@slope.dpri.kyoto-u.ac.jp*), Innes, J.L. (*University of British Columbia, Canada; john.innes@ubc.ca*), Wilford, D.J. (*British Columbia Forest Service, Canada; dave.wilford@gems3.gov.bc.ca*), Grant, G.E. (*USDA Forest Service, USA; gordon.grant@oregonstate.edu*).

Increasingly, forests are being valued for products and services beyond wood fibre. Both natural and managed forests can reduce hydrogeomorphic hazards from floods, debris floods, debris flows, snow avalanches and rockfall. Maintaining high levels of protective function requires active management of these forests as this protective role is largely dependent on the presence of healthy stands. Certain forest features such as snags and downed logs have been found important in addition to standing trees. Protection Forests are not simply reserves, but rather require special management to maintain the specific forest influences for protection. Functions provided by trees and forests have been associated with reduced hazards from a range of hydrogeomorphic hazards; the processes of protection vary depending upon the type of forest, the type of hazard, the features protected and the physical arrangement of the forest with respect to the hazard elements. Roles of protection forests can include: 1) reinforcement of the material in upslope initiation zones, 2) the physical containment of material in areas of transport and deposition, and 3) the effects on hillslope and catchment-level hydrology. The pursuit of safety and sustainability through forest management is resulting in the designation of Protection Forests to reduce hydrogeomorphic hazards.

**Snags, stumps, boles and mounds provide protection against natural hazards in mountainous windthrow sites.** Schönenberger, W., Wehrli, A. (*WSL Swiss Federal Institute of Forest, Snow and Landscape Research, Switzerland; walter.schoenenberger@wsl.ch; andre.wehrli@wsl.ch*).

We studied the protective effect of living trees, snags, stumps, boles and mounds against rockfall and snow avalanches in a steep uncleared windthrow in a mountain protection forest. From this real scenario we derived three virtual scenarios: the unstocked slope, the forested site and the cleared windthrow site. In the scenario 'unstocked slope' all timber elements were virtually removed. In the scenario 'forested site' we virtually reconstructed the former forest. In the scenario 'cleared windthrow' all fallen dead stems were virtually removed, whereas in the scenario 'uncleared windthrow' they were additionally counted. The stems made the surface very rough, sometimes extending several meters above the ground surface. Comparing the results with values from the literature we conclude that the scenario 'unstocked slope' is clearly a rockfall and avalanche release area, and that the other three scenarios have enough structure elements of sufficient height to effectively prevent any release of avalanches and to stop rolling rocks. In protection forests, leaving the thrown timber on the spot can therefore be a good option to best ensure safety for the first decades, whereas removing the fallen timber and clearing the area reduces the protective effect to a level similar to that of the preceding stand.

**Identification of flood relevant forest areas and forest measures for water retention.** Schüler, G. (*Research Institute for Forest Ecology and Forestry Rheinland-Pfalz, Germany; schueler@rhrk.uni-kl.de*).

In addition to flood disasters along major rivers, damage caused by flooding of smaller tributaries is also of significance. Water retention measures in catchments have positive effects on the direct locality. To evaluate the water retention function, GIS-based assessment keys were developed on the basis of digital forest site classifications and tested in relevant forest areas. Digital maps with sensitive forest sites and line structures were produced. The maps show a spatial differentiation of run-off types and intensities. These inventory data are the basis for water retention measures in forests. They comprise most prominently: 1) silviculture in close-to-nature forests and maintaining continuous forest cover, 2) preference for natural regeneration and intensively structured forests, 3) supporting pore space in the soil by liming acidified soils and/or conversion to mixed forests, 4) forest harvesting and skidding systems appropriate for different soil and site conditions, 5) minimal feasible road density for forest management, 6) change of paradigm in forest road drainage—no ditches but extensive water distribution, 7) supporting natural retention spaces of water in the forests, and 8) re-naturalization of creek banks and conservation of natural creek courses. The economic consequences and the eco-efficiency of flood precaution measures will be evaluated using a Decision Support System that includes a GIS-based assessment of landscape and land use.

**A GIS-based interactive spatial decision support system for integrating the management of protection and production forests.** Shiba, M. (*Kyoto University, Japan; mshiba@kais.kyoto-u.ac.jp*).

Protection forests require management strategies that differ from production forests, but it is necessary to integrate management for both forests at the landscape level. This integration is necessary for protection forests to be managed in the most economical and sustainable way possible, and to ensure that management in adjacent production forests do not compromise protection forests. Traditional approaches to forest management planning do not offer this integration because they lack a holistic (i.e., multiple values) and spatial approach. In this paper the author describes the development of a spatial decision support system in combination with a GIS and harvest schedule/allocation model that allows simulation of potential forest resource management activities at the landscape level. This approach combines a landscape perspective with improved analytical tools. The approach enables resource managers to design and demonstrate the long-term conservation outlook of forest resources under alternative management strategies geared to multiple economic, environmental and social objectives.

**Stormflow generation in forest headwater catchments: A hydrogeomorphic approach.** Sidle, R.C. (*Disaster Prevention Research Institute, Japan; sidle@slope.dpri.kyoto-u.ac.jp*).

During the past few decades, different paradigms have emerged to explain the processes of stormflow generation in steep, forested headwater catchments. Findings from recent studies in Japan have generated a linked hydrogeomorphic model to explain stormflow response. This conceptual model recognizes the close coupling of hillslope and channel hydrological processes and the unique contributions of geomorphic features in the catchment. During the driest conditions, catchment water yield is very low and runoff occurs as saturated overland flow from the small riparian zone and via direct channel interception. For slightly wetter conditions, subsurface flow from the soil matrix augments stormflow. As wetness increased, two significant non-linear hydrologic responses occur: 1) threshold response in geomorphic hollows (zero-order basins) where runoff initiates after an accumulation of shallow groundwater, and 2) self-organization and expansion of preferential flow pathways, which facilitate subsurface drainage. Increases in stormflow that occur during periods of increasing antecedent wetness depend upon temporal and spatial linkages and the unique hydrologic behaviour of three components: 1) riparian corridors, 2) linear hillslopes, and 3) geomorphic hollows. These linkages form the basis of the hydrogeomorphic concept of stormflow generation for forest headwater catchments and the components are central to locating Protection Forests designed to maintain natural stormflow generation.

**Mechanical resistance of different tree species to rockfall in the French Alps.** Stokes, A., Salin, F., Kokutse, A.D. (*Laboratoire du Rhéologie du Bois de Bordeaux, (Mixed unit: CNRS/INRA/Université Bordeaux, France; stokes@lrbb3.pierroton.inra.fr)*), Berthier, S. (*Laboratoire du Rhéologie du Bois de Bordeaux, (Mixed unit: CNRS/INRA/Université Bordeaux, France)*), and Forest Research, UK), Danjon, F. (*INRA, France*), Mochan, S. (*Forest Research, UK*), Dorren, L.K.A. (*Cemagref, France*), Fourcaud, T. (*Laboratoire du Rhéologie du Bois de Bordeaux, (Mixed unit: CNRS/INRA/Université Bordeaux I), France*).

In order to determine the mechanical resistance of several species to rockfall, an inventory of the type of damage sustained in an active rockfall corridor was carried out in the Alps. The diameter, spatial position and type of damage incurred were measured in 423 trees. Sixty-six percent of broken or uprooted trees were conifers. Larger trees were more likely to be wounded than smaller trees, although wound size was relatively smaller in larger trees. The species sustaining the least proportion of damage was beech (*Fagus sylvatica*). Mechanical tests were carried out on spruce (*Picea abies*), fir (*Abies alba*) and beech in order to better quantify resistance to rockfall. Trees were winched downhill and the force necessary to cause failure was measured. Most fir broke in the stem and spruce failed through uprooting. Beech was either uprooted or broke in the stem and was twice as resistant to failure as fir, and three times more resistant than spruce. Root system architecture was measured and parameters correlated with overturning resistance. Fir was found to have few, but large roots penetrating deep into the soil and between rocks. Spruce roots were superficial with few branches. Beech possessed many branched roots. Results suggest that beech would be a better species to plant for protection against rockfall.

**Long-term impact of forest dynamics on the protective effect of a Swiss mountain forest.** Wehrli, A. (*WSL Swiss Federal Institute of Forest, Snow and Landscape Research, Switzerland; andre.wehrli@wsl.ch*), Dorren, L.K.A., Berger, F. (*Cemagref, France*), Schönenberger, W., Brang, P. (*WSL Swiss Federal Institute of Forest, Snow and Landscape Research, Switzerland*).

Many mountain forests effectively protect people and assets against natural hazards such as rockfall. However, they provide long-term effective protection only if tree cover is ensured by sufficient renewal. In Swiss mountain forests, regeneration currently seems to be insufficient, and therefore, the protective effect might be impaired in the long-term. The extent of this impairment, however, is difficult to determine since data on the long-term development of regeneration in mountain forests under different conditions are rare. Given the lack of empirical data, we think that simulation models can prove useful tools to study the impact of forest dynamics on the long-term protective effect of mountain forests. We apply a forest patch

model to a protection forest in the Swiss Alps. Based on data from a field survey in 2003, which provide initial forest conditions, we model structural dynamics under consideration of several regeneration scenarios, including different browsing pressure and light regimes. The scenarios are analyzed with an empirical rockfall model to assess their protective effect. We identify indicators related to the long-term protective effect of the forest, and try to assess site specific target values for these indicators, which in turn can be used for more cost-effective and efficient management of mountain forests.

**The hydrogeomorphic role of riparian forest stands on fans.** Wilford, D.J. (*British Columbia Forest Service, Canada; dave.wilford@gems3.gov.bc.ca*), Sakals, M.E., Innes, J.L. (*University of British Columbia, Canada; msakals@interchg.ubc.ca; john.innes@ubc.ca*).

Streamside forests are recognized for providing protection roles to streams through shade, bank stability, input of woody debris and nutrient input. However, riparian forests are also a key element in maintaining channel and forest site integrity on alluvial and colluvial fans subject to debris flows, floods and debris floods (hydrogeomorphic processes). Riparian forests play two hydrogeomorphic roles: enhancement of sediment deposition and reinforcement of the soil mass. Enhanced sediment deposition results from log jam formation against standing trees, storage up-slope of downed logs and reduced stream flow velocities due to 'channel roughness' elements when the stream leaves its unvegetated channel. Tree roots reinforce the soil mass, particularly from erosion due to broadcast flows. The result is that forest stands tend to maintain the location of stream channels on fans and limit the overall disturbance from the hydrogeomorphic events that influence fans in active environments. Characteristic site and dendroecological signatures are present where forest stands play a hydrogeomorphic role. These signatures can be used to determine the minimum boundaries for Protection Forests on fans.

## Managing forests for biodiversity conservation

Organizer: S.A. Hussain *Wildlife Institute of India, India; hussain@wii.gov.in*

**Biodiversity conservation in community forestry in Nepal.** Acharya, K.P. (*Department of Forest Research and Survey, Nepal; kpacharya1@hotmail.com*).

Community forestry was formally launched in Nepal in 1978 to increase participation of local people in forest management as a means to improve the livelihoods of these people. Community forestry is recognized as a one of the most successful approaches to rehabilitate fragmented, degraded and scattered forest patches in Nepal including the biodiversity conservation. However, emerging evidence indicates that the prevalent forest management approach and support mechanism is unfavorable to biodiversity conservation; shrubs and unwanted timber species are increasing threats. This indicates biodiversity conservation is in conflict with participatory forest management. There is a need to develop an approach leading to a win-win situation in managing common forest resources in the mountains of Nepal. The paper presents methodology for the integration of biodiversity conservation into community forestry, leading to a win-win situation. It argues that intensive application of silvicultural activity results in improved livelihoods and the landscape level approach should consider biodiversity conservation in community forestry. The process and mechanism for linking community level networking for the conservation of biodiversity is presented. The policy issues to enhance biodiversity conservation in community forestry have been recommended.

**Issues in biodiversity conservation in forested landscape: Lessons from India.** Badola, R., Hussain, S.A. (*Wildlife Institute of India, India; ruchi@wii.gov.in*).

India's long-term strategy for forest management emphasizes regulatory and production functions pertaining to timber and non-wood forest products. Biodiversity conservation per se was not one of the prime goals of forest conservation. That responsibility belongs to the Protected Area network, covering 4.73% of its geographical area. A majority of the protected areas in India are too small to be viable and need to forge links with surrounding human-influenced landscapes, including managed forests and other habitats. Biodiversity conservation has to be a common agenda for Protected Areas and other forest areas. However, biodiversity conservation, livelihood needs and development aspirations are often not in harmony. The paper traces the impacts of larger political and economic developments on forests in India and their relationship with other stakeholders. It concludes that sectoral battles between the protagonists of conservation and development have led to loss of biodiversity and unsustainable development. The emergence of participatory approaches in conservation in the last two decades has to a certain extent reversed the damages, these however were not sustainable. The paper highlights the lessons learnt from such initiatives and discusses the principles of a new, integrated conservation and development strategy for the management of forests for biodiversity conservation.

**Secondary regeneration of hill dipterocarp forest in Negeri Sembilan, Malaysia.** Hamzah, M.Z., MacMiller, E., Supangat, A. (*Universiti Putra Malaysia, Malaysia; mzaki@forn.upm.edu.my*).

Phytosociological studies were carried out in Compartment Senaling Forest Reserve, Negeri Sembilan, Malaysia in order to elucidate the regeneration status of a logged-over dipterocarp forest, 30 years after logging. Ten sample plots, each with the size of 60 x 40 m, were established to assess the vegetation composition, species abundance and stand structure in relation to the recovery status of the compartment. The studies showed that the species composition can be differentiated into two differential communities, namely of *Shorea longisperma* – *Vatica* sp. community and *Stachphrynium* sp. – *Rhodamnia cinerea* community. The vegetation of the compartment has recorded an average of 8% canopy layer recovery of the emergent layer (ST), and 45%, 36%, 21% and 26% for the dominant and co-dominant (T1), understorey (T2), shrub (S) and herb (H) layers, respectively. The studies also showed that the logged-over stands have not fully recovered towards achieving their status prior to disturbance in terms of canopy structure recovery, species composition recovery and species abundance recovery.

**The influence of fire on the loss of hollow trees and glider dens in Queensland forests.** Kehl, J., Smith, G., Hogan, L. (*Queensland Environmental Protection Agency, Australia; john.kehl@epa.qld.gov.au; geoffrey.smith@epa.qld.gov.au; luke.hogan@epa.qld.gov.au*), Choy, S.L. (*Queensland University of Technology, Australia; s.lowchoy@qut.edu.au*).

As part of a study of the glider, *Petauroides volans*, the condition of trees on 10 ha of forest in south-east Queensland was monitored in 1982, 1993, 2003 and 2004. A total of 108 trees were recorded as lost (fallen) during the study. Both hollow and non-hollow living trees were lost at an average rate of 0.6%/yr. Similarly, there was no difference in loss rates between gliders den trees and other hollow trees. However, at 2.4%/year, the rate of loss of stags was four times greater than for living trees. The cause of this loss also differed. Fuel reduction burning caused the loss of 52% of living trees. In contrast, 81% of stags lost were blown over. There is a shortage of living habitat trees throughout Queensland's forests. Hollow dependent fauna are currently relying on stags. The rate of stag loss recorded in this study suggests that there will soon be a widespread shortage of this critical resource.

**A model for predicting trees used by hollow-dwelling fauna in *Eucalyptus obliqua* production forest in Tasmania.** Koch, A. (*University of Tasmania, Australia; ajkoch@utas.edu.au*), Munks, S.A. (*Forest Practices Board, Tasmania, Australia*), Driscoll, D. (*Flinders University, Australia*).

In Tasmania, all eight bat species, five possums and approximately 35 bird species use hollows during their life cycle. Hollow-dwelling fauna have priority status under the 1997 Tasmanian Regional Forest Agreement meaning that adequate measures need to be taken to conserve these species. In Tasmanian forests used for timber production, there is a generic prescription that a minimum of two habitat trees be kept for every five hectares that are cleared. The guidelines in the 2000 Forest Practices Code state that habitat trees 'with nesting hollows and other old-growth structural elements should be retained'. The aim of this research was to develop a statistical model for the selection of habitat trees in wet and dry *Eucalyptus obliqua* forests in Tasmania using site and tree characteristics. This was done by measuring tree characteristics and hollow abundance in ten trees on approximately 50 logging coupes in Tasmania. After felling, the trees were searched for hollows and any hollow found was examined for secondary evidence of use by fauna. A model was developed to predict the use of a particular tree by hollow-dwelling vertebrate fauna based on site and tree characteristics, to be used when selecting habitat trees for retention.

**The current situation and main problems of National Parks in Turkey.** Kuvan, Y. (*Istanbul University, Turkey; ykuvan@istanbul.edu.tr; ykuvan@e-kolay.net*).

According to the global system of categorizing protected management areas, a national park is one of the six categories and the most popular within this system. Components of the protected area within the forest regime in Turkey consist of national parks, nature parks, nature monuments and nature protection areas. Among these areas, national parks are the most extensive in terms of total area. The number of national parks and other protected areas in the country has gradually expanded since the first national park was created in 1958. Today, there are 33 national parks covering an area of 678,753 ha. Major problems seen in managing national parks in Turkey can be classified into following items: administration- legislation, planning, finding additional sources, public participation, data collection and inappropriate uses such as mass tourism. The main aim of this paper is to determine the current situation and main problems of national parks in Turkey, and to develop recommendations about solving problems and management interventions by considering both international approaches and national circumstances. National park legislation and institutional frameworks, the extent and distribution of the parks according to the main criteria for selection, and major park problems are examined in this paper.

**Differences in breeding success of tits using artificial nest boxes in hog fat-supplied and non-supplied coniferous forests.** Lee, W.-S., Park, Y.-S. (*Seoul National University, Republic of Korea; krane@snu.ac.kr; skybird1@snu.ac.kr*), Rhim, S.-J. (*Chung-Ang University, Republic of Korea; sjrhim@post.cau.ac.kr*).

This study was conducted to describe the difference in breeding success of tits used the artificial nest boxes in hog fat supplied and non-supplied coniferous forests (37° 16' 50" N, 126° 55' 45" E) of the Chilbosan University Forests, Seoul National University in Korea, from November 2002 to June 2003. There were no differences in vegetation characteristics, such as tree density, tree species richness, tree species diversity, total basal area and foliage profiles, between both study sites. There were marked differences in the breeding success and clutch size of three tits species nesting in boxes between hog fat supplied and non-supplied coniferous forests. Food supply would be good for increase of breeding success of tits in poor habitat quality areas. Also, the preference of various entrance diameters of nest boxes was related to body length of tits.

**Conservation of the hollow resource in the dry eucalypt forests of south-eastern Tasmania: To what extent do current measures capture hollow bearing trees?** Munks, S.A., Wapstra, M. (*Forest Practices Board, Tasmania, Australia; sarah.munks@fpb.tas.gov.au*), Corkrey, R. (*University of Aberdeen, UK*), Walker, B. (*West Hobart, Tasmania*).

Information was collected on the distribution of potential hollows in dry eucalypt forest as part of a study looking at the effectiveness of existing mechanisms for the conservation of hollow dependent fauna in Tasmania's forests. The surveyed forest types contained between 17–30 potential hollow-bearing trees per hectare. The relationship between environmental variables and the occurrence of potential hollows was examined using generalized linear modeling. Occurrence of hollows was best explained by: vegetation type; topographic position; dead trees on the ground; the age of the stand; the average total basal area of all trees; and the height of the overstorey vegetation. Models developed using a subset of the environmental variables, were coupled with GIS data to create a map of predicted occurrence of trees with potential hollows. Comparison of the predicted values with the original observed field data, indicated that the map might have moderate ability to predict the occurrence of trees with potential hollows across the study site. Overlaying this map with information on the variety of land-use designations within the study area enabled estimation of the rate at which trees with potential hollows are captured by existing conservation measures. The adequacy of this rate for hollow-dependent populations is discussed.

**An integrated approach for conserving biological diversity.** Sawarkar, V.B. (*Pune, India; woodowl464@yahoo.co.in*).

Protected Areas serve as source populations of wild plants and animals. However, they are often small, isolated and generally constitute only a small percentage of potential wildlife habitats. The forested areas and other categories of lands outside the PA network are managed to produce a variety of goods and services. Processes of development, human activities, land ownerships and multi-agency programs impact wildlife habitats in a variety of ways. Planners are therefore urged to use hierarchical landscape based spatial and administrative planning scales to conserve biological diversity. These scales use ecological tools with habitat classification based on sensitivities of sites, species and communities of plants and animals, key ecological and cultural functions, and micro-habitat elements of biological and geomorphic origins. Species, habitat elements and communities are also selected on account of being representatives of continuing integrity of ecosystems within managed landscapes. Five main groups of anthropogenic stressors associated with resource consumption, non consumptive resource amenities, transport and habitation infrastructure, effluents and assorted human activities impacting resources have been identified to enable formation of appropriate management strategies. Guiding principles are recommended and an adaptive management framework is suggested.

**Forest development economic forecasting as a basis for optimization of forest operations.** Skoupy, A., Simon, J. (*Mendel University of Agriculture and Forestry, Czech Republic; skoupy@mendelu.cz; simon@mendelu.cz*).

Simulation of the forest stand development for optimization of forest operations is a prospective method which makes it possible to target and to precisely respond to the future requirements of forest managers and forest owners. The paper presents a draft procedure to optimize forest operations, based on the latest knowledge about operational reliability of machines, technical logistics and qualimetric procedures of quality assessment. The methods are modified for requirements resulting from forest working conditions in the Czech Republic and from anticipated model situations. They give due recognition to special statutes of forest protection, property size and economic conditions of the forest user. The interconnection of all information systems enables adoption of an entirely new approach to the solution of the given issue as it facilitates fast and sound decision-making.

**Management and non-management: A study case from the Sumava National Park.** Svoboda, M., Podrazsky, V., Remes, J. (*Czech University of Agriculture Prague, Czech Republic; svoboda@fle.czu.cz; podrazsky@fle.czu.cz; remes@fle.czu.cz*).

The Sumava (Bohemian Forest) National Park (NP) is among the largest protected areas in Europe. Since its establishment in 1990, two concepts of management were alternatively applied: active and passive management. The passive management

tendency also prevailed in periods with an active management approach by the National Park Administration – political pressure by the ecological and state administration (nature conservation) spheres excluded any effective management. The situation was complicated by the state of the forest ecosystems: anthropogenic spruce monocultures and an extensive spruce bark-beetle calamity that extended into Germany. The no-management tendency was in the old part of the National Park, on the Czech side of the border and was the only approach for decades. The presentation describes the present situation, risks of a passive NP management, reflected by the forest stands, soils, ground vegetation development, and by the hydrological cycle dynamics. Healthy forest areas, declining areas and clearcuts are compared.

**Ecological effects of small-scale cutting of Philippine mangrove forests.** Walters, B.B. (*Mount Allison University, Canada; bwalters@mta.ca*).

Small-scale wood harvesting is one of the most ubiquitous forms of resource use in the tropics, yet ecologists have barely studied it. This paper examines the effects of small-scale wood cutting on forest structure, composition and regeneration of mangrove forests in the Philippines. Information for the study was obtained through the application of extensive bio-ecological assessments of forests and by interviewing forest users. Cut mangrove forests are characterized by smaller trees, less basal area and more canopy gaps. At least two thirds of all canopy gaps were caused by cutting. In spite of these dramatic structural effects, there was little demographic evidence to suggest that significant changes to current species composition are occurring, although this may, in part, reflect the elimination of some species from study areas by past cutting. Among common species, *Rhizophora mucronata* is the only one that appears to be negatively impacted from cutting in terms of its relative abundance. *Sonneratia* spp., *Avicennia marina* and *R. apiculata* regenerate well by coppice regrowth into the abundant small canopy gaps found in uncut and especially cut forests. Findings from this study highlight the importance of small-scale cutting disturbance and coppice regeneration on mangrove productivity.

**An investigation of the effects of dead trees on natural regeneration in forest stands.** Zolfeghari, I. (*Islamic Azad University of Tehran, Iran; I\_Zolfeghari@yahoo.com*).

The main objective of this study, which was conducted in the Kheiroudkenar Forest of the Chelir district of Iran, was to examine the ecological importance of dead trees and their influence on natural regeneration in the forest. Seedlings around dead trees were recorded in 50 ha plots. Dead trees were divided in four decay classes. Canopy gaps were divided in five sizes, including closed (no gap), very small (0–4 m diameter), small (4–8 m diameter), medium (8–12 m diameter) and large (open crown >12 m diameter). The results indicated the level of decay influenced the establishment of regeneration. Dead trees in decay class 3 accounted for the highest number of seedlings, followed by decay classes 4, 2 and 1. The gaps associated with dead trees had varying effects on the establishment of regeneration, with the size of gap increasing with decay class. The abundance of seedlings was greatest under closed canopies, followed by medium gaps. Very small and large gaps had fewer seedlings. One way analysis of variance indicated that there was no significant difference (at 5% significant limit) among the number of seedlings around dead trees in various decay classes. There was a significant difference between the abundance of seedlings under different gap sizes. Consequently, the size of the canopy gap created by a dead tree is more important than the tree's state of decay.

## **Net environmental benefits of plantation forests in degraded agricultural landscapes**

Organizer: Philip Polglase *CSIRO, Australia; philip.polglase@csiro.au*

**Reversing land degradation: The importance of people.** Adams, M. (*ICRAF, Australia; adamsma@cyllene.uwa.edu.au*).

For more than a quarter of a century, the International Centre for Research In Agroforestry (ICRAF—now the World Agroforestry Centre) has been working with the world's poorest communities in Africa and elsewhere to develop strategies to reverse the human-caused losses of net primary productivity and natural resources on which agriculture depends (soils, water, biodiversity). The lessons of ICRAF's work are clear. The problems of land degradation, and how to reverse it, are as much social problems as they are biophysical problems. ICRAF's current, pro-poor research agenda is increasingly focused at the community level. Equally, ICRAF seeks to identify and quantify, the broader benefits that flow from improvements in more obvious interventions, such as tree crop fallows to improve soil fertility. These include benefits to human health, to social and population structures, to educational levels, as well as to economic status. Only through this 'whole of life' approach can ICRAF implement its vision. This approach has much to recommend it, even to highly developed countries such as Australia.

**Degraded land and its restoration with trees: some lessons from around the world.** Harris, G.P. (*School of Plant Science, University of Tasmania, Hobart, Tasmania; Graham.Harris@csiro.au*).

There are close linkages between the hydrological cycle, vegetation cover, hydrology and water quality in catchments. Catchments covered in what might be called a diverse 'equilibrium' vegetation cover show a series of large scale evolved properties. Removal of the native perennial vegetation in catchments leads to reduced biodiversity and changes in the balance of evapo-transpiration and runoff (the balance of 'green' and 'blue' water), increased erosion and ground-water recharge, dry-land salinity and poor water quality. The hydrological response to clearing is usually rapid. The onset of gullying and erosion may be rapid but the new hydrological equilibrium may take centuries to recover. Land use change and clearing in catchments alters important small scale soil properties which determine connectivity between land and water, and the movement of various forms of inorganic and organic nutrients from the land to the water. We do not fully understand these flow paths but catchments appear to be fractal generators and may possess apparently 'paradoxical' properties. Replacement of trees and other perennial vegetation in catchments goes some way to replacing biodiversity and catchment function, the hydrological balance and water quality, but tradeoffs between 'green' and 'blue' water fluxes need to be made, and response times are long as the trees re-grow and soil properties recover. Sustainable and productive landscapes and waterscapes will require new land use mosaics involving patterns of trees, other perennial and annual vegetation; patterns which will require restoration of biodiversity, connectivity and flow paths at a range of time and space scales. Many countries around the world are attempting to rehabilitate catchments using trees and a variety of incentives and market mechanisms are being used to support this aim.

**Role of mixed planting with fast growing trees for rehabilitating degraded agricultural areas in the central Amazon.** Hirai, K. (*Forestry and Forest Products Research Institute, Japan; hirai@ffpri.affrc.go.jp*), Ferraz, J., Ferreira, S.F. (*National Institute of Amazon Research, Brazil; jferraz@inpa.gov.br; savio@inpa.gov.br*), Kobayashi, M. (*Forestry and Forest Products Research Institute, Japan; kbmasa@affrc.go.jp*), da Silva, C. (*National Institute of Amazon Research, Brazil; cems@inpa.gov.br*).

To evaluate the effect of mixed planting with fast growing trees on improving soil physical properties, we investigated soil hardness and bulk density in a plantation site on a degraded agricultural area. The experiment involved a plantation with (MP) and without (OP) mixed planting of balsa (*Ochroma lagopus*) in a plantation of indigenous Amazon trees. Soil hardness and bulk density were lower in the MP than in the OP. The values of bulk density in the MP were lower than 1.1 g/cm<sup>3</sup> which indicates inhibition of root penetration will occur, but, on the other hand, it was over 1.1 g/cm<sup>3</sup>, and the highest bulk density and soil hardness were observed at a depth of approximately 25 cm which was a compacted soil horizon formed during agricultural cultivation in the OP. It was the reason that root of balsa was well developed into deep horizon in the MP, but roots in the OP were restricted within surface horizon. From these results, it is clear that mixed planting of fast growing trees has a positive effect on improving soil physical properties by balsa root development, and is also effective for rehabilitating soil and forest on the degraded agricultural area.

**Growth characteristics of hybrid poplar clones planted in an arid area of Inner Mongolia, China for combating desertification.** Kang, H. (*Dongguk University, Republic of Korea; HDK0225@dongguk.edu*), Woo, S.-Y. (*University of Seoul, Republic of Korea*), Youn, H.-J., Lee, C.-Y. (*Korea Forest Research Institute, Republic of Korea*), Kim, J.-H., Ahn, J.-Y. (*Dongguk University, Republic of Korea*).

The objective of this cooperative Chinese-Korean study was to investigate growth characteristics of 19 hybrid poplars selected from the USA and China. Tree from ten American clones and nine Chinese clones were planted in an arid area of Inner Mongolia in April, 2003. The site, located in Denkou, China, at latitude 40° 08' N and longitude 107° 09' E, has an average precipitation of 144 mm and mean temperature of 7.6 °C. The planted clones were *Populus deltoides*, *P. nigra* and *P. trichocarpa* hybrids. We measured height, diameter, net photosynthesis, water use efficiency and chlorophyll content. The growth characteristics were significantly different among the clones. Overall, the photosynthetic rate of the clones was higher than those of indigenous desert species grown under similar environmental conditions. DN-34 and 52-225 from the USA, and two Chinese clones showed the best height and diameter growth, and highest photosynthetic rate and chlorophyll content. The results suggest that this method is feasible for selecting desirable clones for the establishment of reforestation in arid desert areas.

**Biodiversity benefits of replanting forests in an agricultural matrix.** Law, B., Kavanagh, R., Lemckert, F. (*Department of Primary Industries, New South Wales, Australia; bradl@sf.nsw.gov.au*).

Extensive areas of trees and shrubs are being planted for land rehabilitation and timber production on previously cleared agricultural land in Australia. Environmental benefits are a major selling point for this change in land management, but data concerning the response of biodiversity are scarce. We outline a large-scale study to guide future planting schemes for biodiversity recovery. Our study was located in south-eastern Australia where re-planting began in the 1970s. We

specifically targeted a range of vertebrates, including birds, bats, arboreal mammals, ground mammals and herpetofauna. We sampled a variety of shapes, sizes, age, landscape context and habitat attributes in 120 sites. We found that plantings provided considerable biodiversity benefits over cleared paddocks, but the different fauna displayed a range of responses. Birds and bats made the most extensive use of plantings. Birds showed a strong effect related to patch size, whereas bats were widespread throughout the area, even in paddocks, although they were generally more common in remnant vegetation. Remnant vegetation was also most important for arboreal mammals, nocturnal birds and reptiles, but older aged plantings were also contributing to the habitat of these species. Ground mammals were virtually absent from the study area due to past management practices. Data analyses considered both site attributes and landscape context.

**Targeting plantations in degraded landscapes for commercial and multiple environmental benefits.** Polglase, P. (*CSIRO Forestry and Forest Products, Australia; philip.polglase@csiro.au*), Moran, B. (*Australian Government Department of Agriculture, Fisheries and Forestry, Australia*), McCormack, B., Booth, T. (*CSIRO Forestry and Forest Products, Australia*), van Dijk, A.I.J.M. (*CSIRO Land and Water, Australia*), Marcar, N. (*CSIRO Forestry and Forest Products, Australia*).

Australia has land and water degradation problems of enormous magnitude, including: salinization of water ways and land, loss of biodiversity, greenhouse gas emissions, and consequent loss of available land for agriculture. One partial solution is the reinstatement of trees into the landscape. The problem with this is that the scale of revegetation required is much larger than the public purse can currently afford, so private investment is needed to off-set costs of establishment. However, most of the degradation is in low-medium rainfall areas (500–800 mm/yr) where the economic viability of plantation forestry is at best marginal. A combination of public and private funds could therefore increase the commercial attractiveness of plantation forestry. For this to be accepted, however, the public investor needs assurance that plantations are established in areas where the environmental benefits are maximized and the disbenefits are minimized. Given that it takes many years to decades for the effects on the environment of plantations and other forms of revegetation to be manifested, modeling approaches are needed to forecast such impacts. We present the background and outputs from the Commercial Environmental Forestry project to show how integration of fundamental science into modeling tools and geospatial software can be used to target plantations for multiple benefits.

**Commercial environmental forestry: Balancing salt against stream flow.** van Dijk, A.I.J.M., Hairsine, P.B., Austin, J., Gilfedder, M. (*CSIRO Land and Water, Australia; albert.vandijk@csiro.au*).

Forest clearing in many parts of Australia has led to increased groundwater recharge and ensuing discharge of saline groundwater to the surface. Re-establishing forests may reduce this salinity and produce other environmental outcomes. The establishment of plantations on pasture land reduces groundwater recharge by virtue of their higher water use, and therefore any reduction in stream salt load will be associated with a reduction in stream flow. If afforestation is to produce a net reduction in stream salt concentrations, the former has to outweigh the latter. The Commercial Environmental Forestry project investigates ways of maximizing the environmental and commercial benefits of forestry in medium rainfall areas (500–800 mm/yr). The southwest Goulburn catchment in Victoria was selected to further develop this concept. Analysis of hydrological data and modeling helped to estimate the likely in-stream benefits of afforestation in different parts of the region. The main factors determining the trade-off between salt and water were rainfall, geology and topography. The results emphasize the importance of targeted planting if in-stream benefits are to be realized. Nevertheless, there appear to be substantial areas where stream benefits, as well as commercial growth rates, can be achieved.

## **Carbon balances in planted forests established in agricultural landscapes**

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### **Carbon pools of afforested arable land in Finland and changes in pools over time with forest succession.**

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In Finland the area of agricultural land afforested within past 30 years totals over 248,000 ha (i.e., 1% of the forest area) and afforestation continues at a rate of 5000 ha/yr. One important positive environmental impact of afforestation could be sequestration of atmospheric CO<sub>2</sub> in soils and biomass. We studied the development of C pools in soil, ground vegetation and litter, humus different soil horizons and stand biomass in the chronosequence of afforestation ages. Altogether, 88 mineral soil fields were afforested 10 to 70 years ago with Scots pine, Norway spruce and Silver birch. Carbonate-carbon was eliminated from the soil samples by treating them with HCl. With increase in stand age the



amount of carbon bound in litter increased considerably. In the tilling layer (0–20 cm) the carbon pools decreased with the increase of stand age while those below tilling layer (20–40 cm) remained rather constant. When the carbon bound in tree stands is taken into account afforestation of arable land is a sink of carbon that increases with the time from afforestation. The effect of tree species is significant both in biomass and litter production.

**The potential role of plantations in global carbon sequestration.** Kirschbaum, M.U.F. (*CSIRO Forestry & Forest Products, Australia, and CRC for Greenhouse Accounting, Australia*).

Deforestation has significantly contributed to past net greenhouse gas emission to the atmosphere, and on-going land-use changes, especially in tropical regions are continuing that trend. At the same time, forest cover and size is increasing in temperate and boreal regions. These changes significantly affect atmospheric CO<sub>2</sub> concentrations. In addition to these immediate effects of changing forest cover, there is a complex array of positive and negative consequences of plantation establishment, many of which change with time and location. Optimal utilization of that potential requires an understanding of the various factors that affect the net contribution of forests. Forests can have many beneficial effects such as the provision of industrial wood, protection of biodiversity, preventing land degradation through erosion and salinity control and improving visual amenities. On the negative side, there are feedback effects via the global carbon cycle. Increased atmospheric CO<sub>2</sub> leads to carbon uptake by natural carbon reservoirs, such as the oceans. When the atmospheric CO<sub>2</sub> concentration is reduced through carbon storage in biomass, it reduces the subsequent inherent rate of CO<sub>2</sub> removal from the atmosphere. Forests also affect terrestrial radiative properties by increasing the absorption of sunlight and changing the hydrological cycle.

**Soil CO<sub>2</sub>-fluxes in afforested peat fields in Finland.** Mäkiranta, P., Hytönen, J. (*Finnish Forest Research Institute, Finland; paivi.makiranta@metla.fi; jyrki.hytonen@metla.fi*), Maljanen, M. (*University of Kuopio, Finland; marja.maljanen@uku.fi*), Minkkinen, K. (*University of Helsinki, Finland; kari.minkkinen@helsinki.fi*), Laine, J. (*Finnish Forest Research Institute, Finland; jukka.laine@metla.fi*).

Northern peatlands are major reservoirs for carbon. More than half of the original peatland area in Finland (10.4 million ha) has been drained for forestry (5.7 million ha) and agricultural purposes (1 million ha). Today the area of organic soils under cultivation in Finland is about 300,000 ha. Despite the small area they account for 8% of the anthropogenic CO<sub>2</sub> emissions in Finland. Within the past 30 years, over 248,000 ha of agricultural land has been afforested. After afforestation, gradual changes in the soil structure and biology may change the peat decomposition rate of the fields. Afforestation of former peat fields could become one of the means to reduce the CO<sub>2</sub> fluxes from these areas, but only scarce data on the effects of afforestation exists. During three years soil CO<sub>2</sub> emissions in afforested peat fields were measured at Kannus, western Finland. Effects of peat thickness, tree species, afforestation ages and soil preparation are presented. Also the comparisons of the heterotrophic respiration emissions obtained from agricultural fields, afforested fields and peatlands drained for forestry are presented.

**Issues associated with small-scale community-based carbon offsets.** Murdiyarso, D. (*Center for International Forestry Research, Indonesia; d.murdiyarso@cgiar.org*).

Procedures and modalities to implement small-scale land-use, land-use change and forestry (LULUCF) activities under the Clean Development Mechanism (CDM) have been decided at the recent Tenth Session of the Conference of Parties (CoP10) to the United Nations Framework Convention on Climate Change (UNFCCC). The challenges to project developers are to learn whilst doing the projects. These mainly deal with transaction costs and meeting sustainable development objectives. Selecting community-based projects with carbon benefits of 8 kt CO<sub>2</sub> per year could be both practical and problematic depending on the ownership or status of lands and their distribution. Technically speaking, reliable estimates of carbon removals by sinks depend on the methodologies used. The development of baseline and monitoring procedures should be done in a cost-effective manner to avoid high transaction costs. This paper attempts to evaluate these issues during the selection of project sites in Indonesia at which a project design document (PDD) will be developed. Optimizing carbon benefits and sustainable forest development merits further discussions with relevant stakeholders. Criteria and indicators proposed by the designated national authority could be further improved without substantially increasing transaction costs.

**Carbon accounting in forests.** Paul, K. (*CSIRO Forestry & Forest Products, Australia*), Zhang, X.-Q. (*Chinese Academy of Forestry, P.R. China*).

Carbon accounting methodologies will need to be accurate, cheap and reliable to decrease the risk for investors. Features of a number of forest carbon accounting systems, including CO2FIX, CBM-CFS2 and GORCAM, are outlined. One of the most widely tested models is FullCAM, which is capable of carbon accounting in transitional (afforestation, reforestation and deforestation) and mixed (e.g. agroforestry) systems. It integrates carbon tracking models for agriculture and forests (CAMFor and CAMAg, which are based on CO2FIX) with previously tested sub-

models for predicting forest growth, decomposition of litter and soil carbon turnover. FullCAM can also be run in a spatial mode. As part of the Australian Greenhouse Office's (AGO) National Carbon Accounting System, FullCAM is a key component of a fully integrated operational system capable of delivering results at project, regional or national levels. Working with the developer of FullCAM, the AGO, CSIRO Forestry and Forest Products has calibrated the model to a number of plantation systems in southern Australia. This has entailed prediction of growth rates, biomass partitioning, decomposition of litter and turnover of soil carbon under eucalypts and pines. Recently, FullCAM was applied to predict sequestration of carbon in *Cunninghamia lanceolata* (Chinese fir) plantations in China.

**Role of soil in the carbon sequestration reforestation abandoned agricultural land.** Podrazsky, V. (*Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz*).

The restoration of forest soil after the change of agricultural land use has not yet been studied, despite the large areas reforested since the last century, and the situation is widespread in Europe. The restoration of forest soils was studied in the area of Český Rudolec town, in the Czech-Moravian Highland, altitude 600–630 m a.s.l. The soil type was a Cambisol, and situated on granites and gneisses. The humus used in the restoration of plantations of 3 deciduous species (American Red Oak (*Quercus rubra*), White Birch (*Betula pendula*), European Larch (*Larix europea*), one coniferous species (Norway Spruce (*Picea abies*)) was analyzed. The particular tree species accumulated 12.81, 13.81, 46.57 and 44.76 t/ha of surface organic matter, respectively, during last 30–40 years. The results showed that forest soils can be restored, with respect to surface humus accumulation and soil chemistry, in the lower and middle altitudes, and in a relatively short time. Birch exhibited the best revitalization effect among the species studied; red oak and Norway spruce humus accumulation potentials differed, although the soil chemistry was comparable. Norway spruce did not show a degrading effect although European larch did.

**Tree-biomass production potentials in agroforestry, afforestation and short-rotation bio-energy plantation systems, Canada.** Thevathasan, N.V. (*University of Guelph, Canada; nthevath@uoguelph.ca*), Sidders, D. (*Natural Resources Canada, Canada*), Gordon, A.M. (*University of Guelph, Canada*).

Of the estimated 140 million ha of non-forested land available for agroforestry and afforestation establishment in North America, 50–57 million ha are in Canada. In order to exploit this potential land-base, several agroforestry, afforestation and short-rotation bio-energy initiatives are currently underway. Under the auspices of the Canadian Biomass Innovation Network (CBIN), ten research centres will cooperate to develop short-rotation plantation/agroforestry systems for energy production and GHG reduction. Approximately 1.3 million ha will be established by 2025, with the potential to contribute 15–23 million tonnes of feedstock per year. The University of Guelph, in collaboration with the Canadian Forest Service is currently investigating tree-biomass production options through agroforestry, afforestation and short-rotation bio-energy plantations in southern Ontario, Canada. In agroforestry land-use systems, where trees are integrated at low densities (120 trees/ha or less) into agricultural systems with conventional field crops or with pasture, initial results suggest that fast growing hybrid poplars can accumulate significant amount of biomass and carbon, almost 4 times that seen in monoculture field crop or pasture systems. Results from agroforestry (low tree density), afforestation (medium tree density) and short-rotation bio-energy (high tree density) land-use systems are discussed below. When carbon credit schemes become operational, industries that emit GHG may be required to invest in C credits: agroforestry and afforestation practices may become an attractive land-use option.

## Planted forests and water

Organizer: Adam Gerrand *Bureau of Rural Sciences, Australia; Australia; adam.gerrand@brs.gov.au*

**Impacts of land-cover change in Amazonia on the regional and global water cycle.** Avissar, R., Werth, D., Ramos da Silva, R. (*Duke University, USA; avissar@duke.edu*).

The regional and global implications of the replacement of natural forest by degraded vegetation in the Amazon on the regional and global hydroclimate have yet to be fully understood and quantified. In this study, regional and global climate models are used in conjunction with scenarios of land-cover change resulting from socio-economic and ecological analyses for the coming decades, to estimate potential hydroclimate changes in and outside of the Amazon basin. Four ensembles of six realizations, twelve years each, are produced with the NASA-GISS GCM II: (1) a 'control' ensemble that simulates the land cover in the Amazon basin before massive deforestation started; (2) a 'current land cover' ensemble; (3) a 'scenario for 2030' ensemble; and (4) a 'scenario for 2050' ensemble. In addition, The Regional Atmospheric Modeling System (RAMS) is used at a high resolution (20 km grid size) over the Amazon Basin and using the same four land-cover scenarios but with the NCEP reanalysis for three different years

(wet, dry and typical) forcing its lateral boundaries. The combination of these different simulations reveals significant impact of deforestation on the regional and global hydroclimate.

**Criteria and indicators for hydrological monitoring of planted forests.** Câmara, C.D., do Carmo Calijuri, M., Lima, W. de P., Brito Zákia, M.J. (*Universidade de São Paulo, Brazil; cdcamara@esalq.usp.br; calijuri@sc.usp.br; wplima@esalq.usp.br; zzakia@aol.com*), Fonseca-Gessner, A.A. (*Universidade Federal de São Carlos, Brazil*).

This study proposes a new analysis of data from hydrological monitoring of seven catchments, considering that the monitored variables can be used as indicators of forest management quality. The objectives of the study were: a) select, among the monitored variables, potential indicators for the hydrological monitoring of planted forests; b) investigate whether macroinvertebrate communities can be used as biological variables. The study was carried out in catchments covered by *Eucalyptus* forests located in the four Brazilian states. The study involved data analysis of precipitation, stream flow and water quality variables measured during different periods and the analyses of macroinvertebrate communities during a one-year period. Three sets of criteria and indicators were developed: 1) maintenance of catchment hydrological processes and forest management quality, for which the indicators are water balance, peak flow, suspended solids, turbidity, conductivity, phosphorus, dissolved oxygen, potassium, water temperature and benthic macroinvertebrates; 2) maintenance of soil productivity, with the indicators phosphorus, nitrogen, calcium, potassium, magnesium and suspended solids, and 3) maintenance of the dynamic equilibrium of aquatic ecosystems with the indicators dissolved oxygen, phosphorus, nitrogen, water temperature, suspended solids, pH and benthic macroinvertebrates community composition.

**Water resource management and policy implications of reforestation in water limited landscapes in Australia.** Goss, K. (*Cooperative Research Centre for Plant-based Management of Dryland Salinity, Australia; kgoss@fnas.uwa.edu.au*).

There is a dilemma for the long term security of water supply from catchments in south-east and south-west Australia. Reforestation is both a solution – it addresses the long term threat to water quality from salt mobilized in landscapes, and a threat – the land use change from pastures to forests reduces water supply and elevates river salinity in the short term. This phenomenon challenges effective policy making for water resource management and for growth in the forestry industry. The hydrology and economics of the dilemma are now better understood, and there is a new language of “targeting” forestry in sub-catchments where the trade off is predicted to be least. Large-scale plantation forestry has been recognized as a risk to the future integrity of water resources in the 2004 National Water Initiative, an agreement of the Australian and most State governments. It foreshadows a requirement for a water access entitlement should plantation forestry exceed a threshold in fully allocated or over-allocated water systems. However, there is unfinished business for science and policy-making: 1) greater precision in estimating trade-offs in the context of other perturbations to water resources; 2) continued R&D into land use options for salinity and water quality management – for instance, forestry integrated with high performance livestock production that can inherently reduce the trade off; and 3) development of the policy initiative for plantation forestry – specifically, the planning, monitoring, regulatory and compliance measures that may apply, with a deadline for implementation of 2011.

**Managing forests for water production: A case study of evolution of scientific and modern forest management practices in India.** Gupta, H.K., Dasgupta, S. (*Forest Survey of India, India; ghemant\_sml@hotmail.com; saibaldasgupta@hotmail.com*).

This paper traces the beginning of scientific forest management in India by taking the example of Shimla Water Catchment Forest (SWCF), India comprising 1015 ha of forest located in the Northwest Himalayas. The forest is a representative of Himalayan temperate forests and its associated biodiversity is conserved exclusively for water production since 1878. The objective of the paper is to demonstrate multi-functional management of forests primarily for water conservation and supply for urban use. The SWCF demonstrates management practices such as leasing, settlement of rights, survey and demarcation, legal status classification, preparation and periodical review of working plans and redefining objectives as needed. The process of settlement of rights of communities, demarcation of boundaries, preparation of working plans simultaneously utilizing the water produced from 27 aquifers through gravity flow is described. The variable discharge ranges from 0.23 million liters per day (mld) in summer to 6.81 mld in monsoons. The SWCF represents the change of management practices from single use to multi functional purposes as forests are managed for sustainable production of services like maintenance of biodiversity, watershed function and eco-tourism by reconciling interests of different stakeholders.

**Hydrological role of forests in mountain regions.** Krovak, F., Pankova, E., Podrazsky, V. (*Czech University of Agriculture Prague, Czech Republic; krovak@fle.czu.cz; pankova@fle.czu.cz; podrazsky@fle.czu.cz*).

Forests in the regions in high altitudes exhibit multiple environment protection functions. Among the most appreciated by the society are the effects on the hydrological cycles in the landscape. One of the reasons for forest decline in the Czech

Republic is the passive management of spruce monocultures in the Bohemian Forest National Park. The presentation reports on a comparison of three micro-catchments in different site conditions: a productive forest, a forest in decline and a clear-cut. The quantity and quality of out-flow was compared; electrical conductivity of out-flow water and its chemical composition (nitrate, nitrite, ammonia, phosphate, Ca, Mg, Na, K, Fe and pH) were studied. Preliminary results indicated a high similarity between the forest in decline and the clear-cut, as for the hydrological cycle of the area. The characteristics of the water showed visible effects of the forest decline and clear-cutting. From the hydrological point of view, the situation after forest decline and cutting is very similar and these phenomena affect the hydrological cycle of the catchments, profoundly.

**Planted forests and water impacts: Cross-scale analysis through hydrological indicators – South American experiences.** Lima, W. de P. (*University of São Paulo, Brazil; wplima@esalq.usp.br*).

Planted forests have been the center of worldwide discussions about their possible impacts on water resources, with plenty of reason, for water and forest management are inseparable. As water supply decreases, forest production declines and water use conflicts may arise. In more humid climates, planted forest management may cause hydrological impacts to water quality, streamflow regime and catchment values. Therefore, as water resources dwindle and as the search for sustainable management of planted forests consolidates, there is an urgent need for an integrated strategy for the analysis and monitoring of water impacts in planted forest management decisions. The catchment offers such integrated strategy. As a systemic landscape unit, the catchment is a very adequate framework for dealing with the question of scales of sustainable forest management, in terms of water values. It is also very convenient for the implementation of landscape attributes into planted forest management plans and policy. In this paper we discuss some fundamentals of this landscape strategy, build on results of a program of integrated catchment monitoring for sustainable management of planted forests in Brazil, as well as on available related information for the South America region as a whole.

**Water use of *Hopea oderata* in a plantation in northeastern Thailand.** Luangjame, J. (*Royal Forest Department, Thailand; jesada@mozart.inet.co.th*).

A heat pulse velocity (HPV) technique was used to monitor the water use of *Hopea oderata* trees planted on dryland in Chiang Yuen district, Mahasarakam province, northeastern Thailand in 1963. This water-use study occurred during the 12-month period from June 2002 till June 2003, when the *Hopea* plantation was about 40 years old. Annual precipitation was 1368 and 654 mm in the years 2002 and 2003, respectively. The results showed that water use of the *Hopea* plantation in northeastern Thailand was 1.41 mm/day. The tree diameter at breast height (Dbh) and the sapwood area were 314 cm and 30.8 cm<sup>2</sup>/tree, respectively.

**Study on preferential flows in a dark coniferous forest ecosystem in the Upper Reach Area of the Yangtze River, China.** Niu, J.Z., Yu, X.X. (*Beijing Forestry University, P.R. China; niujianzhi@126.com; nexk@bjfu.edu.cn*).

Based on the law of soil water movement in an unsaturated zone, this study investigated tree growth characteristics and water movement through litter, moss and root. The research discusses movement of the preferential flow within the dark coniferous ecosystem in the upper reach area of the Yangtze River. Experimental methods included setting up a classified system of preferential flow, and performing theoretical analyses such as determining its occurrence and analyzing its characteristics. This was accomplished with a soil column experiment, using homemade apparatus in young, middle-aged, mature and over mature forest stands, and combining the dye-tracer analyzes. The objectives of this research are to analyze the effects of preferential flow on the runoff process, and provide theoretical support for efficient watershed management by studying soil water movement within the dark coniferous ecosystem in the upper reach area of the Yangtze River.

**The European transnational project “Water Retention by Land-use” (WaReLa).** Schüler, G. (*Research Institute for Forest Ecology and Forestry Rheinland-Pfalz, Germany; schueler@rhrk.uni-kl.de*).

Flood damage caused by lower order rivers can be prevented by the reduction and time delay of run-off waves. Within this project, effective water retention and run-off delaying measures in forest areas, agricultural land, river valleys and residential areas will be developed. The effectiveness of flood damage prevention measures will be evaluated on a process-controlled basis at local and mesoscale river basin level, taking into account geological factors, landscape structures and the storage capacity of soils. At the river basin level, they have transnational significance by the reduced and delayed inflow from tributaries into higher order rivers. Efficient measures will be incorporated in an expert spatial planning system. Ecological and economic evaluations of the efficiency of possible flood prevention measures and packages of measures will be integrated. This ‘eco-efficient Decision Support System (DSS) for flood and retention potential in spatial planning’ will function as a decision-making aid to put flood-relevant land use measures into action. A Geographic Information System (GIS) will facilitate projection of flood and retention potential. These instruments and regional planning procedures can form the basis for co-operative transnational river basin management to ensure permanent prevention of flood damage.

**Opportunities for managing the growth and water use of plantations in southern Australia.** White, D. (*CRC for Plant Based Management of Dryland Salinity, Australia; don.white@csiro.au*), Battaglia, M., Benyon, R., Mendham, D.S. (*CSIRO Forestry and Forest Products, Australia*), Carter, J. (*CRC for Plant Based Management of Dryland Salinity, Australia, and CSIRO Forestry and Forest Products, Australia*), McGrath, J., Kinal, J. (*Forest Products Commission, Western Australia*).

The Plantations for Australia Vision 2020 promotes a trebling of the nations plantation estate by 2020. This vision has been accelerating the rate of plantation establishment and has focused the attention of policy makers, plantation managers and researchers on the impact of this land use change on surface and ground water resources. Recent studies indicate that plantation water use (evapotranspiration) is highly variable within and between years, ranging between 350 and 1800 mm/yr. This large variation in evapotranspiration has been attributed to a range of edaphic factors (rainfall, evaporative demand, soil depth, soil texture, depth to groundwater, soil and groundwater salinity) and variation in tree responses to these factors. In the Australian environment the relationship between plantations and available water presents at least two major challenges: i) optimizing the trade-off between drought risk and higher rates of production, ii) understanding and minimizing the impact of large scale plantations on water resource. We will review the stand level management options that can make a contribution in meeting these challenges including site selection, choice of species genetic improvement, fertilizer addition, thinning, spacing and pruning. We will also explore the role of process based modelling in generalizing the results of silvicultural research to develop management options that balance between wood and water benefits from plantations.

### **Field experiments in the conservation of forest biodiversity**

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**Cumulative effects of a severe windstorm and subsequent silvicultural treatments on plant and arthropod diversity in the Gunflint Corridor of the Superior National Testing ecosystem management in the southeastern boreal mixedwood forest: the safe project.** Brais, S., Harvey, B. (*Université du Québec en Abitibi-Témiscamingue, Canada; suzanne.brais@uqat.ca*).

Fire history reconstruction, ecological classification and studies of stand-level processes in the Lake Duparquet Forest (LDRTF), situated in northwestern Quebec, Canada, have provided the basis for a natural disturbance-based silvicultural and management approach for the boreal mixedwood forests of this region. Within the area, stands have been associated with three 'cohorts', or broad stand development stages, according to time since initiation, structure and composition. At the stand level, the silvicultural strategy used even-aged systems to recruit 1st cohort stands, a surrogate for stand reinitiation by fire, and partial harvesting to move stands into 2nd and 3rd cohort stand types, similar to the process of natural succession from hardwoods to mixedwood to conifer-dominated stands. The SAFE study (*Sylviculture et Aménagement Forestier Écosystémique*) was established between 1998 and 2002 to evaluate operational aspects and short- to medium-term responses to treatments of the proposed model. At a rate of one cohort a year, these cohorts were subjected to different experimental cutting treatments. This research will enable us to identify the range and configuration of partial harvesting treatments that will lead to desired regeneration trajectories or conservation objectives, and an improved understanding of the implications of these new systems on forest productivity.

**Large-scale experiments and high-resolution taxa: effects of forest management on beetle and spider biodiversity in Canada's eastern boreal forest.** Buddle, C.M. (*McGill University, Canada; chris.buddle@mcgill.ca*), Work, T.T. (*Université du Québec à Montréal, Canada; work.timothy@uqam.ca*), Brais, S. (*Université du Québec en Abitibi-Témiscamingue, Canada; suzanne.brais@uqat.ca*).

Meeting silvicultural goals must be balanced with effects on non-timber values such as biodiversity. The SAFE project (*Sylviculture et Aménagement Forestier Écosystémique*) was established in 1998 to test whether natural forest dynamics could be closely matched with specific silvicultural treatments over a successional gradient of mixedwood cover-types in Canada's eastern boreal zone. The response of arthropod biodiversity at the SAFE project is an ecologically-relevant, integrated measure of the concordance between natural and managed stands. The early-successional deciduous cover-type at SAFE consists of three replicated blocks, each containing the following experimental compartments: 1/3 partial cut, 2/3 partial cut, clear-cuts, controls and wildfire. In 2004, rove beetles and spiders were sampled continuously with 10 pitfall traps placed in each experiment compartment for over 100 days. We address effects of SAFE treatments on arthropod biodiversity in terms of changes detected in species diversity and community composition, relying on species level

identifications to meet these goals. Differences in arthropod composition were also compared to shifts in the dynamics of dead wood and canopy opening as a result of harvesting treatments. The value of using arthropod biodiversity as biological indicators for understanding effects of forest management is discussed.

**Testing ants as bioindicators of fragmentation effects in semi-arid woodlands.** Debus, V.J., King, J. (*Department of Primary Industries and Fisheries, Queensland, Australia; valerie.debus@dpi.qld.gov.au; judy.king@dpi.qld.gov.au*), House, A.P.N. (*CSIRO Sustainable Ecosystems, Australia; alan.house@csiro.au*), Taylor, D.W., Swift, S.A. (*Department of Primary Industries and Fisheries, Queensland, Australia; dave.taylor@dpi.qld.gov.au; scott.swift@dpi.qld.gov.au*).

Ants have been used as bioindicators of habitat condition and disturbance in Australia, largely outside arid and semi-arid areas. We tested the response of ant community structure to fragmentation and site condition measures in *Eucalyptus populnea* remnants in southern Queensland, to explore relationships with local land use patterns and woodland condition in semi-arid areas. Of fragmentation measures tested, nearest neighbour distance between *E. populnea* patches and the degree of interspersion of *E. populnea* patches with other land uses were most strongly aligned with ant species composition. Clay content and site disturbance exhibited the strongest relationships with differences in individual species composition, but the amount of bare earth, the stocking density of midstorey tree species and site disturbance were more closely associated with changes in the relative abundance of ant functional groups. Sampling month and selected site variables or fragmentation metrics explained a maximum of 40% of the total variance. Models including fragmentation metrics explained more variation than those including site variables when analyzing individual species changes, but this trend was reversed for functional group analysis. We discuss possible reasons for the relatively low amount of variation explained by the models.

**How 'natural' is the response of biodiversity to clearfelling and to alternative silvicultural systems in Tasmanian wet eucalypt forest?** Grove, S.J., Neyland, M.G. (*Forestry Tasmania, Australia; simon.grove@forestrytas.com.au*).

Tasmania's wet eucalypt forests are amongst the more productive in the world when the standard silviculture of clearfell, burn and sow is applied. However, ecological considerations have led to trials of alternative silvicultural systems (variable retention) that were conceived to better emulate natural disturbance (chiefly wildfire) while still yielding acceptable amounts of timber. The trials were commenced in 1998 and form part of a wider research agenda at the Warra Long Term Ecological Research site. Biodiversity studies at Warra, including those associated with the trials, are progressively allowing an ecological assessment of variable retention alternatives. These include community-level and/or autecological studies of invertebrates, vertebrates and vascular- and non-vascular plants. This paper describes some of these biodiversity studies and their preliminary findings. One is that the cooler regeneration burns associated with variable retention can facilitate the survival of fire-sensitive (rainforest) biota that would be extinguished by the hotter regeneration burns routinely practiced following clearfelling.

**Long-term effects of forest fertilization on ground vegetation in the northern Black Forest, Germany.** Höcke, C. (*Freiburg University, Germany; carl.hoecke@waldbau.uni-freiburg.de*).

This study investigated the long-term effects of fertilization on the ground vegetation of five sites situated on nutrient-poor, red sandstone in the northern Black Forest and Baar, Germany. The sites were fertilized in the 1950s and 1960s with differing amounts of lime, mostly with phosphate addition, and in a few cases with nitrogen. The investigated stands were mostly coniferous and dominated by *Abies alba*, *Picea abies* and *Pinus sylvestris*. Cover and abundance of species in the forest canopy layer, the herb- and moss-layers were recorded on 335 randomly selected 40 m<sup>2</sup> plots, distributed over the five sites. The vegetation composition was largely similar on fertilized and unfertilized stands. However, fertilized stands contained a higher abundance of more nutrient demanding vascular plant and moss species as e.g., *Athyrium filix-femina*, *Oxalis acetosella* or *Thuidium tamariscinum*. At one site, the grass *Festuca altissima* and bramble (*Rubus fruticosus* agg.) occurred only in the fertilized stands. Species that have been mentioned in literature as being highly sensitive to forest liming as e.g. the liverwort, *Bazzania trilobata*, showed no apparent changes in abundance. The overall effects of forest fertilization after 40 to 50 years are very small, but evident in some cases.

**Are boreal bird and beetle abundance and richness affected by fire severity, salvage logging and spatial scale?** Koivula, M.J., Schmiegelow, F.K.A., Spence, J.R. (*University of Alberta, Canada; john.spence@ualberta.ca*).

Fire is one of the most important 'natural' disturbances in boreal forests, and it has both economic and ecological effects. In addition to initiating primary succession, fire creates a pulse of food and habitat resources for various forest organisms, many of which are specialized to exploit these spatially and temporally patchy resources. However, the

process of post-fire succession is often altered by salvage logging i.e. post-fire removal of merchantable timber. We studied the effects of fire severity and post-fire logging at the House River fire area, central Alberta, Canada, during 2003–2004 by examining a total of 24 landscapes (625 ha each) that varied in relation to merchantable timber, salvage-logging intensity and fire severity. We route-censused forest birds along triangular routes (1.5 km per side), and sampled beetles (pitfall and window trapping) and vegetation (percent coverages) in 16 sampling stations placed into mature mixedwood stands. Preliminary results, based on 2003 data, on a fire specialist Black-backed woodpecker (*Picoides borealis*) indicate a strong positive response to fire severity (the factor explaining 37.6% of the variation) but much less (and negative) to salvage logging (16.5%). In my talk I will present 2-yr results on multiple organisms at various spatial scales.

**Development of soil and litter arthropod assemblages in rainforest restoration.** Nakamura, A., Catterall, C.P., Kitching, R.L. (*Griffith University, Australia; a.nakamura@griffith.edu.au; c.catterall@griffith.edu.au; R.Kitching@griffith.edu.au*), House, A.P.N. (*CSIRO Sustainable Ecosystems, Australia; alan.house@csiro.au*).

The devastating impacts of forest clearance are widely recognized, and considerable efforts have been employed to restore cleared areas. However, little is known about the re-assembly of soil and litter fauna in replanted areas, or how assemblages may be affected by different restoration practices. Development of soil and litter arthropod diversity in restored plantings arguably deserves more attention, as arthropods play vital roles in decomposition, soil formation and other ecosystem services. For the present study, a manipulative experiment has been established on the Maleny plateau, in the Sunshine Coast hinterland of eastern Australia. Experimental sites are combinations of factors that might influence the diversity of soil and litter dwelling arthropods in restoration sites. These factors include: distance from remnant rainforests; inoculation; litter quality and quantity; and the efficacy of timber plantations versus ecological restoration. Testing the effects of different restoration practices required an initial baseline survey to establish the habitat preferences of a range of arthropod taxa. The field experiment is expected to demonstrate the re-colonization patterns of soil and litter arthropods in response to different restoration practices. Various arthropod taxa are used in the present study, with particular emphasis on ants (Hymenoptera: Formicidae).

**Conservation of biodiversity in managed boreal forests.** Schroeder, M., Larsson, S., Ekbom, B. (*Swedish University of Agricultural Sciences, Sweden; Martin.Schroeder@entom.slu.se; Stig.Larsson@entom.slu.se; Barbara.Ekbom@entom.slu.se*), McGeoch, M.A. (*University of Stellenbosch, South Africa; mcgeoch@sun.ac.za*).

In response to the increasing awareness of the importance of preserving biodiversity, forest management practices have been radically revised over the past few years. A crucial question is whether or not the 'New Forestry' will actually achieve the goal of maintaining biodiversity. A major threat to biodiversity in Swedish forests is the decline of Coarse Woody Debris (CWD), which is an essential resource for many organisms and plays an essential role for the structure and function of boreal forests. Replenishment of CWD has been a prominent goal of the 'New Forestry'. In Sweden much of the efforts have been directed towards clear-cutting through practices such as creation of standing dead wood (high-stumps), retention of living trees (with a high risk of being wind-felled) and non-removal of wind-felled trees. The importance of these practices for conservation of biodiversity was evaluated in a managed forest landscape in central Sweden. Special attention was paid to the creation of high-stumps. The contribution of CWD from clear-cuttings to the total amounts in the landscape was estimated. The production and species richness of wood-living beetles on clear-cuts in relation to the rest of the landscape was assessed. Results from the project will be presented.

**EMEND, Forest management and managing biodiversity.** Volney, W.J.A. (*Natural Resources Canada; jvolney@NRCan.gc.ca*), Spence, J.R. (*University of Alberta, Canada; john.spence@ualberta.ca*), Langor, D.W. (*Natural Resources Canada; dlangor@NRCan.gc.ca*).

The long-term Ecosystem Management Emulating Natural Disturbance (EMEND) experiment was designed to determine how best to manage forests sustainably. This is focused on biotic reactions to harvesting practices *vis-à-vis* putative normal reactions of the biota to natural disturbances such as fire. A fully replicated factorial experiment was implemented to compare the reactions of the biota to harvesting regimes in which 75, 50, 20, 10 and 2 % of the original stand volumes were retained. Comparisons were conducted in 4 forest-cover types, representing the dominant boreal forest successional sequence of the region. Six years following treatment, it is evident that, even at the highest levels of retention (75%), harvesting has a detrimental effect on populations of a variety of taxa and several trophic levels in these communities. Most obviously affected were rare species in the normal assemblages of birds, ground beetles, saproxylic beetles and moths as well as understory plants specializing in each of the cover-types studied. Further, comparisons of fauna with that of recently burned stands suggest that 'pyrophylic' species assemblages are generally not conserved in harvested stands. Variable retention harvesting is not an effective life-boating solution for pyrophylic species and rare species that specialize in late-succession closed-canopied forests.

## Forests and people: Valuation of the forest ecosystems' outputs

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**Techniques for valuing forest benefits: A state-of-the-art review.** Ellatifi, M. (*Forest Service, Morocco*; [mellatifi@yahoo.fr](mailto:mellatifi@yahoo.fr); [m.ellatifi@altbox.org](mailto:m.ellatifi@altbox.org)).

Forests are multifunctional. They provide a wide range of goods and services, contributing to human wellbeing. Until recently, only extractive forest products were taken into account in forest economic valuation, because they are traded in the market and, therefore, are easy to estimate in monetary terms. Non-marketed forest goods and services were quasi impossible to value in monetary terms, and for this reason they were ignored and so not included in the nation's GDP. During the last decade, economists developed new valuation techniques to estimate the forest ecosystem total economic value (TEV), including direct and indirect use values, and non-use values (option, bequest and existence values). The present state-of-the-art review brings the break-through made by economists, presenting the latest methods for valuing forest benefits, i.e. market price, surrogate price, production function, stated preference and cost-based valuation approaches, with the objective to assist private forest owners and government policy-makers make well informed and sound decisions towards a sustainable forest management, with significant environment impacts for the present as well as for the future generations.

**Preference uncertainty in contingent valuation: the case of forest conservation in southern Finland.** Lehtonen, E., Kuuluvainen, J. (*University of Helsinki, Finland*; [emmi.lehtonen@helsinki.fi](mailto:emmi.lehtonen@helsinki.fi); [jari.kuuluvainen@helsinki.fi](mailto:jari.kuuluvainen@helsinki.fi)), Li, C.-Z. (*University of Uppsala, Sweden*; [chuanzhong.li@nek.uu.se](mailto:chuanzhong.li@nek.uu.se)), Pouta, E., Rekola, M. (*University of Helsinki, Finland*; [eija.pouta@helsinki.fi](mailto:eija.pouta@helsinki.fi); [mika.rekola@helsinki.fi](mailto:mika.rekola@helsinki.fi)).

Contingent valuation (CV) is a widely used survey-based method for valuing environmental goods and services. This study investigates the preference uncertainty that respondents have expressed in a dichotomous choice (DC) CV survey about forest conservation in southern Finland. The assumption is that a respondent has a true willingness-to-pay (WTP) for environmental quality, but she does not know the value with certainty and thereby feels uncertain when making a choice in a survey that requires difficult trade-offs between money income and environmental quality. The objectives of this study are to apply a model that allows uncertainty, to test if the respondents can express their preference uncertainty in a follow-up question, and whether respondents' characteristics can reveal the reasons for uncertainty. We also investigate the distribution of the uncertainty interval and compare our results to somewhat contradicting results of earlier preference uncertainty studies. Our results indicate that the uncertainty intervals are asymmetric and considerably wide. The uncertainty that the respondents expressed may result both from cognitive difficulties of the choice task and pure preference uncertainty. The model that allowed uncertainty leads to a higher mean WTP compared to the conventional model.

**Gender and forestry in Europe and North America.** Lidestav, G. (*SLU, Swedish University of Agricultural Sciences*; [gun.lidestav@siko.slu.se](mailto:gun.lidestav@siko.slu.se)), Springfors, A. (*FAO, Italy*; [anna.springfors@fao.org](mailto:anna.springfors@fao.org)).

The lack of gender awareness constrains the sustainable use and management of forests and forest ecosystems throughout the world. Women are often strongly under-represented in management and decision-making and have therefore difficulties to advocate for their rights. As a result, there is often infringement on legislation requiring equality of treatment. More and better information is not only essential to guide policies and strategies promoting greater equality and participation of women, but also to raise the visibility of the women in the sector. A team of specialists on gender and forestry in Europe (including Eastern Europe and CIS) and North America is working on the following topics: 1) gender structures in forest organizations, 2) gender structures in forest ownership, and 3) gender and the perception of forests. Data from the review of the gender representation in forest organizations and forest ownership will be presented.

**Prevailing shifting cultivation in the Chittagong Hill Tracts, Bangladesh: Some thoughts on rural livelihood and policy issues.** Nath, T.K. (*University of Tokyo, Japan, and University of Chittagong, Bangladesh*; [tapankumarn@yahoo.com](mailto:tapankumarn@yahoo.com); [tknath@fr.a.u-tokyo.ac.jp](mailto:tknath@fr.a.u-tokyo.ac.jp)), Inoue, M. (*University of Tokyo, Japan*), Chakma, S. (*University of Chittagong, Bangladesh*).

Shifting cultivation (jhum) is the dominant hill farming system practiced by the tribal people of the Chittagong Hill Tracts (CHT), Bangladesh. Earlier, the system was considered sustainable and productive, and farmers maintained their livelihood. But now, productivity is reduced drastically and it is viewed as a main cause of land degradation and forest losses. Drawing an empirical study conducted in Khagrachari district, this research focused on the input-output scenario of shifting cultivation under present production system, farmers' income and expenditure situations, their perceptions about past and prevailing methods of shifting cultivation, and their opinion for improvement of shifting cultivation for better livelihood outcomes. Results of the study showed that the returns from shifting cultivation are almost equals to input values when



opportunity costs of family and exchanged labour are excluded. Comparison of past and prevailing shifting cultivation indicated that productivity is reduced notably and farmers experienced food shortage for two to six months in a year. Recently, farmers have been required to adopt new occupations. Government policies could not reduce the intensity of shifting cultivation nor improve the livelihoods of tribal people and of the region's forest resources. Secure land title, necessary institutional supports and active participation of locals is required to find alternative land uses in the region.

**Role of women in tea-based agroforestry systems in the Himalayas.** Punam (*HP Agriculture University, India; punam@email.com; punam@hillagric.org*).

A close link exists between rural women and tea-based agroforestry (TAF) systems of the Himalayas. The fine plucking of new emergent tea leaves needs patience and efficiency—both found only in women workers. This is the main reason why mainly women are employed in the TAF systems, which has direct bearing on their social status and livelihood. A study was formulated to know and quantify this very impact in Kangra Valley of Himachal Pradesh in India. Caste and size of landholdings emerged to be important factors forcing women towards TAF systems. In spite of working for an average of about 9 months, approximately 43% of the respondents had no basic knowledge about the TAF system, and 70% felt lack of technical guidance. This aspect, if taken care of, can enhance their efficiency. Women contributed 51.4% of the monthly family's income. This was one of the major reasons that 68% of the respondents had an important role in the decision making of the family. Increase in household expenditure can be directly linked to the rise in the social status of the respondents. These TAF systems in the Himalayas need to be sustained for the ecological and economical stability of the region.

**The impact of negative externalities on the total economic value of Turkish forests in the context of sustainable forestry.** Türker, M.F. (*Karadeniz Technical University, Turkey; mft@ktu.edu.tr*), Öztürk, A. (*Kafkas University, Turkey; atak08@hotmail.com*), Pak, M. (*Kahramanmaraş Sütçü İmam University, Turkey; mpak@ksu.edu.tr*), Durusoy, I. (*Karadeniz Technical University, Turkey; durusoy@ktu.edu.tr*).

Forests supply a combination of market and non-market goods and services. Conventional forest products pass directly through markets, while, many benefits derived from forests do not—bird watching to weather regulation. It is increasingly important to identify and evaluate non-market benefits due to increased pressures on natural resources. The sum of all natural resource values is Total Economic Value (TEV). Components of TEV can be classified into positive and negative externalities or use, non-use, option, existence and bequest values. Development of sound and sustainable policy and strategies requires increasing the TEV, by raising the positive externalities and reducing the negative ones. Assessment of the negative externalities is very important because they cause the TEV to reduce, added value of the sector and financial resources allocated to forestry is lower than it would be—endangering implementation of sustainable forest management. Negative externalities such as erosion and forest fires have a negative impact on the TEV—estimated at the national level by the replacement cost method. Negative externalities reduce the TEV for Turkish forests by 12%. In this paper, the TEV concept is applied to Turkish forestry, and findings, especially negative externalities, are presented and discussed from the point of view SFM and the Turkish forestry sector.

### **The role of forests in carbon sequestration: Accounting for ecosystem dynamics**

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### **Development of soil carbon stocks following clear-cutting and regeneration in Finland: A chronosequence study.**

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Clear-cutting and regeneration can be expected to have a major impact on carbon sequestration. However, little is known about the development of soil carbon stocks following clear-cutting and regeneration in Finland. Since the 1970s, some 250,000 ha have been harvested annually, half of which is through clear-cutting. Rotation times vary from 80 years in southern Finland to >100 years in Lapland. Nearly all the clear-cutting removes only tree stems, and large amounts of logging residue are left on-site. It is generally believed that soil carbon is lost following clear cutting, but this may not be the case if the carbon associated with the logging residues and changes in the ground vegetation, plus the original organic layer and mineral soil, are taken into account. We determined soil carbon stocks from the surface to a depth of 30 cm in the mineral soil in 18 clear-cuts ranging in age from 12–27-years-old, located throughout

Finland (60–68° N). Carbon stocks calculated from samples taken in 2001 were compared with those calculated from samples taken in the year of clear-cutting. The change in carbon stocks were evaluated in relation to a number of factors, including age of clear-cut, estimated logging residue input and latitude.

**Regional variation in the net primary productivity to gross primary productivity ratio of forest ecosystems: Implications for carbon cycle models.** Janssens, I.A. (*Universiteit Antwerpen, Belgium; ivan.janssens@ua.ac.be*).

One of the large remaining uncertainties in the carbon cycle of forests is the relationship between net and gross primary productivity (the ratio of NPP to GPP). In forests, this NPP/GPP ratio has long been assumed to be close to 0.5 at an annual timescale, but a substantial amount of recent field data and process-based models indicate that this ratio is not constant but varies with stand development. Furthermore, the NPP/GPP ratio appears to be close to 0.5 only in temperate forests and declines towards colder and warmer climates. With the recent boom in stand-level carbon budget studies, there are now many estimates of GPP, NPP and net ecosystem productivity in forests. Hence, the time has come to revisit the unresolved issue in NPP/GPP. This paper reviews all available studies on NPP and GPP and attempts to assess the relevance of the observed findings for carbon cycle budgets and models.

**The role of fire in forest carbon and nitrogen balances.** Johnson, D.W. (*University of Nevada, USA; dwj@cabnr.unr.edu*).

The role of fire in long-term ecosystem carbon (C) and nitrogen (N) balance changes is not straightforward. While the immediate effects of a fire are limited to only losses of C and N by volatilization, a stand-replacing wildfire can also indirectly cause long-term increases in soil C and N because of the incorporation of charcoal into soils and by post-fire N<sub>2</sub> fixation. In an N-limited system, increases in soil N by N<sub>2</sub> fixation could eventually cause more C to accumulate in the system than was present before the fire (unless another fire occurs). Prescribed fire that burns only understory and forest floor components causes much less C and N loss during any given burn, but over time may actually result in more N loss than an infrequent stand-replacing wildfire, and these losses may not be replenished by N<sub>2</sub> fixation if the burning interval is too short to allow N fixers to occupy the site. This paper reviews available studies on the effects of fire on C and N budgets, and attempts to place these into perspective with the use of a simple spreadsheet model to investigate various scenarios regarding fire frequency and post-fire N<sub>2</sub> fixation.

**Estimation of carbon pool changes in litter and soil through soil monitoring: Possibilities and pit-falls.** Karlton, E. (*SLU, Sweden; erik.karlton@sml.slu.se*), Lindqvist, H. (*Umeå University, Sweden; hakan.lindqvist@matstat.umu.se*), Ståhl, G., Stendahl, J., Lundin, L. (*SLU, Sweden; goran.stahl@resgeom.slu.se; johan.stendahl@sml.slu.se; lars.lundin@sml.slu.se*).

Two of the carbon pools to be reported in the LULUCF sector under the Kyoto-protocol requirements are litter and soil. Changes in these two pools can be estimated through soil monitoring. We have assessed the precision of estimated changes on the basis of data from soil inventories integrated with the Swedish NFI made 1983–1987 and repeated 1993–2002. Given a high number of observation points, in our case approximately 10 000, small changes can be estimated despite the considerable spatial variation in soil carbon because the random error will be small. Reporting small changes requires the assumption that the inventory method can be kept constant between inventories. However, the inventory is a chain of events: sampling, transport, drying and preparation, and subsequent analysis of C concentration. The risk that changes in staff, leadership, equipment and funding of the survey are introducing systematic errors cannot be neglected. We conclude that the uncertainty level for estimating a true change is probably higher than indicated by the small random error, and suggest that an error term based on an assessment of possible systematic errors of all single steps in the process of determining carbon content in soil carbon pools be introduced.

**Determination of carbon in fine-root fractions using near-infrared spectroscopy (NIRS).** Khanna, P., Bauhus, J. (*Freiburg University, Germany; pkhanna@gwdg.de; Juergen.bauhus@waldbau.uni-freiburg.de*), Beese, F. (*Göttingen University, Germany; fbeese@gwdg.de*).

Measurement of fine roots in ecosystems is highly labour intensive and has so far remained a major drawback in accurate evaluation of root-related parameters in any tree and cropping system, yet the fine-root carbon (C), and nutrient contents and their turnover are highly relevant for ecosystem functioning and C sequestration. The separation of fine roots from different species, and live and dead roots poses common problems. In this paper we present a methodology that permits the distinction between fine roots in different soil fractions, and between fine root-C and soil C by using near-infrared reflectance spectroscopy (NIRS). Results to date have shown that fine-roots of *Fagus sylvatica*, *Picea abies* and *Robinia pseudoacacia* could be separated on the basis of NIRS. Results are presented for important European forest tree species and a range of soil conditions.

**Impacts of disturbances and forest management on boreal forest carbon dynamics.** Kurz, W.A. (*Natural Resources Canada, Canada; wkurz@nrcan-rncan.gc.ca*).

The carbon (C) dynamics of many boreal forest ecosystems are dominated by natural disturbances such as wildfire and forest insects. In Canada, emissions from forest fires in extreme fire years can approach 100 Teragrams (million tons) C/yr. In such years, disturbances transfer approximately 300 Tg C/yr from biomass to dead organic matter pools. Disturbances also affect forest growth and successional dynamics. Stand-replacing disturbances in the recent past determine the current age-class structure of the forest, which affects the potential for future C sequestration. Changes in the type, rate and intensity of disturbances impact C dynamics. Understanding and quantifying how disturbance regimes affect the net balance of carbon emission and removals in the boreal forest is pre-requisite to developing forest management strategies aimed at enhancing forest sinks and reducing sources. While land-use change in the boreal forest must also be considered, the disturbance regime will likely be the primary driver of the C balance of boreal forests in Canada, Russia and Alaska in this century.

**Carbon biomass in tree rings of *Balfourodendron riedelianum* and *Esenbeckia leiocarpa*, in the Southeast of Brazil.** Lisi, C.S., Tomazello Filho, M. (*University of Sao Paulo, Brazil; mtomazel@esalq.usp.br; cslisi@esalq.usp.br*), Botosso, P.C. (*Brazilian Forest Research Center/EMBRAPA, Brazil; botosso@cnpf.embrapa.br*).

Forest trees are recognized by their strategic importance in the assimilation of excess atmospheric carbon and several methods of wood-carbon biomass determination are available in the literature to calculate the carbon concentrations in different forest ecosystems. With this aim, *Balfourodendron riedelianum* and *Esenbeckia leiocarpa* trees, commonly found in semi-deciduous seasonal forest fragments in southeastern Brazil, were selected. The site is characterized by climatic seasonality (hot with rain during the spring/summer, and cold and dry during autumn/winter), inducing annual tree-ring formation due to cambium activity variation. A total of 59 trees of the two species were selected, and wood cores were extracted to determine the radial annual tree-ring thickness and their respective density by X-ray densitometry technique. With the wood biomass of annual tree-rings, the percentage of carbon/wood was calculated to determine the amount of carbon in of each individual tree-ring. To *B. riedelianum* and *E. leiocarpa* trees it was determined that during the period analyzed, the carbon assimilated in the annual tree-rings of both species increased in relation to tree age, with intra-inter tree ring variation.

**Temporal changes in soil organic carbon under *Pinus pinaster* afforestation on sandy soils in south-western Australia.** Ritson, P. (*Forest Products Commission, Western Australia; peterr@fpc.wa.gov.au*).

Soil organic carbon (SOC) concentrations in the <2 mm soil fraction were measured in 130 paired *Pinus pinaster* and agriculture plots. The pine plots were in stands ranging in age from 9–37 years. Samples were taken from the surface soils (0–10 cm depth) and at 30 cm (25–35 cm) depth. Estimates of change in SOC under pine were highly variable. However, averaged across all ages, there was an 18% loss of SOC in the surface soils but no significant change in SOC at 30 cm depth. The loss of SOC in surface soils varied with stand age. It was greatest in the youngest stands—a loss of 2.8 t SOC/ha under pine at age 10 years, but with a trend of gradual recovery of SOC under pine to no difference between pines and agriculture by age 20–30 years. Sampling of biomass carbon showed any losses of SOC under *P. pinaster* afforestation are small compared to gains in carbon stocks in tree growth over a rotation.

**Estimating carbon sequestration patterns with tree-ring analysis in northern Yucatan, Mexico.** Ruiz-Garvia, C., Worbes, M., Tiessen, H., Reuter, M. (*Georg-August University of Göttingen, Germany; cruiz@gwdg.de; mworbes@gwdg.de; htiessen@gwdg.de; ManjaReuter@gmx.net*).

Rehabilitating large areas of degraded lands in northern Yucatan with afforestation and agroforestry systems may be a feasible alternative to increase the welfare of marginalized farmers by producing food, timber and non-timber forestry products, plus the associated payments for carbon sequestration. Proper design and management practices for afforestation practices can make cost-effective carbon sinks. The uses of tree ring studies for certifying Clean Development Mechanisms (CDM) under the Kyoto Protocol may serve as an attractive tool for describing tree dynamics and development. However, this tool is only being introduced in tropical areas. In this research we studied tree growth, using tree-ring-based techniques, of *Cordia dodecandra* planted under agroforestry established on calcareous soils of northern Yucatan. We investigated tree-ring differentiation and growth trends. We then expressed these growth patterns in economic terms in order to make this forest-based CDM project comparable to projects in other tropical regions. The study shows that in this and many other species, tree ring analysis is a feasible tool for assessing carbon sequestration patterns in tropical regions. Finally, we explain why *C. dodecandra* may serve as a cost-effective and sustainable option to convert non-productive areas of northern Yucatan into long-term productive ones.

**Allometric relationships for estimating above-ground biomass for woodland savanna trees in the Pantanal of Mato Grosso do Sul, Brazil.** Salis, S.M. (*Embrapa Pantanal, Brazil; smsalis@cpap.embrapa.br*), Assis, M.A. (*UNESP-Rio Claro, Brazil; massis@rc.unesp.br*), Povoá de Mattos, P. (*Embrapa Florestas, Brazil; povoá@cnpf.embrapa.br*), Pião, A.C.S. (*UNESP-Rio Claro, Brazil; piao@rc.unesp.br*).

Vegetal biomass estimation and distribution are important aspects of ecosystems studies. Unfortunately, there is not much information available about Pantanal woodland savannas. This work aimed to develop regression equations of aerial biomass for native tree species in a woodland savanna in Rio Negro farm, Pantanal of Nhecolândia, Brazil. The samples were taken from ten trees of *Protium heptaphyllum* (Aubl.) Marchand, *Magonia pubescens* A. St.-Hil., *Diptychandra aurantiaca* Tul., *Terminalia argentea* Mart. & Zucc. and *Licania minutiflora* (Sagot) Fritsch, and another miscellaneous group with 11 different species. Linear and non-linear regression analyses were used to develop relationships between breast height diameter and dry weight of wood, branches and leaves, wood volume and total aerial biomass. Using  $P < 0.05$ , all regressions had correlation coefficients near or above 0.8. The biomass curves predicted by linear regression analysis were similar to the non-linear regression obtained, except for *Licania minutiflora* and the miscellaneous group. The breast height diameter was confirmed as a good parameter to estimate biomass and wood volume. The wood volume and biomass estimation of Pantanal woodland savanna are fundamental information for the understanding of carbon cycle, conservation and sustainable use in this region.

**Effect of charcoal application on growth of *Acacia mangium*.** Siregar, C.A. (*Forestry Research and Development Agency, Indonesia; siregar@forda.org*), Kato, T., Ando, K. (*JICA – FORDA Project, Indonesia; caffm@indo.net.id*).

Charcoal application is important not only in carbon fixation and inactivation in the atmosphere but also in environmental conservation when used as soil conditioner to improve plant growth and soil carbon sequestration. Greenhouse and field experiment were designed to examine the effect of charcoal incorporation to marginal soils on *Acacia mangium* growth. Charcoal treatments were 0, 10, 15 and 20% (v/v). Representative samples of Orthic Acrisol (very fine, mixed, semi-active, isohyperthermic, Typic Paleudult) were collected from a B horizon for the greenhouse experiment. This experiment indicated that charcoal significantly increased seedlings height, diameter and ratio of the aboveground to belowground biomass. Ratio of stem and root weight to leaf significantly decreased. Charcoal significantly increased soil pH, C organic, N total, 25% HCl extractable P, 25% HCl and Bray-extractable K, exchangeable bases (Ca, Mg, Na and K), percentage of base saturation, and significantly decreased, CEC, KCl 1 N extractable  $Al^{3+}$  and  $H^+$ . Significant effect of charcoal plant growth in field experiment was not observed when the plantation was 7-months-old, and only becoming evident at 26 months. Research results indicated that charcoal application at a rate of 10–15% was adequate to improve soil nutrients availability, and hence significantly induce a better plant growth response.

**Impact of land-use changes and wild fire on carbon stock of tropical peat-swamp forest in central Kalimantan, Indonesia.** Siregar, U.J., Massijaya, M.Y. (*Bogor Agricultural University, Indonesia; ulfahjsiregar@yahoo.com; yusram@indo.net.id*), Adijaya (*Palangkaraya University, Indonesia*), Siregar, C.A. (*Forestry Research and Development Agency, Indonesia; siregar@forda.org*), Kato, T. (*JICA – FORDA Project, Indonesia; caffm@indo.net.id*).

Establishment of a mega rice field project in a tropical peat-swamp forest in central Kalimantan has proven to be disastrous, as it has not only destroying the ecosystem, but has caused recurrent wild fire, which burns the forest and peat soil. This study was aimed at quantifying the loss of carbon stock in a peat-swamp forest due to changes in land use and fire. Using the destructive sampling method developed by JICA–FORDA, based on 100 m<sup>2</sup> plots, above ground carbon content of primary peat-swamp forest was estimated as ranging from 413–682 ton/ha. When the forest was logged, the above ground carbon stock in the logged over area decreased to 205–338 ton/ha. In the post forest fire area, of which fire had only taken place once, carbon content decreased sharply to 35.2–62.8 ton/ha. When the area experienced recurrent wild fire, only grassland would be present, and carbon content left was 2.0–3.6 ton/ha. Huge amount of carbon emitted due to land use changes and fires was accompanied by changes in vegetation structure, and severe forest hydrological dysfunction. Such tremendous loss of carbon sink has posed tropical peat-swamp forest as critical in the perspective of global climate change.

**Comparative method of carbon biomass estimation in tropical peat-swamp forest, central Kalimantan, Indonesia.** Siregar, C.A. (*Forestry Research and Development Agency, Indonesia; siregar@forda.org*), Siregar, U.J., Massijaya, M.Y. (*Bogor Agricultural University, Indonesia; ulfahjsiregar@yahoo.com; yusram@indo.net.id*), Adijaya (*Palangkaraya University, Indonesia*), Kato, T. (*JICA – FORDA Project, Bogor, Indonesia; caffm@indo.net.id*).

A reliable, yet simple method in estimating biomass and carbon stock is needed for calculating the carbon budget in a carbon mitigation project. Two widely used methods are available—the Brown allometric equation, and the Yamakura

allometric equation. This study was designed to evaluate aboveground biomass and carbon estimates from those allometric equations in comparison with direct measurement in the field using destructive sampling method developed by JICA–FORDA. Three 10 x 10 m<sup>2</sup> plots were established in primary peat-swamp forests. All trees with diameter  $\geq$  2 cm were identified and then cut. Parameters recorded included: dbh, height, above ground fresh weight and above ground dry weight. The number of trees in plot 1, 2 and 3 were 41, 51 and 77, respectively. Dry weight biomass estimated in plot 1 employing Yamakura, Brown (linear and exponential), and direct measurement were 829, 931, 876 and 904 ton/ha, respectively; those estimated in plot 2 were 311, 412, 364 and 359 ton/ha, respectively; and those estimated in plot 3 are 466, 640, 546 and 486 ton/ha, respectively. Results from this study indicated that the three allometric equations are reasonably applicable. Further study using larger plot sizes is suggested.

**Carbon densities, stocks and flows for a small-forested catchment in eastern Finland.** Starr, M. (*University of Helsinki, Finland; mike.starr@helsinki.fi*).

To better understand and quantify the role of forests in carbon (C) sequestration, an integrated approach looking at the densities and stocks of C in the forest biomass and soil pools, and flows through and between them is helpful. At the landscape scale, an appropriate natural unit for such an approach is that of the headwater catchment. The small, forested Hietajärvi catchment in eastern Finland has been monitored since 1988. It has a total area of 464 ha, of which 23% is covered by lakes and small ponds, 30% by peatland (forested and open), and 47% by upland forest soil. The forests, mainly mature Scots pine, have been protected from management since the beginning of the 20<sup>th</sup> century and thus represent undisturbed conditions. The C densities and stocks associated with the forests and soils were calculated, and repeated three times at four-year intervals at permanent plots. Furthermore, the flow of dissolved organic carbon (DOC) in precipitation, throughfall and soil water was monitored at these plots, and its composition and quality ascertained. Besides changes in carbon sequestration and emissions of CO<sub>2</sub>, the impact of climate change can be expected to make, if not already occurring, significant changes to the flow of DOC and associated transport of heavy metals from forest ecosystems to surface waters.

**Estimation of carbon budget in eucalyptus plantations in Portugal.** Tomé, M., Soares, P. (*Instituto Superior Agronomia, Portugal; magatome@isa.utl.pt; paulasoares@isa.utl.pt*), Canaveira, P. (*CELPA, Associação Indústria Papeleira, Portugal; paulo.canaveira@celpa.pt*).

To implement the Kyoto Protocol, estimation of the carbon budget of forests is essential. The objective of this paper is to present a model (GLOB–CARB) to estimate the carbon budget of *Eucalyptus globulus* plantations in Portugal—occupying 21% of the 762,149 ha of forested area. The model includes three components: 1) a stand growth and yield model with a system of equations for the estimation of total aboveground biomass and biomass per components that are converted to carbon by coefficients estimated on the basis of chemical composition of each biomass component, 2) a soil carbon model, and 3) the carbon budget of wood-based products. The model can be used to estimate the carbon budget over the whole rotation of a plantation under different management options. GLOB–CARB model is used, in combination with forest inventory data at the national level, to estimate the long-term carbon budget of the whole area of eucalyptus in Portugal under different scenarios of management options, rate of expansion of the area, forest fire incidence and land-use conversion. Due to the Kyoto protocol, particular interest is put on the use of the GLOB–CARB model to estimate carbon stocks for the period 2008–2012 of plantations established after 1990.

**Analysis of the carbon flux balance of a wood plantation and a close-to-nature regime: Linking environmental performance of the technosphere with carrying capacity of the ecosphere.** Wollenmann-Brandenberger, R. (*Swiss Federal Institute of Technology, Switzerland; brandenberger@env.ethz.ch*).

Traditional land-use impact assessments treat the carbon source and sink capacities of land separately, resulting in two environmental performance indicators—occupied land area and carbon sequestration area. The present study aims at linking the environmental performance of the production process (i.e., the carbon source) with the carbon sink capacities of the land occupied by it in order to assess the carbon balance. A eucalyptus plantation is compared to a close-to-nature forest, by using a life cycle assessment (LCA) approach. The carbon release for stand establishment, stand tending and harvesting is approximately 15 kg C/ha/yr for the close-to-nature regime and approximately 65 kg C/ha/yr for the *Eucalyptus* plantation. The release per m<sup>3</sup> is quite similar for both systems. Assuming that belowground sink capacity is approximately 1500 kg C/ha/yr for the close-to-nature regime and approximately 2500 kg C/ha/yr for the eucalyptus plantation, the remaining carbon sink capacity is approximately 85 kg/m<sup>3</sup> for the plantation and approximately 180 kg/m<sup>3</sup> for the close-to-nature regime. Preliminary results indicate that available sink capacities of close-to-nature regimes cannot support endless further processing of wood. From the perspective of a sustainable carbon balance, the degree of further processing therefore determines the appropriate production method for wood.

## Environmental goods, institutions and markets

Organizers: Shashi Kant *University of Toronto, Canada; Shashi.kant@utoronto.ca*, and Sen Wang *Natural Resources Canada, Canada; Sen.Wang@nrcan-rncan.gc.ca*

**Is there a market premium for certified logs? A comparative price analysis from Sabah, Malaysia.** Kollert, W. (*German Agency for Technical Cooperation/University Malaysia Sabah, Malaysia; walter.kollert@gtz.de*), Lagan, P. (*Sabah Forestry Department, Malaysia; peter\_lagan@hotmail.com*).

The controversy about the benefits of certification to timber producers has centred on the 'market premium' and 'market access' arguments. Some studies claim evidence that consumers are willing to pay between 5% and 19% more for sustainably produced, certified timber products. Others doubt or flatly deny this notion. Most of these studies are based on willingness-to-pay surveys of consumer demand leaving aside the crucial question, whether or not the producers of certified logs, who bear the higher costs of sustainable forest management, obtain a financial award for their efforts. The paper will contribute quantitative evidence to the on-going debate. Time series (2000 to 2004) provided by three forest concessions were examined in a comparative price analysis of certified and uncertified logs of 6 qualitatively different species groups. A significant price difference could be established for high-quality heavy and medium hardwoods. Species groups with a high share of lower grade timbers did not produce the expected price premium. Further, certification was found to indirectly enhance log pricing. It serves as a catalyst for amendments to the timber marketing system by introducing log auctions and the sorting of species into user-oriented species groups.

**Transaction process, rights changes and sustainable forest management.** Naskali, A. (*Finnish Forest Research Institute, Finland; arto.naskali@metla.fi*).

Recent developments in ecological sciences, environmental and ecological economics, environmental ethics and social values and technology have led to the identification and justification of new claims for public intervention in private land-use decisions, and for reconsideration of existing uses of public lands. Of these new claims, ecosystem management, calls for an active human role in the preservation of biodiversity, complexity, resilience, productivity and sustainability of human used lands. However, the justification for ecosystem management, in terms of landowners and other land users, is still a contested issue. In this paper, I develop a conceptual basis for changes to property rights with respect to forest resources; it includes the definitions of rights, forces behind the changes and a discussion about the ecological, ethical and economic basis of those changes. Accordingly, an analysis of the complete production process is needed and a framework based on institutional economics is required in analysing sustainable forest management (SFM). The most difficult question then is about how adaptability can be embodied in institutions so that they are capable of responding to those processes, which secure the resilience of ecosystems. Ecosystem management, and especially adaptive management, concentrates on dynamic processes crossing boundaries. The goal is a set of desired future conditions, and not a set of outputs such as timber volumes or wildlife numbers. Instead, outputs are produced in the process of managing the ecosystem in the direction of those desired future conditions. Besides, the economies of configuration can make the intervention very difficult as they claim that all work should be done in the whole landscape and not only in individual stands alone. Actually, new forms of collective management or some kinds of coalitions need to be sought out, enabling the parties concerned to benefit at least in the very long term.

**Economic analysis of carbon sequestration on stand and forest level.** Pohjola, J. (*Finnish Forest Research Institute, Finland; johanna.pohjola@metla.fi*), Valsta, L., Mononen, J. (*University of Helsinki, Finland*).

A stand level model describing joint production of timber and carbon sequestration is used to analyze financially optimum silvicultural strategies for Scots pine and Norway spruce in Finland. This study expands the earlier analysis by considering (1) thinnings as measures to increase carbon stocks in forests, in addition to lengthening the rotation age, and (2) different initial stand ages. The economics of carbon sequestration are included in the form of returns based on the carbon content of the stemwood and costs based on carbon release to the atmosphere after wood product life-cycles. Our results show that the cost-effective measures to increase carbon sequestration varied between tree species. For Scots pine, delaying and lightening thinnings was a more cost-effective measure to sequester carbon than increasing the rotation length. In contrast, postponing the final cutting was a more cost-effective measure for Norway spruce. The impacts of applying forest management practices that increase carbon sequestration depend on how the policy is implemented. Applying carbon sequestration policy immediately for stands of all ages would have a positive impact on near-term carbon balance but the costs might be higher. Short-term disturbances in the timber market would be more severe the larger the forest area included.

**Cost efficiency of measures to increase the amount of coarse woody debris in managed Norway spruce forests.** Ranius, T., Ekvall, H., Jonsson, M., Bostedt, G. (*Swedish University of Agricultural Sciences, Sweden; thomas.ranius@entom.slu.se; mattias.jonsson@entom.slu.se; goran.bostedt@sekon.slu.se*).

Changing silvicultural methods in managed forestland in order to improve habitat quality for forest organisms can contribute to biodiversity preservation. In boreal forests, coarse woody debris (CWD) is an important substrate for red-listed species. We analyze cost-efficiency of five management measures taken in Swedish forestry, which aim at increasing CWD in managed forests: retention of living trees at harvest, artificial creation of high stumps, manual scarification in clearcuts to avoid destruction of CWD, prolongation of the rotation period and retention of naturally dying trees. We predicted the amount of CWD that will be present if the same management method is used over a long time, and calculated the present value of Norway spruce (*Picea abies*) stands in different parts of Sweden. To retain reasonable amounts of naturally dying trees was always inexpensive. Creation of high stumps was a cost efficient method to increase the amount of CWD. Prolonging the rotation period was the most expensive way to increase CWD. We conclude that adopting several different measures to increase CWD in managed forests, as prescribed by certification standards today, is a good concept, but to be cost efficient, the focus should be on different measures in different parts of Sweden.

**Counting on the environment! Forest environmental incomes and the rural poor.** Vedeld, P., Angelsen, A., Sjaastad, E. (*Agricultural University of Norway, Norway; pal.vedeld@umb.no*).

The paper has two main objectives. The first is to investigate the extent to which people in rural areas of developing countries depend on income from forest environmental resources, and how this dependence is conditioned by different political, economic, ecological and socio-cultural factors. This is accomplished by a meta-analysis of 54 case studies. The second objective is to review research methodology and make recommendations for 'best practices' in assessment of forest environmental income. The report analyzes poor people's level of dependence upon forest environmental incomes through a meta-study of 54 cases drawn from third world countries. Although there is substantial variation in methodology and quality of case studies, results indicate that forest environmental income represents a significant income source, contributing an average of about 22% to household income. The main sources of forest environmental incomes are fuelwood, wild foods and fodder for animals. The income goes into complex household strategies for survival and livelihood diversification, and especially poor households depend on such incomes for gap-filling and safety net functions. Forest environmental income has a significantly equalizing effect on local income distribution. Cash income constitutes half of total forest environmental income. The reviewed studies display much theoretical and methodological pluralism.

## **Stem and shoot fungal pathogens and parasitic plants: The values of biological diversity (B)**

Organizer: Simon Shamoun *Natural Resources Canada, Canada; sshamoun@nrcan.gc.ca*

**Influence of wound location on disease spread in *Eucalyptus nitens* and *E. globulus*.** Deflorio, G. (*Albert-Ludwigs-Universität Freiburg, Germany; Giuliana.Deflorio@fobot.uni-freiburg.de*), Barry, K. (*University of Tasmania, Australia; Karen.Barry@ffp.csiro.au*), Mohammed, C. (*University of Tasmania, Australia, CRC for Sustainable Production Forestry, Australia, and CSIRO Forestry and Forest Products, Australia; Caroline.Mohammed@csiro.au*).

In Australia, stem defect caused by wood decay fungi can downgrade timber quality and reduce the economic value of industrial eucalypt plantations. Fast-growing *Eucalyptus nitens* and *E. globulus* plantations require pruning and thinning to produce high quality solid wood products. These operations result in wounds, and in this study we assessed the severity of decay spread in relation to both inoculum potential and wound location. The sapwood of *E. nitens* and *E. globulus* in Esperance (Tasmania, Australia) were artificially wounded and inoculated with two white rot fungi (an unknown 'Isolate D' and *Acanthophysium sparsum*) by placing each wood inocula in holes drilled in the stem and branch. Trees were destructively sampled 13 months after inoculation. The extension of axial decay originating from stem wounds was greater than that from branch wounds. However, no differences were detected in fungal virulence or in the extension of decay within the two tree species. Tree-to-tree variation was high. Total phenol production in the reaction zone did not differ between treatments, including control treatments (fungal species, tree species and wound location). Results are discussed in respect to the anatomy and histochemistry of trees.

**Barrier zone formation in *E. nitens* after wounding and inoculation: A microscopic study.** Deflorio, G. (*Albert-Ludwigs-Universität Freiburg, Germany; Giuliana.Deflorio@fobot.uni-freiburg.de*), Mohammed, C. (*University of Tasmania, Australia, CRC for Sustainable Production Forestry, Australia, and CSIRO Forestry and Forest Products, Australia; Caroline.Mohammed@csiro.au*).

Trees employ both passive and active mechanisms for responding to injury and infection by wood invading micro-organisms. Among the latter, barrier zone formation typically occurs when the cambium is damaged. In trying to understand whether wood decay fungi elicit a different response in relation to their inoculum potential, this study employed light microscopy for assessing the anatomy and extension of the barrier zone formation. The sapwood of plantation grown *Eucalyptus nitens* in Esperance (Tasmania, Australia) was artificially wounded and inoculated with two white-rotting fungi (an unknown 'Isolate D' and *A. sparsum*) by inserting wood inocula in drilled holes. Thirteen months after inoculation, trees were felled and infected material was obtained from five replicates for each treatment. The extent of barrier zone formation did not significantly differ in infected wounds. In control wounds, however, little or no barrier zone was formed. Vessels, parenchyma cells and fibers were occluded with phenolic compounds, thus followed by several rows of thicker-walled fibers and by the juxtaposition of parenchyma cells, axially and radially. Stone cells in groups or rows were typically present. Moreover, the tissue formed soon after wounding showed a higher degree of lignification. The results provide a basis for a better understanding of defense mechanisms in these tree species.

**Histological study on barrier zone formation after wounding and inoculation with six wood decay fungi.**

Deflorio, G. (*Albert-Ludwigs-Universität Freiburg, Germany; Giuliana.Deflorio@fobot.uni-freiburg.de*), Schwarze, F.W.M.R. (*Albert-Ludwigs-Universität Freiburg, Germany, and Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), Switzerland; Francis.Schwarze@empa.ch*).

Trees possess both passive and active host response mechanisms against damage and infection by wound colonizing micro-organisms. Among the latter, barrier zone formation typically occurs when the cambium is injured. In an attempt to understand whether a range of wood decay fungi specifically trigger different host responses in relation to their inoculum potential, histological studies of the anatomy and extension of the barrier zone formation were performed. The sapwood of Douglas fir, beech, oak and sycamore trees growing in Mooswald (Freiburg i.Br., Germany) was artificially wounded and inoculated with four white-rotting (*G. resinaceum*, *G. adspersum*, *G. applanatum*, *T. versicolor*), one soft-rotting (*K. deusta*) and one brown-rotting (*F. pinicola*) fungi by placing wood inocula in drilled holes. Sixteen months after inoculation, a number of trees were felled and infected material was obtained from two individuals of each tree species. Barrier zone formation in the different hosts showed distinct anatomical and histochemical features between and within each tree species investigated. In controls and infected wounds of all tree species, the extent of barrier zone formation did not differ significantly. The results provide the basis for a better understanding of interactions at the host-fungus interface.

**Does inoculum potential affect disease severity in a range of tree species?** Deflorio, G. (*Albert-Ludwigs-Universität Freiburg, Germany; Giuliana.Deflorio@fobot.uni-freiburg.de*), Schwarze, F.W.M.R. (*Albert-Ludwigs-Universität Freiburg, Germany, and Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), Switzerland; Francis.Schwarze@empa.ch*).

In recent studies it has been postulated that brown-, white- and soft-rot fungi show a co-evolutionary adaptation to the host substrate which may also play a significant role during early stages of infection and colonization of trees. In an attempt to test this hypothesis Douglas fir, beech, oak and sycamore trees growing in Mooswald (Freiburg i.Br., Germany) were artificially wounded and inoculated with four white – (*G. resinaceum*, *G. adspersum*, *G. applanatum*, *T. versicolor*), one soft – (*K. deusta*) and one brown-rotting (*F. pinicola*) fungi. Two different wood inocula for each fungal species were placed in holes drilled in the sapwood. After 16 months the trees were felled and the severity of discoloration and decay was recorded. Results of the response variables for longitudinal decay extension and weight losses showed a significant interaction between the factors host and fungal species ( $P < 0,0001$ ). A significant effect of fungi ( $P < 0,0001$ ) was detected for the variable total phenols. Douglas fir was more susceptible to brown rot, whereas beech and sycamore wood were more susceptible to white rots. Oak was the most resistant tree species to decay. Results are discussed in regards to co-evolutionary adaptation of wood decay fungi and the anatomy and histochemistry of the tree species.

**Modelling the effect of *Fusarium circinatum* spore concentration, wound type and environment on disease development.** Hammerbacher, A., Coutinho, T.A., Wingfield, B.D., Wingfield, M.J. (*University of Pretoria, South Africa; almuth.hammerbacher@fabi.up.ac.za; teresa.coutinho@fabi.up.ac.za; brenda.wingfield@fabi.up.ac.za; Mike.Wingfield@fabi.up.ac.za*).

*Fusarium circinatum* is an economically important pathogen of pine seedlings and cuttings in South Africa. Yet, little research has been conducted on the epidemiology of the pathogen in this country. The aim of this study was to



consider the effects of wound type, spore concentration, environmental stress as well as a fungicide treatment on disease development and symptom expression. Results showed that the mean percentage disease caused by increasing spore concentrations can be described by the Michaelis–Menten function. The gradient of the function as well as the asymptotic maximum level of disease was dependant on the environment and physiological state of the host, as well as the wounding method. The highest rate at which spore concentration influenced disease incidence was observed in stressed seedlings. However, vigorously growing seedlings reached the same maximum disease incidence as stressed seedlings. Fungicide treatment did not influence the rate of disease incidence, but significantly lowered the asymptotic maximum level of disease incidence. Seedlings with stem wounds displayed the highest disease incidence, when compared to other wounding methods. These findings provide useful information that can be applied to reduce levels of *F. circinatum* in South African pine nurseries.

**Stress induced dieback of Austrian pine in Slovenia and a suggestion for a new category of tree diseases: Compound Disease.** Jurc, D. (*Slovenian Forestry Institute, Slovenia; dusan.jurc@gozdis.si*).

Severe dieback is occurring on more than 20,000 ha of plantations of Austrian pine (*Pinus nigra*) in Slovenia. The tree crowns on six research plots had an average of 17% dead branches (range: 6–34%). Fungal isolations were performed on 1575 pieces of dead bark (from 525 branches) and on 576 pieces of healthy bark (from 192 branches). 68 fungal taxa were isolated (35 determined to the species level) from dead branches, while 14 taxa were isolated (5 determined) from healthy branches. The fungus *Sphaeropsis sapinea* was the dominant cause of branch mortality, but the following fungi may also be involved in branch dieback: *Sydowia polyspora* (isolated as *Hormonema dematioides*), *Cenangium ferruginosum*, *Truncatella hartigii*, *Phomopsis occulta* and *Alternaria alternata*. Most of these fungi occur as endophytes in healthy bark. We hypothesize that in periods of strong drought facultative parasitic fungi may invade the weakened bark tissues of branches and cause their dieback. The disease is characterized by a variety of involved fungi and with common disease syndrome. For such diseases we propose the term compound disease of drought and heat on forests.

**Rhizoctonia fungi associated with diseased seeds of European beech (*Fagus sylvatica*) in forests of the Italian Alps.** La Porta, N. (*IASMA, Italy; nicola.laporta@iasma.it*), Hietala, A. (*Skogforsk, Norway; ari.hietala@skogforsk.no*).

Natural generation of European beech (*Fagus sylvatica* L.) has almost completely failed in worst cases due to animal and insect damage and fungal infection. Regarding pathogenic fungi, *Rhizoctonia solani* Kühn (teleomorph *Thanatephorus cucumeris* [Frank] Donk) has been indicated as the most important pathogen attacking nuts of European beech on forest floors in France and Germany. The disease is characterized by decay of cotyledons, resulting in failure to sprout or death after emergence. In previous studies, the pathogen has not been thoroughly described, and the aim of the present study was to further characterize the associated *Rhizoctonia*. Fungal isolations were made from un-germinated beech seeds from several natural forests of European beech located in the Italian Alps. Surprisingly, only bi-nucleate *Rhizoctonia* isolates were obtained. Sequence analysis of the ITS region of rDNA indicates that the isolates belong to the teleomorph genus *Ceratobasidium*. Based on anastomosis tests, these isolates were divided into several anastomosis groups, these including AG-I of genus *Ceratobasidium*. Pathogenicity tests will now be carried out to investigate the ecological role and mode of infection of these binucleate *Rhizoctonia* species.

**Studies on growth characteristics and optimum solid medium for *Antrodia cinnamomea* culture.** Lee, S.-H., Liao, Y.-K., Lee, M.-H. (*National Chiayi University, Chinese Taipei; yklliao@mail.ncyu.edu.tw*).

*Antrodia cinnamomea*, a folk medical fungus found only in Taiwan, has increasing become the focus of medical research. It is a brown rot fungi and usually parasites the decayed hollow trunk of *Cinnamomum kanehirae* Hay. In this study, optimum solid mycelial culture media for *Antrodia cinnamomea* were investigated by measuring colony radius and growth curves, and the characteristics of the mycelial growth were also observed. Red-brown colour on the mat's surface, yellow-brown colour on the reverse side and clamped generative hyphae were observed in the slowly grown mycelial colony of *A. cinnamomea*. This study found that MEA was a better solid culture medium than PDA, and that the growth rate, as measured by the radius of mycelial colony, is significantly affected by the agar concentration.

**Genetic and cultural characteristics of *Cenangium ferruginosum*, depending on three different host pine species in Korea.** Lee, S.K. (*Korea Forest Research Institute (KFRI), Republic of Korea; leesk77@foa.go.kr*), Lee, S.Y. (*Kangwon National University, Republic of Korea; sangyong@kangwon.ac.kr*), Kim, K.H. (*KFRI, Republic of Korea; Kyung624@foa.go.kr*), Jung, J.H. (*KNU, Republic of Korea; jhj6334@chol.com*).

Distinctive symptoms and seasonal variations in maturing fruiting bodies of *Cenangium ferruginosum* were investigated in South Korea for its host trees: the two-needled *Pinus thunbergii* (PT) and *P. densiflora* (PD) and the

five-needled *P. koraiensis* (PK). Fifteen isolates of *C. ferruginosum* from the three pine species were analyzed with Random Amplified Polymorphic DNAs (RAPD). We found there were no differences in the RAPD profiles among the isolates from the same host. Phylogenetic homology of isolates between PD and PT was 91%, but homology of isolates between PK and PD and PT was comparatively low at 22%. These genetic homologies among the isolates agreed well with the cultural characteristics based on woody extract media of host pine species. In conclusion, it is strongly suggested that taxonomic evaluation of *C. ferruginosum* species should be taken into consideration in deciding if this is a sole species causing die-back disease in pines.

#### ***Quambalaria pitereka* on spotted gum plantations in Queensland and northern New South Wales, Australia.**

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The establishment of a sustainable hardwood plantation industry in Subtropical regions of Australia will require effective pest and disease control strategies to be developed. Spotted gum (*Corymbia citriodora*) is a valuable commercial timber and suitable for a wide range of different soil types in large parts of Queensland and New South Wales. The main biological constraint to further expansion of spotted gum plantations is the disease *Ramularia* shoot blight caused by the fungus *Quambalaria pitereka*. *Ramularia* shoot blight, caused by the fungus *Quambalaria pitereka*, has been found in most spotted gum plantations in Queensland and northern New South Wales. *Q. pitereka* infection often results in the repeated destruction of the growing tips resulting in the formation of a bushier crown or death of the tree in severe cases. Spotted gum growth rates can also be negatively impacted upon. Any impact on the growth rates in the first 2 years after planting will impact negatively on the formation of the butt log, the most valuable part of the log. Forest health surveys indicate that disease incidence can reach 100% with an average of 25% of the trees showing moderate to severe infection levels at the time of inspection. Initial studies into the population of *Q. pitereka* have indicated variability at the morphological and genetic level. A degree of variation in virulence between isolates has also been shown.

#### **The phenology of *Caliciopsis arceuthobii*, an ascomycete pathogen of spring flowering dwarf mistletoes.**

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*Caliciopsis arceuthobii* (ex. *Wallrothiella arceuthobii*) is restricted to the spring flowering dwarf mistletoes, including *Arceuthobium americanum*. The pathogen infects the stigma of the female flower in the spring of the first year and colonizes the developing fruit, preventing the development of seed. Following fungal establishment, infected flowers are easily recognized by the black perithecia present on the infected flowers. In this experiment, 30 female *A. americanum* plants were examined yearly for four years to observe the spread of the fungus and to calculate the effect of fungal infection on dwarf mistletoe seed production. The hypothesis that infection by *C. arceuthobii* of some *A. americanum* flowers on a particular plant predisposed the following year's flowers on that plant to infection was tested with the Fisher exact test and it was found that *C. arceuthobii* infection did not differ significantly from random occurrence. At the study site, *C. arceuthobii* caused a reduction in seed production ranging from a low of 46% in one year to a high of 72% two years later. Natural incidence of *C. arceuthobii* can exert a significant degree of biological control that has a direct impact on spread and intensification of *A. americanum*.

**New canker gall of five-needle pines newly found in Japan.** Yamada, T., Takahashi, Y., Ikeda, H., Aoki, K., Suzuki, K. (University of Tokyo, Japan; yamari@uf.a.u-tokyo.ac.jp; y\_tahah@fr.a.u-tokyo.ac.jp; ikeda@uf.a.u-tokyo.ac.jp), Kanzaki, N. (Kyoto University, Japan; kanzaki@kais.kyoto-u.ac.jp).

New canker gall disease was found on five-needle pines in Japan. It causes gall and canker on stems and branches, death of twigs and seedlings. Thus, inhibition of natural regeneration of refugee species *Pinus parviflora* becomes a serious problem in Boso peninsula, central Japan. Indigenous species *Pinus parviflora*, *P. parviflora* var. *pentaphylla* and exotic *P. strobes* were found as hosts of the canker gall in eastern Japan. In addition, it has been recorded on indigenous species *P. parviflora*, exotic species *P. peuce*, *P. strobiformis*, *P. wallichiana* and an unknown *Pinus* spp. planted in arboretum of Kyoto University, but not found on *P. armandii* var. *amamiana*, *P. koraiensis* and *P. leiophylla*. Galls consisted of several layers of wound periderm, which was quite different from the structure of other gall tissues. Neither hypertrophy nor hyperplasia was not conspicuous in cortex / phloem, and was not observed in xylem. *P. parviflora* var. *pentaphylla* seedlings were inoculated with fungus and natural lesion from *P. parviflora*, and galls were reproduced. Conidia were produced and dispersed remarkably in May, then decreased. Conidia seemed to be dispersed with rainfall. First visible symptom, minute swellings, was observed on current shoots in autumn. The galls were gradually enlarged for years.

## **Sub-theme: Advancing The Role of Communication, Education and Capacity Building in the Future of Forestry**

### **Advancing the role of communication, education and capacity building in the future of forestry**

Organizer: John Innes *University of British Columbia, Canada; innes@interchg.ubc.ca*

#### **A new paradigm for a knowledge-based society: Testing our assumption and establishing new goals for performance in the knowledge sector.** Hollstedt, C. (*FORREX, Canada; chris.Hollstedt@forrex.org*).

The world economy is shifting from the industrial age to the information age. Some would argue the shift to a knowledge-based economy has already occurred. Have existing research institutions adjusted to this new economy? Sustainable development goals clearly stress the need for science and knowledge-based policy and actions. Success and failure to achieve these goals rests in the ability of client organizations and individuals to capitalize on their knowledge assets, taking advantage of what is known, and recruiting new knowledge and expertise where it is not known. Research and educational institutions, as developers and providers of science and knowledge to their client, must position themselves in this new economy by establishing knowledge generation and implementation performance goals and means to achieve these goals. This paper will explore and test our assumptions about our core business, our partners, clients and product line. Performance goals, and indicators of performance, will be suggested.

#### **Shaping the future: Forestry education and forestry.** Kanowski, P. (*Australian National University, Australia; peter.kanowski@anu.edu.au*).

From its formal beginnings in the late 18<sup>th</sup> century, tertiary forestry education has expanded progressively to be offered by some 350 institutions worldwide. Worldwide, economic and social changes have diminished the appeal to many young people of careers based in rural communities and primary industries. Concurrently, the demand from employers for professional foresters, and from students for forestry degrees, in the traditional mould has also progressively diminished in many countries. These changes challenge the viability of many forestry education institutions. At the same time, environmental, institutional and technological changes are creating new needs and opportunities for both forestry education and practice. Given the profound importance of forests, and of their conservation and sustainable management, to people, education about forests and forestry should be helping to shape the future of both. However, this outcome is far from assured in many cases. Both the reconceptualization of forestry education, and the reinvigoration of broadly-based partnerships to sustain it, seem necessary if forestry education is to play the role it should in shaping the future. While forestry education institutions are responding to these challenges, it seems likely that considerable further transformation remains necessary for many.

#### **The necessity to reorient forest education.** Paschalis-Jakubowicz, P. (*Warsaw Agricultural University, Poland; paschalis@delta.sggw.waw.pl*).

If we assume the necessity to understand forestry-related issues in a broad context, forest education must also encompass knowledge that pertains to the questions seemingly distant from forest issues. The issues include a) mechanisms operating in politics and finance at the national and international levels, and b) changes in people's preferences, legislation, methods of solving conflicts, etc. Neither forest education, nor forestry itself, has ever addressed broadly the issues of threats to forestry. These issues often are accompanied by intense manipulation of the public by various media. It means that in the course of educational processes, we must take into consideration those factors that can easily get out of our control and which may have an effect on the recipient that is contrary to that which was planned. The vision of the world, including forestry, becomes a view for spectators and this phenomenon leaves its stamp on contemporary culture. The paper identifies new educational issues regarding the threats and questions posed by our civilization, and urges society to utilize its accumulated knowledge to reorient forestry education.

#### **Forestry education in the Philippines and Latin America: Problems, challenges and strategic response.** Rebugio, L.L. (*University of the Philippines Los Baños, Philippines; lucreb@laguna.net*), Hoeflich, V.A. (*Embrapa Forest, Federal University of Paraná, Brazil; vitorah@hotmail.com*).

The environment of forestry education is dynamic. It is characterized by global, societal, structural, sectoral and technological changes, all of which have implications for forestry education, specifically, on the demand, type and capabilities of forestry professionals, fundamental philosophy of forestry education, capabilities of forestry faculty, and on forestry institutional re-engineering and change. To maintain its relevance and to ensure its sustainability forestry

education must adopt appropriate changes in response to the dynamic environment. This paper is an attempt to examine the various environmental changes and their implications to forestry education in the Philippines and Latin America. It will also discuss the current status and problems of forestry education in these two countries, brought about by a dynamic environment. Lastly it will explain the strategic responses adopted by the Philippines and Latin America to maintain the relevance, effectiveness and sustainability of their forestry education.

**Challenges facing forest educators: A student perspective.** Vuillermoz, M. (*International Forestry Students' Association e.V., France; Vuillermoz\_morgan@yahoo.fr*), Kostilainen, A. (*International Forestry Students' Association e.V., Finland; anniina.kostilainen@helsinki.fi*).

Higher forestry education has an important role to play in the future of world forestry. The future decision-makers, the students of today, will need to have adequate skills to be able to meet the future challenges. Without undermining the importance of traditional forestry-related subjects, forestry students recognize that forestry education should be better informed about the needs of the entire forest sector, instead of the narrow view presented by the current system. Besides the good knowledge base of basic forest sciences, broader skills in communication, language and technical knowledge should be required in all professions. If higher forestry education wants to meet its new challenges, it needs to be ready to accept deep transformation. The success of education comes also from the ability of the educators to transmit their knowledge further to the students. Forest researchers, who are mainly playing the role of educators, should be exposed to adequate teaching methodologies and universities should play a greater role in improving the image of foresters. Forestry students are willing to participate in the process of transforming forestry education to be more complete and attractive for new students, who will be responsible for the future of forestry.

## **Horizontal communication: Combining traditional expressions in communication strategies**

Organizer: Ajith Chandran, *New Delhi, India; ajithchandran@yahoo.com*

**Overview and potential for "People to People Education" in forestry.** Chandran, A. (*India; ajithchandran@yahoo.com*).

A collaborative agreement by the Forest Department and village communities to foster forest management, called Joint Forest Management (JFM), have been in vogue in India for some years now. The paper gives an overview of 'People to People Education' based on the experience of 'JFM Cell', a collaboration of Aga Khan Foundation and Gujarat Forest Department. It looks at the institutional mechanisms that allowed the flexibility and credibility for initiatives. The Cell, while enjoying the credibility due to its closeness with the Department, was also designed to have flexibility to experiment and initiate activities, unencumbered by Departmental restrictions. Once the initial mobilization and motivation was achieved, the Department stepped in for concrete actions with the community. The paper further looks at the need to effectively sustain initial motivation, and the need for continuous communication flow between communities and stakeholders using similar 'Horizontal Communication' methods. It explores new mediums, such as community radio, that are controlled by the community and reach a much larger audience. The paper looks at how institutional mechanisms, such as the JFM Cell, can develop the link between the Government, NGOs and funding agencies, to assist in the development of communication strategies in community forestry.

**Linking technology with indigenous communications: Emerging trends.** Gera, P. (*UNDP, India; prema.gera@undp.org*), Chandran, A. (*India; ajithchandran@yahoo.com*).

The paper provides a snapshot of emerging trends in the use of indigenous communication tools with modern technology in forestry and related development projects. For a long time, use of traditional artists and puppetry were among the most popular media used by grassroots organizations to convey messages and foster community-to-community interaction. In recent years, a powerful tool for communication, known as community radio, is being promoted as a means for communications. At present four community-radio programs for development have been sustained in India by NGOs. The paper will explore the potential of using community radio in forestry programs. Community radio is defined as radio that is owned by a community, airing programs designed and produced by it specifically for its own developmental needs. The paper will also briefly look at experiments with community videography, another technological innovation. Many stakeholders are involved in community forestry, ranging from forest-dependent communities, to forestry departments, NGOs and policy makers. Hence, sustained communication is vital for program effectiveness. With communication programs designed and produced by communities themselves, in their own idiom, community radio has the potential to foster forest management at the community level, while building solidarity.

**Public dialogue: bringing community perspectives into sustainable forest management.** Langer, E.R. (*Forest Research, New Zealand; lisa.langer@forestresearch.co.nz*), Goven, J. (*University of Canterbury, New Zealand; joanna.goven@canterbury.ac.nz*).

Policy makers throughout the world have begun to realize the desirability and necessity of public dialogue in science and technology. It is vital that forest managers adopt similar approaches to understand community perspectives and to ensure sustainable forest management. In recent years there has been a shift away from the 'deficit model', which assumed that, provided the public was 'educated' to understand the benefits, virtues and technologies behind science, they would accept them. The notion of 'consultation' was similarly rejected, as often consultation was viewed as an end in itself, practiced by one party on another, rather than achieving genuine deliberation and enriching policy formulation with broader perspectives. Demand has increased for genuine and meaningful consultation, which is more interactive and prospective than reactive. There are internationally tested dialogue methods that can support two-way and meaningful dialogue with the public, such as scenario workshops, consensus conferences and future panels. Involvement of the community where all parties contribute and share knowledge and perspectives in addressing areas of concern could provide a substantive contribution to long-term sustainable forest management.

### **Technology and tradition at the desktop: effective use of global forest information resources**

Organizers: Carol Green, *University of Washington, USA; ccgreen@u.washington.edu*, and Roger Mills, *University of Oxford, UK; roger.mills@ouls.ox.ac.uk*

**Delivering science information and technology through the Encyclopedia of Southern Fire Science and the Southern Fire Portal.** Fowler, C.T. (*University of Hawaii, USA; cynthiafowler@gmail.com*), Hubbard, W. (*Southern Regional Extension Forestry Office, USA*), Kennard, D., Rauscher, M. (*University of Hawaii, USA*), Jordin, B. (*Southern Regional Extension Forestry Office, USA*), Gaines, J. (*U.S. Geological Survey, USA*), Morgan, P., Gollberg, G. (*University of Idaho, USA*), Masters, R., Bruce, A. (*Tall Timbers Research Station, USA*), Hiers, K. (*The Nature Conservancy, USA*), Brownlie, D. (*U.S. Fish and Wildlife Service, USA*).

Landowners in all spheres are demanding that natural resource managers and scientists communicate more effectively and collaborate to solve critical issues. From all points in the forest management community, people are requesting syntheses of the vast scattered, difficult-to-locate information on fire science. This presentation will discuss how the Encyclopedia of Southern Fire Science (ESFS) and the Southern Fire Portal (SFP) address this problem by synthesizing the large body of fire science in the southern United States. ESFS is a compilation of original syntheses of a broad range of topics including: the human ecology of fire; fire behaviour; fire effects; ecology of fire-influenced communities; uses and types of prescribed fire; fire weather; smoke management; and wildfire occurrence, impacts and mitigation. SFP ties together multiple, related but independent applications. In a highly applied environment, the SFP contains fire-related metadata, data, modeling tools, literature syntheses, an index of fire publications and a fire thesaurus. SFP will be the gateway website for ongoing information and technology transfer between the fire management and research communities and their publics. The information in ESFS and SFP will be available in a fully-linked and searchable hypertext via the Internet, making access to this information universal, convenient and free.

**The International Directory of Forest Information Services, its use and value.** Green, C. (*University of Washington, USA; ccgreen@u.washington.edu*).

One of the important roles of librarians and information professionals is to provide access to information for their clients. Librarians often turn to colleagues and other institutions for help in finding the resources they need. In countries without established communication links, finding the location of resources can be problematic. In order to facilitate the formation of information networks, regional as well as international, IUFRO 6.03.00 developed the International Directory of Forest Information Services: Libraries, Documentation Centres and Subject Specialists. This online directory currently has nearly 140 registrants from over 30 countries. For this presentation, a survey will be conducted among the directory participants soliciting information about the use and value of this directory to its users. In addition to demographic information, issues such as value, relevance and needed improvements will be surveyed. The results of the survey will be presented in a short presentation or poster.

**Global Forest Decimal Classification update project.** Holder, B. (*Forintek Canada Corp., Canada; holder@van.forintek.ca*), Green, C.C. (*University of Washington, USA; ccgreen@u.washington.edu*).

'GFDC is a tool for organizing and retrieving electronic and paper forest and forestry related information resources'. Begun in 1903 and last updated in 1992, under IUFRO leadership, the classification system was in need of updating. To accomplish the update, under the IUFRO 6.03.00 umbrella, an international team of forestry information professionals used a web-based database. An editorial board then made final decisions. The project goal was to have paper copies of the new English edition of the classification available at the Brisbane IUFRO meeting. The poster will discuss the project progress to date and demonstrate uses of faceted hierarchical classifications in online information systems.

**Context links and forest-related coverage of information services.** Kempf, A. (*Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland; kempf@wsl.ch*).

The Web has become the favourite user interface for accessing and exchanging scientific information. Within this hypertext framework new applications were made possible, e.g. forward linking to aggregated information resources or cited reference searching. In parallel to the technical developments one can observe the convergence of primary and secondary literature services. More and more scholarly journals, university theses and research reports are available in full-text. However what the user can access in a specific situation will heavily depend on the subscriptions made by the institution the researcher is affiliated with. What service would fit best one's information need? Due to the multidisciplinary character of forest research there is no simple answer to this question. But looking at the coverage of databases and service packages of information providers helps the end-user to make a sound decision. This contribution presents the results of a comparison between CAB Abstracts, CrossRef, SCOPUS and ISI Web of Science that focussed on coverage of forest-related journals in particular.

**Accessing and sharing research information in the Asean region: Malaysia's perspective.** Lee, S.S., Mohd. Zaki, M.I. (*Forest Research Institute Malaysia (FRIM), Malaysia; leess@frim.gov.my*).

One of the fundamental requirements for conducting research is access to and sharing of information. Traditionally, books and journals were the main sources of reference materials but over the last decade, the internet and other sources of electronic information have played an increasingly important role, e.g. the recent advent of APAFRI's e-loan and GFIS-ASIA. Electronic access varies widely within the ASEAN region. Researchers in Singapore, Malaysia, Brunei and Thailand have excellent to reasonably good access, but many in the other ASEAN countries may not even have access to a computer. However, even with good electronic access, the availability of appropriate information can vary. For example, university libraries in Malaysia, with more generous budgets, generally have much wider access than small research institutions, such as FRIM. Similarly because of budget constraints and economies of scale, developing country research institutions find it difficult to subscribe to many international journals either in print or electronically. Close interaction and personal contact between researchers is one of the most important means of information access and exchange for researchers in developing countries and here senior researchers have the advantage over junior researchers who have yet to develop such extensive contacts.

**Preserving the past for the future: the importance of archival information in forestry.** Mills, R. (*University of Oxford, UK; roger.mills@ouls.ox.ac.uk*).

Trees include some of the longest-lived organisms on Earth and gathering comprehensive data about them may take decades or even centuries. The long-standing problems of identifying, preserving and making accessible printed or hand-written information which will be of use to future generations have now been joined by new challenges in the handling of electronic and multimedia sources, in often short-lived formats and in overwhelming volume. This paper reviews some of the initiatives at local, national and international level which are seeking to support sustainable forest management through sustainable management of information.

**100 years of forestry information from Oxford.** Mills, R. (*University of Oxford, UK; roger.mills@ouls.ox.ac.uk*).

Over the past century, the name of Oxford has become synonymous with forestry information throughout the world, and from its inception in 1905 the Oxford Forest Information Service has served the profession globally as well as locally. A responsive and demand-led facility developed in close co-operation with its users and with other information providers, OFIS has embraced the opportunities offered by new technologies as they develop, ensuring continuing and secure access to all its materials, and trained many generations of students in their use. This poster marks the centenary by highlighting past milestones and identifying future trends and opportunities within the global information village.

**Forestry research in the balance? Trends in the published literature 1939–2005.** Pasiecznik, N.M., Petrokofsky, G. (CAB International, UK; [g.petrokofsky@cabi.org](mailto:g.petrokofsky@cabi.org)).

Total world timber production has increased significantly over the past 65 years to meet increasing global demand, whereas research into timber production, as a percentage of total forestry research, has seen a steady decline over the same period. CAB International's Forest Science database is the largest repository of abstracted forestry knowledge in the world, with over 600,000 fully indexed and electronically searchable records collated since 1939. These were analysed for trends in research, indicated by the number of papers published per year, on a selection of pre-defined topics, both timber and non-timber, physical, social, economic and geographic. Results clearly show a decline in timber production research, with accompanying waves of interest in related topics, here termed 'fashion forestry'. Trends in research on aspects of silviculture, wood processing and utilisation and other core forestry subjects are also analysed and discussed. These findings may be alarming to those involved in traditional forestry activities and forestry research, as they indicate that research priorities appear to have shifted away from the pressing needs of producing wood and industrial cellulose for an ever-expanding population, towards peripheral aspects of forestry which may be best left to other disciplines.

**Enhancing access to forestry information in Africa to ensure sustainable forest management.** Sraku-Lartey, M. (Forestry Research Institute of Ghana, Ghana; [mrlartey@forig.org](mailto:mrlartey@forig.org)).

Access to and provision of high quality forest-related information is crucial to the sustainable management of the world forests resources as recognized by both the United Nations Conference on Environment and Development (UNCED) and the United Nations Forum on Forests (UNFF), as a priority for the implementation of Agenda 21 and the UNFF/IFF proposals for action. Addressing this priority need is, however, a great challenge for developing countries, especially in Africa, where significant investment in information and communication technologies and information management strategies is urgently needed. This paper discusses efforts and initiatives being made to improve access to forestry information in Africa; and further analyses the huge unexplored potential of using ICT's to manage forestry information on the African continent. The impact of these initiatives in meeting the needs of researchers and other forest stakeholders and on the quality of research in Africa in general and Ghana in particular is also discussed. Inadequacies and weaknesses in infrastructure, skills, linkages and finance are some of the challenges that need to be addressed in order to realize such potential. Achievements in creating partnerships on the African continent to improve skills and transfer knowledge on information management are described.

**Information resources for forest researchers and managers: strengths, weaknesses, threats and opportunities.**

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Pathways for disseminating information have been significantly strengthened in the last decade by development of electronic tools for the reproduction, storage, transmission and retrieval of information. Workers in developed countries have benefited where high-speed networks, funding and other institutional factors encourage use of these tools. In developing countries, impediments to use include erratic power supplies, limited line access, access fees and language barriers. Positive developments are the global access to catalogues of major libraries, free or inexpensive publishing on the web or CDs, powerful search engines and the practices of some publishers in making material available at little or no cost to users in developing countries. Effective abstracting services have a key role. Currently, abstracting emphasizes northern hemisphere literature, but is weak in coverage of developing country and regional information, and expensive to purchase. While cheaper international travel has made face-to-face workshops and conferences more accessible than in the past, information professionals can increase their value by seeing that proceedings are published and reviewed promptly, fully analyzed by abstracting services and collected by major libraries. Collation of research and operational experience, sometimes with a specific audience in mind, remains a key process for end users.

## **Added value of terminology work for forestry stakeholders**

Organizers: Michèle Kaennel Dobbertin WSL, Switzerland; [kaennel@wsl.ch](mailto:kaennel@wsl.ch), and Renate Prüller IUFRO, Austria; [prueller@iufro.org](mailto:prueller@iufro.org)

**Harmonizing terminology in an international project: Chestnut research as an exemplary case.** Giudici, F. (WSL, Switzerland; [fulvio.giudici@wsl.ch](mailto:fulvio.giudici@wsl.ch)), Zingg, A. (WSL, Switzerland; [andreas.zingg@wsl.ch](mailto:andreas.zingg@wsl.ch)), Kaennel Dobbertin, M. (WSL, Switzerland; [kaennel@wsl.ch](mailto:kaennel@wsl.ch)), Pividori, M. (Università di Padova, Italy; [mario.pividori@unipd.it](mailto:mario.pividori@unipd.it)), Amorini, E., Manetti, M.C. (Istituto Sperimentale per la Selvicoltura, Italy; [amorini@selvicoltura.org](mailto:amorini@selvicoltura.org); [manetti@selvicoltura.org](mailto:manetti@selvicoltura.org)), Martins, A., Loureiro, A. (UTAD, Portugal; [amartins@utad.pt](mailto:amartins@utad.pt)), do Loreto Monteiro, M. (Bragança Polytechnic

Institute, Portugal; sampat@ipb.pt), Chatziphilippidis, G. (Forest Research Institute, Greece; gregor@fri.gr), Gallardo-Lancho, J.F. (Consejo Superior de Investigaciones Científicas, Spain; jgallard@usal.es), Sevrin, E. (Centre régional de la propriété forestière, France; eric.sevrin@crpf.fr).

Management of European chestnut (*Castanea sativa* Mill.) crops has to take into account two different goals: timber production (in coppice or in high forests) and fruit production (orchards). To deal with the different aims it is necessary to be clear about: i) the production goal and ii) the management system. While timber production in high forests may be described and defined using traditionally- and internationally accepted silvicultural terminology and definitions, this is not the case for coppice forests and orchards. Chestnut is widespread on more than 2 million hectares and present in at least 25 European countries. To ensure an efficient exchange of scientific data and information and to promote the dissemination of research results to the end users it was necessary to harmonize the terminology and the measurement standards. Therefore a reference document was compiled by an international task force within the COST Action G4 – Multidisciplinary research on Chestnut. This process and the resulting document are presented in this poster.

**Definitions in Global Forest Resources Assessments: The trade-off between terminology accuracy and data precision.** Holmgren, P. (UN FAO, Italy; Peter.Holmgren@fao.org).

Global Forest Resources Assessments, led by FAO since 1947, include close collaboration with all countries and use of globally-agreed definitions. These reports are the most recognized overviews of global forest resources, their management and uses. They facilitate international negotiations and monitor forestry progress at the international level, which in turn stimulate political action at national levels. This paper examines difficulties in arriving at agreed global definitions, and the complexities of transforming national data into international reports. As global terminology must be accurate – i.e., understood in the same way by users with different backgrounds and purposes – lengthy deliberations sometimes result in compromises and detailed specifications. At the same time, global definitions must allow for a precise conversion of national data into the international context so that reports become comparable over time and resemble perceptions in national contexts and decision processes. It is suggested that global definitions may more efficiently serve their purpose if they are generically formulated, allowing more flexible transformations from national data, thereby ensuring consistency and relevance of international reports in the national context. Consequently, international reports would emphasize consistency over time rather than comparability between static country data.

**(Key)words in citations: Potential indicators of trends in forest research.** Kaennel Dobbertin, M. (WSL, Switzerland; kaennel@wsl.ch), Nobis, M. (WSL, Switzerland; nobis@wsl.ch), Prüller, R. (IUFRO-SilvaVoc, Austria; pruellerr@iufro.org), Haddon, B. (Natural Resources Canada, Canada; Bhaddon@NRCan.gc.ca), Kempf, A. (WSL, Switzerland; kempf@wsl.ch).

Words are units of thought and witnesses of their time. In particular, technical and scientific words (terms) appearing in bibliographic citations can be used as indicators of trends and shifts of priorities in a field of knowledge. We combine techniques of bibliometrics and terminology to investigate the spatial and temporal dynamics of words used in forest science and policy. We sampled terms used in titles and abstracts of all articles published 1980–2004 in 12 international, peer-reviewed forestry journals and in posters and presentations of the IUFRO World Congresses 1995, 2000 and 2005. We compared temporal trends in the occurrence and aggregations of terms. Finally, we focused on shifts in use of terms remarkable for their dynamics or their dominance. Our study will provide critical insights into issues such as the emergence and life cycle of new terms, the behaviour of established terms through time, especially in reaction to their younger competitors, and the dynamics of terms within specific disciplines. It will examine the potential for predicting the development of selected terms and their relevance for future research.

**Coming to terms with confusion of tongues: Forestry experts for consensus and diversity.** Kaennel Dobbertin, M. (WSL, Switzerland; kaennel@wsl.ch), Helms, J. (Society of American Foresters, USA; helms@nature.berkeley.edu), Haddon, B. (Natural Resources Canada, Canada; Bhaddon@NRCan.gc.ca), Prüller, R. (IUFRO-SilvaVoc, Austria; pruellerr@iufro.org).

Increases in international forestry activities over past decades have resulted in the use and distribution of a diverse array of technical terms that often describe the same concept. This is due to the independent development of terminology designed to meet local, regional, or national needs. When used internationally, these diverse terms result in confusion or imprecise communication that can result in the independent development of additional terms. While this process mostly affects definitions coined in English as the lingua franca of international communication, it also complicates communication nationally and regionally. To increase precision in the use of terms it would be desirable if potentially ambiguous terms were documented with respect to scope or limitations of use. With its four official languages and long-lasting commitment to terminology, IUFRO is currently addressing how best to reconcile consensus and diversity. In one approach, IUFRO is involved in harmonization processes with other international bodies, seeking common grounds for critical terms such as forest or deforestation. Additionally, with its 15,000 member scientists in over 100 countries, and activities in Working Party 6.03.02 and SilvaVoc, it is perhaps the best resource for addressing international multilingual forest terminology issues.



**The process of harmonizing forest-related definitions for use by various stakeholders.** Killmann, W. (FAO, Italy; [wulf.killmann@fao.org](mailto:wulf.killmann@fao.org)), Prüller, R. (IUFRO, Austria; [prueller@iufro.org](mailto:prueller@iufro.org)), Katsuhisa, H. (FAO, Italy; [Hikojiro.Katsuhisa@fao.org](mailto:Hikojiro.Katsuhisa@fao.org)).

International Conventions, Processes and bodies use definitions of forest and related terms for monitoring and reporting on forest status and trends, when assessing the effectiveness of forest related policies and providing a common basis for international forest dialogue. In order to foster common understanding of the definitions and the context in which they are developed, the Food and Agricultural Organization of the United Nations (FAO), in collaboration with the Intergovernmental Panel on Climate Change (IPCC), the Centre for International Forestry Research (CIFOR), the International Tropical Timber Organization (ITTO), the United Nations Environment Programme (UNEP) and the International Union of Forest Research Organizations (IUFRO) organized a series of three Expert Meetings on Harmonizing Forest-Related Definitions for Use by Various Stakeholders. In this process harmonization – unlike standardization – can include adjustments for improved compatibility and consistency, establishing common elements, linkages and relationships between terms, as well as documenting differences. The resulting comparative analytical framework for core forest-related terms can be used to effectively compare definitions, thereby improving communication. The first two meetings concentrated on harmonizing core forest-related definitions of forest, afforestation, reforestation and deforestation, whereas the third dealt with definitions related to the naturalness of forests, planted forests, trees outside forests and forest management.

**Urban forestry terminology in Europe and North America: Towards harmonization.** Konijnendijk, C.C. (*woodSCAPE consult*; [cecil@woodscape-consult.com](mailto:cecil@woodscape-consult.com)), Randrup, T.B. (*Danish Centre for Forest, Landscape and Planning, KVL, Denmark*; [tbr@kvl.dk](mailto:tbr@kvl.dk)), Kenney, A. (*University of Toronto, Canada*; [a.kenney@utoronto.ca](mailto:a.kenney@utoronto.ca)), Ricard, R. (*University of Connecticut, USA*).

Urban forestry is defined broadly as the art, science and technology of managing trees and forest resources in an urban community for the physiological, sociological, economic and aesthetic benefits trees provide. Based on experience obtained during more than a century of urban tree care, the concept was introduced in North America during the 1960s as a comprehensive and interdisciplinary approach to the specific challenges related to growing trees in urban environments. Later, urban forestry evoked the interest of scientists and practitioners in other parts of the world. However, harmonization of urban forestry terminology has been complicated by, for example, the involvement of different disciplines and translation difficulties. In many European languages, for example, the direct translation of ‘urban forestry’ relates more to forest ecosystems than to street and park trees. The presentation introduces ongoing efforts in Europe and North America to find common ground in defining urban forestry and related terms. A comparative analysis of the current status of urban forestry terminology in both parts of the world will be used to point out how further international harmonization may be achieved. This could result in a stronger international profile of urban forestry and a better basis for cross-boundary cooperation.

**Clarification of ‘biodiversity’ for coherent and effective uses of the term.** Mayer, P. (*Zurich, Switzerland*; [philippmayer@gmx.net](mailto:philippmayer@gmx.net)).

Biodiversity is a successful concept both in politics and science. However, its potential is weakened because different uses of the term resulted in ambiguities and misunderstanding. In this paper different understandings of biodiversity are described and a general concept is presented. Natural history approaches biodiversity with classification and description of nature. Natural science considers biodiversity as a measurable parameter relevant for ecosystem processes and functions. Social science considers biodiversity in the context of the effect of natural resources on human societies. And finally environmentalism is concerned about species extinctions, habitat destruction and pollution. In social science and environmentalism, biodiversity is used in a value-laden way which contrasts to approaches in natural science and natural history. The consequence of this diversity in usage is that it is most appropriate to consider biodiversity as a meta-concept. In this sense biodiversity is a non-measurable framework for the variety of life on earth. However, specific features of biodiversity are implementable and quantifiable. Features of biodiversity can be unambiguously defined with attributes (e.g. insects) and measures (e.g. species richness). An understanding of biodiversity in this sense contributes to coherent and effective uses of the term and supports the ongoing success of biodiversity.

**Terminology of forest management: A cooperation of experts to produce a multilingual series of parallel publications.** Nieuwenhuis, M. (*University of Dublin, Ireland*; [Maarten.Nieuwenhuis@ucd.ie](mailto:Maarten.Nieuwenhuis@ucd.ie)), Griess, O. (*Austria*), Schram, P. (*Luxemburg*; [schram@pt.lu](mailto:schram@pt.lu)), Pommerening, A. (*University of Bangor, UK*; [arne.pommerening@bangor.ac.uk](mailto:arne.pommerening@bangor.ac.uk)).

Forest management is a central concept and an important field of operations in forestry. English and Central European forestry traditions lead to different interpretation of the concept in several parts of the world. A few examples illustrate the confusion caused by technical terms which have no identical equivalent in other languages. In 1998 a group of forestry experts began to provide definitions for the terms related to forest management, inventory, planning and

control. In order to acknowledge the differences in the several languages, terms and definitions are compiled separately for each language then followed by establishment of linkages (i.e. similarities or differences) between them. The resulting multilingual terminology of forest management which presents the concepts and definitions in English as well as equivalent terms in eight languages, and its parallel publications in German, French, Spanish, Japanese and Chinese are available in the IUFRO World Series. The group is extending its work on other European languages such as Polish, Czech, Swedish and Finnish. Acknowledging the value of terminology collaboration of forestry experts with a terminologist and following the same concept-based approach, a parallel project on the terminology of forest management has been developed for minority languages like Welsh and possibly Irish.

**Back to the future: Using a modern thesaurus to bring to life bibliographic archives.** Petrokofsky, G. (*CAB International, UK; g.petrokofsky@cabi.org*).

The importance of using controlled vocabularies to describe information resources in Metadata schema is well understood. Bibliographic databases have for many decades used controlled vocabularies to organize their records into manageable portions of information. Forestry stakeholders use the same controlled vocabularies to retrieve specialized information from ever-expanding databases. Terminology varies greatly within any subject discipline and it changes over time and space. The use of controlled vocabularies and subject-specific thesauri to classify information helps to reduce the adverse effects of variance. Thesauri themselves change over time, too, in order to reflect changes in subject and changes in definitions and usage of terminology. Harmonizing the search interface in large archives dating back many years is a significant challenge for information managers. CAB International's Heritage project aims to provide seamless searching for 90 years of research by removing access barriers to older information which is still of relevance. The value added to old abstracts in the CAB Abstracts database, and particularly to the subset of forestry records, by assigning index terms using a combination of manual and automatic methods from the current Thesaurus is discussed.

## **Communicating forest science to the public: From theory to practice**

Organizer: Daniela (Krumland) Kleinschmit *University of Göttingen, Germany; dkrumla@gwdg.de*

**Forests, science and people: bringing them together through the media.** Hailu, M., Clough, G. (*Center for International Forestry Research, Indonesia; m.hailu@cgiar.org; g.clough@cgiar.org*).

Public interest and media attention about the world's rainforests were at saturation levels in the 1980s and 1990s, reaching a peak at the 1992 Rio Earth Summit. Subsequently, global concern and donor interest in forests and the people who depend on them has steadily decreased, largely due to the failure of efforts to curtail the destruction of tropical forests. The media spotlight has been taken by other issues—HIV/AIDS, hunger and the water crisis, not to mention the war on terrorism. Putting forests back on the international agenda requires a concerted communications effort by the environmental community, scientific groups and forestry organizations. Scientists and science communicators need to focus on shaping both public and political perceptions. To succeed, they need to make some significant changes in how they communicate in order to influence politicians, government agencies and donors. These include recognizing the importance of mass-media in informing decision makers, adjusting their attitudes towards the media, developing proper strategies, devoting resources and finding the right balance between advocacy and satisfying the competing needs of different stakeholders. If harnessed, the media can play a key role in creating the political will and policy changes necessary for the survival of tropical forests and the livelihoods of those who depend on them.

**Using a content management system to communicate science to the public.** Jordin, B. (*Southern Regional Extension Forestry, USA; bryan@sref.info*), Hubbard, B. (*Southern Regional Extension Forestry, USA; whubbard@uga.edu*), Rauscher, M. (*USDA Forest Service USA; mrauscher@fs.fed.us*), Fowler, C.T. (*University of Hawaii, USA; cynthiafowler@gmail.com*), Kennard, D. (*USDA Forest Service, USA; dkennard@fs.fed.us*).

A well developed Content Management Systems (CMS) can provide a mechanism for information producers to author and manage material for delivery to information consumers without having to be adept web developers. Combining creation, placement, review and management of content, a CMS can streamline the delivery of information to the specific audiences. The Forest Encyclopedia Network (<http://www.forestencyclopedia.net>) is one example of utilizing a CMS to deliver the latest scientific information in a collaborative process. Based on a hierarchical topic model, the Forest Encyclopedia Network allows scientists from multiple government agencies, universities and the private sector to author and manage scientific synthesis material that will become a part of collective body of knowledge to help land managers and the public meet their objectives. This paper describes the key components of a quality CMS and explores

important considerations for the development of an effective CMS to deliver forestry information in a timely manner.

**Forest science and global media discourses.** Kleinschmit, D., Park, M.S., Real, A. (*University of Göttingen, Germany; dkrumla@gwdg.de*).

Policy agenda setting is influenced by the media discourses. Therefore science, focusing on policy, has to take media into account. This paper explores the power of interpretation of science in a global media discourse. This approach links the 'deliberative model of public' with the theories of 'media input' and 'mediatization of science'. The empirical analysis deals with the global forest discourse. A qualitative-quantitative analysis of the International Herald Tribune and TIME magazine reconstructs the published picture of the forest situation. Results of this case study show the possibilities of scientists in publishing their statements, despite their low political status and minor resources for public relations.

**Facilitating constructive responses to policy challenges: Case studies on the role of forestry extension in a complex world.** Smith, G.K.M. (*Natural Resources Canada; gusmith@nrcan.gc.ca*), Reed, S. (*Oregon State University, USA; scott.reed@oregonstate.edu*), Norland, E.R. (*USDA Cooperative State Research, Education and Extension Service, USA; enorland@csrees.usda.gov*), Hollstedt, C. (*FORREX, Canada; chris.hollstedt@forrex.org*).

In Canada and the United States, more people and more diverse interests are influencing forest planning and decision-making. In part, this phenomenon is both a cause and an effect of complex policy environments that have evolved in the two countries. A result has been unprecedented needs for knowledge and information. Extension and knowledge transfer professionals occupy a front-line position between policy and practice, helping facilitate rapid learning and adoption of knowledge relevant to the needs of recipients. However, demand is overwhelming limited institutional capacity. Faced with shrinking budgets, extension programs are finding new ways of fulfilling their missions, drawing support from a range of sources. The paper presents case studies from the U.S. and Canada to show how extension and knowledge transfer function to effect constructive, practical solutions to policy challenges. The cases bring to the fore key factors essential to the integrity and longevity of forestry extension and knowledge transfer efforts, and address the need for demonstrating value and accountability.

### **Crossing borders: International perspectives on interdisciplinary research**

Organizer: Craig Nitschke *University of British Columbia, Canada; nitschke@interchange.ubc.ca*.  
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**Biodiversity conservation: Officials' illusions and discord with community forest management in Nepal.** Acharya, U., Petheram, R.J., Reid, R. (*University of Melbourne, Australia; u.acharya@pgrad.unimelb.edu.au; johneth@unimelb.edu.au; rfr@unimelb.edu.au*).

Two topics receiving much attention in design of forest policy and management in Nepal are conservation of biodiversity and participation of forest-local people. Government officials, forest users and development workers are all involved in shaping policy for the management of the forest for biodiversity and other values. It is therefore crucial to understand the different viewpoints about biodiversity among stakeholders. The results from a case study that focused on understanding the views of policy-level government officials in regards to biodiversity conservation are presented. Using a grounded theory approach, qualitative data were collected on two field visits in 2002–2003 to the study area. The results of interviews indicate a diverse set of perspectives in the interpretation of biodiversity conservation. These include illusions about the forest user's understanding of diversity, their dependence on the forest for their livelihood and their strong beliefs regarding the definition of biodiversity. Implications of the results include a need for a broader understanding of the different concepts and views held about biodiversity conservation by government staff and the other agencies involved in community forestry. A deeper knowledge of other views could help in the design and implementation of conservation policies and programs through community forest management.

**Using perceptual maps to communicate concepts of sustainable forest management: Collaborative research with the Office of the Wet'suwet'en First Nation in British Columbia.** Allen, S.D. (*University of British Columbia, Canada; sdallen\_77@chrysalisforestry.com*).

This article discusses collaborative research with the Office of the Wet'suwet'en First Nation on their traditional territories in northcentral British Columbia, Canada, a forest-dependent region where contemporary and traditional forest resources management regimes overlap. In-depth personal interviews with the hereditary chiefs and concept mapping were used to identify social-ecological linkages in Wet'suwet'en culture to inform the development of

culturally sensitive social criteria and indicators of sustainable forest management (SFM) in this region. The preliminary results demonstrate how the CatPac II software tool can be applied to identify key component concepts and linkages in local definitions of SFM, and translate large volumes of [oral] qualitative data into manageable information resources for forest managers and decision-makers.

**The importance of identifying common purpose in aboriginal community, forest industry and government negotiations.** Casimirri, G., Kant, S. (*University of Toronto, Canada; g.casimirri@utoronto.ca; shashi.kant@utoronto.ca*).

In the Northeast Boreal forest of Ontario, Aboriginal communities have been engaged, for almost a decade, in forestry-related conflicts and negotiations with the provincial government and the forest industry which hold the harvesting licenses. Little effort has been made to evaluate the outcomes of these negotiations or to examine their contributions to the development of collaborative forest management. A framework consisting of a collaborative process and structural prerequisites is used to evaluate the outcomes of the negotiation processes. This framework is used to examine the experiences of parties in an on-going forestry-related negotiation process and to evaluate the development of one key prerequisite – common purpose. The study identified that parties did not develop a common purpose or shared understanding of their problems. Forestry negotiations at the minimum must foster the development of a common purpose if they are to produce positive collaborative results.

**Multidisciplinarity, interdisciplinarity and training in forestry and forest research.** Innes, J.L. (*University of British Columbia, Canada; john.innes@ubc.ca*).

The nature of forestry is changing rapidly, with the social component becoming as or even more important than the traditional biophysical components. The role of participatory approaches to forestry has increased dramatically, and meeting of the needs of people is now seen as a primary function of forestry. Increasingly, those needs are being defined through bottom-up approaches, rather by governments or corporations. Foresters and forest scientists are poorly equipped to deal with this change, which is necessitating a much broader knowledge than has previously been required. At the undergraduate level, forestry programs are failing to teach the skills necessary for successful participation in this new form of forestry. At the graduate and post-graduate levels, young scientists are particularly disadvantaged, as the conservative nature of the academic system can actually work against attempts to be more interdisciplinary and more relevant. Scientists who are genuinely interdisciplinary may have difficulties finding employment, and current academic reward systems do not cope well with individual contributions to team efforts. The problem extends to the forestry profession, with many professional foresters being ill-equipped for their new roles, while at the same time they and/or their employers remain reluctant to enter into any form of re-training.

**Mapping, modelling and measurement: Assessing the impacts of regional of air pollution in Western Canada's Boreal Forest.** Krzyzanowski, J. (*University of British Columbia, Canada; judik@sprint.ca*).

Methodologies for assessing the ecological impacts of air pollutants from oil and gas activities in northeast British Columbia are presented in this paper. As the primary source of airborne contaminants in the ~360,000 km<sup>2</sup> study area, the oil and gas sector poses a real threat to ecosystem function due to emission toxicity and the rapidity of development. The sensitivity of an ecosystem to pollutants are being mapped as 'critical loads'; while an atmospheric transport model is being used to estimate pollutant deposition. Field measurements of the chemical criteria will be used to verify the results of the modelling. Indigenous knowledge is being applied to set environmental goals from which ecosystem health can be assessed, while policy recommendations are being developed from the emission reduction scenarios. The environmental goals and policy recommendations should help protect ecosystems from acidification caused by the expanding oil and gas sector in north-eastern British Columbia.

**Participatory requirements in forest management planning in Eastern Canada: A temporal and interprovincial perspective.** Lecomte, N. (*Université du Québec en Abitibi-Témiscamingue, Canada; nicolas.lecomte@uqat.ca*), Martineau-Delisle, C. (*Université Laval, Canada; catherine.martineau-delisle@soc.ulaval.ca*), Nadeau, S. (*Natural Resources Canada; sonadeau@NRCan.gc.ca*).

With the introduction of the concept of sustainable forest management, the practice of public participation has become omnipresent. This study focuses on provincial participatory requirements in forest management planning (FMP). A comparative framework composed of four participatory process attributes (power, moment of participation, learning/interaction and procedure) was used to obtain a temporal and interprovincial perspective of Quebec's new participatory process. Our results indicate that with respect to past processes, Quebec's current approach allows certain stakeholders but not the general public to have more access to FMP. Comparatively, Ontario and Newfoundland have implemented different, clearly stated, approaches

that involve the general public at numerous stages of FMP. Future research should concentrate on how these participatory requirements are implemented and on the public satisfaction with regard to this implementation.

**A method for estimating vulnerability of Douglas-fir growth to climate change in the Northwestern USA.** Littell, J.S. (*University of Washington, USA, and JISAO/CSES Climate Impacts Group, USA; jlittell@u.washington.edu*), Peterson, D.L. (*USDA Forest Service, USA; peterson@fs.fed.us*).

Borrowing from landscape ecology, atmospheric science and integrated assessment, we aim to understand the complex interactions that determine productivity in montane forests and utilize such relationships to forecast montane forest vulnerability under global climate change. Specifically, we identify relationships for precipitation and temperature that govern the spatiotemporal variability in Douglas-fir (*Pseudotsuga menziesii* (Mirb. Franco)) growth by seeking similarities in patterns of growth/climate models across a significant portion of the climatological range of the species. In the 21st century and beyond, sustainable forestry will depend on successful adaptation to the impacts of climate change and climate variability on forest structure and function. The combination of these foci will allow improved prediction of the fate of montane forests over a wide range of biogeoclimatic conditions in western North America and thus allow improved management strategies for adapting to climate change. We describe a multi-disciplinary strategy for analyzing growth variability as a function of climate over a broad range of local-to-regional influences and demonstrate the efficacy of this sampling method in defining regional gradients of growth-limiting factors.

**Challenges, achievements and impacts from interdisciplinary research and training: The Sustainable Forest Management Network.** Macnab, B. (*Sustainable Forest Management Network, Canada; bruce.macnab@ualberta.ca*).

One of the big challenges of research in support of sustainable forest management (SFM) is the need for increased collaboration of researchers from different academic disciplines. The Sustainable Forest Management (SFM) Network's approach to interdisciplinary research has evolved over the past ten years. One of the most significant changes has been a shift to larger and more integrated project teams. Increased integration in research in the SFM Network has resulted in benefits, particularly in relation to Canada's capacity to address SFM related research questions and management issues.

**Re-evaluating our approach to forest management planning: A complex journey.** Mathey, A.-H., Krcmar, E., Vertinsky, I. (*University of British Columbia, Canada; mathey@interchange.ubc.ca; ekrcmar@interchg.ubc.ca; ilan.vertinsky@commerce.ubc.ca*).

The evolution of forest values from timber supply to ecological and social values are leading to the redefinition of the Sustainable Forest Management (SFM) paradigm. In parallel, scientific knowledge is expanding and uncovering the interconnectedness of the various processes that support these values. We thus have many wishes and much knowledge but do we have the decision support tools that will pull them together to promote SFM? After a broad review of the evolution of decision support tools in forest management, this paper presents a case for more holistic numerical planning tools. To illustrate that such a tool can be designed, a simple decentralized approach is proposed. In this approach, a landscape management strategy evolves based on local-level decisions that integrate spatial, aspatial, multi-period and period-specific goals. Such tools could become a useful platform for sustainable forest management planning.

**The Amazon Initiative: A multidisciplinary, international consortium for prevention, mitigation and reduction of resource degradation.** Porro, R. (*Centro Internacional de Agricultura Tropical (CIAT) and World Agroforestry Centre (ICRAF), Brazil; Rporro@cgiar.org*), Serrão, A. (*EMBRAPA Amazônia Oriental, Brazil; aserrao@cpatu.embrapa.br*), Cornelius, J.P. (*World Agroforestry Centre (ICRAF), Peru; jcornelius@cgiar.org*).

An institutional consortium has been formed in the Amazon to implement collaborative programs to reverse resource degradation through sustainable land use systems. The Amazon Initiative (AI) Consortium for Conservation and Sustainable Use of Natural Resources was created in mid-2003 and formalized in 2004 by the National Agricultural Research Institutions of Brazil, Colombia, Peru, Ecuador, Venezuela and Peru, together with four centers of the Consultative Group on International Agricultural Research: CIAT, CIFOR, ICRAF and IPGRI. Associate institutions include regional research centers and universities. Consortium partners are creating an inter-institutional and inter-disciplinary team, which will function as a 'distributed network' of scientists, working at different sites in the Amazon. Under this assumption, the Amazon Initiative will create conditions for institutional articulation and strengthen analytical skills to identify priorities for research and development intervention. In addition, the AI will develop methodological tools and information communication mechanisms to enhance the role of local agents for the sustainable development of their regions. In doing so, the AI will contribute to enhancing living conditions of traditional populations and smallholders in the region, while effectively contributing to integrated natural resource management and conservation efforts in sites highly exposed to development pressures in six Amazonian countries.

**Model of open access forestry in a tropical climatic zone.** Sadykov, A. (*International Centre of Insect Physiology and Ecology, Nairobi, Kenya; leo@icipe.org*), Sadykova, D., Coe, R., Tomich, T. (*World Agroforestry Centre (ICRAF), Kenya; d.sadykova@cgiar.org; r.coe@cgiar.org; t.tomich@cgiar.org*), Nedorezov, L.V. (*International Centre of Insect Physiology and Ecology, Kenya; leo@icipe.org*).

A model for resource use in an open access forestry system is presented. The model takes into account the seasonal variation that typically limits access to forest resources during the rainy season. The modeling results show that various modes of forest use can exist, sustainable use and exploitation that inevitably leads to degradation. Also, the model is used to investigate the effect of constant charges or taxes on resource use and the conditions under which such a tax may lead to forest stands being conserved. The modeling results suggest that a policy option that permits temporary felling bans should be implemented and is required to convert forest stands from unproductive to productive states. Conversion of open access forests to productive states will allow for sustainable use and management of forest resources in these areas.

**Diet composition of bearded pig (*Sus barbatus*) in lowland dipterocarp forest of East Kalimantan, Indonesia.** Setyawati, T. (*University of Melbourne, Australia; tsetyawati@pgrad.unimelb.edu.au*), Read, S. (*Forestry Tasmania, Australia*), Coulson, G. (*University of Melbourne, Australia*), Sheil, D. (*Center for International Forestry Research (CIFOR), Indonesia*).

The diet composition of the bearded pig (*Sus barbatus*) in a lowland dipterocarp forest of East Kalimantan, Indonesia, was investigated. Stomach and faecal samples were collected from three pigs during the dry season of 2003. Microhistological techniques were applied to the diet fragments, with plant epidermal fragments being identified by comparison with reference slides. Plants and other potential food sources at the study site were also recorded. Plant parts comprised  $70 \pm 13\%$  (mean  $\pm$  SE) of stomach contents, and  $87 \pm 6\%$  of faecal pellet material, with animal, fungal and mineral components comprising the remainder. Leaves and tubers of herbaceous monocotyledons (*Amorphophallus* and *Curculigo*) were the most abundant plant components.

**Production constraints on cocoa agroforestry systems in West and Central Africa: The need for integrated pest management and multi-institutional approaches.** Sonwa, D.J., Weise, S., Ngobo, M. (*International Institute of Tropical Agriculture, Cameroon; dsonwa@cgiar.org; desonwa@yahoo.com*), Adesina, A.A. (*The Rockefeller Foundation, USA*), Nkongmeneck, A.B. (*University of Yaounde I, Cameroon*), Tchatat, M. (*Institut de recherche Agricole pour le Développement (IRAD), Cameroon*), Ndoye, O. (*Center for International Forestry Research (CIFOR), Cameroon*).

Cocoa producing countries of West and Central Africa experienced a serious economic crisis in the early 1980s when the cocoa sector was liberalized and the macroeconomic policies of the sector changed. These institutional changes created new difficulties and challenges for sustainable cocoa farming. Farmers in this region have recently turned to timber and non-timber production to offset the fluctuation of cocoa prices. In a survey of 300 cocoa farmers in the humid forest zone of Southern Cameroon, pest and disease outbreaks were identified as the major limiting factors to sustainable cocoa production. An analysis of pests and diseases affecting the cocoa plantations in the humid forest zone of West and Central Africa revealed strong links to the type of forest cover found on or near the cocoa plantation. An integrated approach to pest management is proposed along with a discussion on the current efforts being made to address the constraints posed by pests and diseases on sustainable cocoa farming in the four main cocoa producing countries of West and Central Africa.

**Forest conditions and management under rapid legislation change in Romania.** Strimbu, B.M., Hickey, G.M. (*University of British Columbia, Canada; strimbu@interchange.ubc.ca*), Strimbu, V.G. (*Ministry of Agriculture, Forests and Rural Development, Romania*).

This paper evaluates the effects of post-communist economic transition on forest resources in Romania. Using data from 1993 and 2003, our research describes a sample of forested landscape units based on seven environmental attributes. These attributes were then compared to four technical attributes associated with forest management planning. The comparative analysis revealed that many forest stand attributes were significantly affected between 1993 and 2003, potentially by the forest ownership change, while most of the forest management attributes were not. Our results suggest that a dramatic change in forestry legislation does not necessarily result in a dramatic change in the descriptive characteristics of forest resources in that jurisdiction but, rather, in the structure of the forest.

**Crafting interdisciplinarity in an M.Sc. programme in Management of Natural Resources and Sustainable Agriculture.** Vedeld, P., Krogh, E. (*University of Life Sciences, Norway; pal.vedeld@umb.no*).

This paper discusses the challenges of an educational program where interdisciplinarity is an important ambition. A theoretical perspective on interdisciplinarity must be more than adding insights from different disciplines. Surprisingly many actors still take it to be just this. Interdisciplinary candidates must learn about and develop skills in how to identify,

select, translate and integrate knowledge from different disciplines into coherent frameworks. From theories in interdisciplinarity, explicit theories for interdisciplinarity must be developed. A common and practical field focus can motivate integration and translation between disciplines. As an example, the multi-purpose re-orientation of natural resource management in modern forestry demonstrates the need for the development of a new management expertise. This must be related to both multi-purpose management and to social issues and interactions that occur between conflicting stakeholders. Within traditional forestry, interdisciplinary challenges have often met through tacit and experience-based 'common sense' knowledge. An explicit focus on the integration of and translation between disciplines as well as the development of experience-based skills is required to build good interdisciplinary expertise. This includes using practical field assignments and problem-based learning approaches to develop a candidate's ability to select, translate and integrate knowledge.

## **International networking in forest education**

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### **Curricular development in temperate and subtropical sustainable forest management and forest certification.**

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Sustainable forest management (SFM) and forest certification are salient cross-cutting themes in forestry throughout the world today. Every region and almost all countries in the world have developed international agreements and Criteria and Indicators for Sustainable Forest Management, and most have developed or considered means of forest certification. Forest certification and SFM are likely to guide forestry science, practice and education for the foreseeable future. Despite the prevalence of these paradigms, forestry education covering the subjects is sparse in most countries and programs. In response to this need, we developed an integrated, multi-lateral approach to developing forestry education in sustainable forest management and certification in selected countries with temperate and subtropical SFM and certification processes. The project developed communications among cooperators to develop SFM/forest certification courses or course components in at least one university in each country. University personnel served as the lead for curricular guidelines, and government, NGO and industry personnel provided expertise on content and implications of SFM and forest certification criteria and indicators. Our proposed course contents, readings and implementation plans are summarized, and the similarities and differences in approaches deemed necessary in different countries are discussed.

### **Cooperative development of university textbooks on the planning and implementation of diversified management of broadleaf tropical forests in tropical America.** Galloway, G. (*Tropical Agricultural Research and Higher Education Center – CATIE, Costa Rica*; [galloway@catie.ac.cr](mailto:galloway@catie.ac.cr)).

Over a five-year period, CATIE organized a series of six workshops as part of the following program involving forestry faculties and technical schools from five countries in Central America. One of the tangible results of this program has been the publication and distribution of four widely used, didactic texts for university courses: '*Silviculture of Humid, Tropical Forests with an Emphasis on Central America*'; '*Diversified, Forest Inventories of Broadleaf, Humid Tropical Forests with an Emphasis on Central America*'; '*Reduced Impact Harvesting of Broadleaf Tropical Forests*' and '*Planning for the Diversified Management of Humid, Tropical Forests with an Emphasis on Central America*'. The publication of this latter text received support from the International Partnership for Forestry Education (IFPE). These texts, and others planned for the future, provide up-to-date information for the sustained management of tropical forests, incorporating information from promising initiatives underway throughout the neotropics.

### **Challenges and strategies of forest research and education for the 21st century: A Brazilian perspective.** Hoeflich, V.A. (*Embrapa Forest, and Federal University of Paraná, Brazil*; [hoeflich@cnpf.embrapa.br](mailto:hoeflich@cnpf.embrapa.br); [hoeflich@ufpr.br](mailto:hoeflich@ufpr.br)).

The paper points out a great deal of problems that are facing professional forestry education in Brazil. Also, it describes how some of the fundamental changes in the Brazilian society, in the economy and in the development of the

forest sector may affect forestry education. Additionally, some discussions are presented on issues related to the following: 1) the status of the Brazilian forest research and education system, 2) the challenges/issues of forest education and research in Brazil, 3) the status and perspectives for the forestry profession and employment in Brazil, 4) strategies to improve forest education and an agenda of forest research for the future.

**Approaches and methods for curriculum development at the School of International Tropical Forestry, Kota Kinabalu, Malaysia.** Kammesheidt, L., Mohamed, A. (*University Malaysia Sabah, Malaysia; gtzlk@ums.edu.my; aminmohd@ums.edu.my*).

The School of International Tropical Forestry was founded in 1996 and became one of 10 Schools at University Malaysia Sabah. The first student intake was in 1997. Currently, the School offers four programs of specialization within a three-year BSc course, i.e. 'International Tropical Forestry', 'Forest Plantations and Agroforestry', 'Parks and Recreation' and 'Wood Fibre and Technology'. The Malaysian-German Forestry Education Project aims at adjusting the current BSc curriculum to better integrate sustainable forest management issues and to raise the professional career prospects of future graduates. The paper reports on the approaches and methods applied to curriculum development, i.e. (1) workshops with teaching staff, (2) tracer study, (3) employers' demand studies, (4) practical training concept, and (5) formation of partnerships with other universities in the region and overseas. The review is put into the context of national resource and environmental policies, recent developments in the forest, environmental and higher education sector in Malaysia, and national and international curriculum standards. Achievements and future challenges are outlined.

**An International Partnership for Forestry Education.** Kanowski, P. (*Australian National University, Australia; peter.kanowski@anu.edu.au*).

The concept of a new International Partnership for Forestry Education (IPFE), to support institutions and networks committed to education about forests and forestry, has emerged since 2001. This embryonic partnership includes existing forestry education networks, universities; multilateral organizations such as FAO, IUFRO, IFSA and the World Bank, and research institutions. IPFE objectives and proposed activities are to: 1. enhance education of students about forests and forestry locally, regionally and internationally. Its purpose is to help understand issues, trends and needs relevant to education about forests and forestry, and how curricula and approaches to learning should be adapted to reflect these. It enhances the capability and skills of teaching staff and their institutions to facilitate active, effective learning, in a variety of modes, and it enhances the status of forestry education worldwide. IPFE received Development Phase Funding from PROFOR and used most of this to support a diverse suite of pilot projects which tested the proposed activities. IPFE is now consolidating its plans on the basis of the experience of these projects, and building the foundations for its next phase.

**Worldwide survey of forestry education.** Lewark, S. (*University of Freiburg, Germany; Siegfried.Lewark@jobawi.uni-freiburg.de*).

Concern about declining numbers of applicants, students and graduates in a number of forestry education institutions led to a survey on numbers of forestry students on different levels. This survey is undertaken by the IUFRO Education Group 6.15.00, following earlier surveys by ANAFE and FAO. The purpose is to develop a good understanding of issues that impact on quality, volume and relevance of forestry education worldwide, so stakeholders can be sensitized appropriately. The enquiry was sent out to IUFRO officers in August 2003. In this first attempt there were 30 responses (25 for Master's, 22 for PhD, 18 for BSc. curricula) worldwide, whereof nearly half came from European forestry education institutions. First results have been presented at the meeting of the IUFRO policy committee during the World Forestry Congress. A strong trend of declining numbers of graduates was documented for some forestry education institutions; thus there was no general worldwide trend in decline. As the data basis is still rather small the enquiry sheet will be sent out again in 2004 in order to broaden the base of information.

**Networks for integrating European higher forestry education.** Pelkonen, P. (*University of Joensuu, Finland; paavo.pelkonen@joensuu.fi*), Tahvanainen, L. (*University of Joensuu, Finland; liisa.tahvanainen@joensuu.fi*).

Partnership through networking is a new programmatic and pragmatic concept of federalism. The core issue is the strong commitment of partners. European integration is based on networks, especially in the field of higher education. The European university landscape is characterized by a high degree of heterogeneity which is reflected in all operations. The competence of the European Union does not allow direct measures to influence on the national educational targets and policies. The lack of competence has been replaced by a cooperative initiative, the Bologna process. Most countries have committed themselves to attain the Bologna objectives within a few years. The universities in almost every country in Europe will introduce a new two-cycle-degree-program. The uniform credit



system and full recognition of courses and degrees is the most important precondition for new graduates who really benefit from Europeanization. The forestry education has been in the first wave of development through efficient Europe-wide networking. The SILVA Network, academic network for forest sciences, founded in 1989, has currently 44 member institutions in 27 European countries. The network gives emphasis to joint curriculum and degree programs, distance education and the needs and requirements for forestry education in the future.

**Opening of the Faculty of Forestry and Environment Prague: A study in internationalization.** Podrazsky, V., Viewegh, J., Pech, P. (*Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz; viewegh@fle.czu.cz; pech@fle.czu.cz*).

The Faculty of Forestry and Environment, Czech University of Agriculture in Prague, was established 1919; it was closed for political reasons in 1964, and re-opened in 1990. Most of the activities were re-established and there has been considerable development, especially in the last two years. The staff now consists of 77 persons, including 17 professors, 15 associated professors and 45 assistants. There are 15 study programs, including forestry, wood processing, landscaping and ecology. A new English study program, open to all students including the foreign ones, was accredited in 2004. Doctoral study programs (PhD. degree) represent an integral part of the scientific activities and professional education. Six study programs, encompassing 11 specializations, have a total registry of 134 students. The study is strictly split into B.Sc., M.Sc. and Ph.D. stages. The rate of research, as well as the receipt of international grants, is increasing. The Grant Agency of the Faculty of Forestry and Environment (GAFLE) was established in 2001 to help young workers to initiate their independent research and scientific activities. Despite its initial state, our Faculty is becoming recognized on the international scene.

**Development and delivery of a Social Forestry course in the Asia-Pacific region.** Race, D. (*Australian National University, Australia; Digby.Race@anu.edu.au*), Vanclay, J. (*Southern Cross University, Australia; jvanclay@scu.edu.au*), Sands, R. (*University of Canterbury, New Zealand; roger.sands@canterbury.ac.nz*), O'Brien, N. (*Regional Community Forestry Training Centre, Thailand; obrien@ku.ac.th*).

Social forestry, the relationship between communities and forestry, remains a critical socio-economic and political issue in most countries throughout the world. Indeed, forestry requires proponents to have a sound understanding of its complex human dimensions, including how government agencies, companies and forest-dependent communities can sustainably harvest benefits without compromising others sought by the wider society. There are numerous examples of inappropriate forestry that has provided only a narrow range of short-term benefits and failed to make a positive contribution to the livelihoods of local communities. An increasing number of people involved in forestry at the local, national and international levels, have expressed a desire to undertake university-level training to better understand the complex social issues of forestry, and to design pathways to maximize the opportunities for communities through forestry. Notwithstanding the growing international interest in Social Forestry, it is often at risk because of financial cutbacks, and the challenges facing IPFE in forestry education are particularly acute for Social Forestry. However, Social Forestry includes many topics with much to gain from co-learning and sharing of experiences between countries. This paper will report on the experiences and lessons of a new partnership between several forestry education institutions in the Asia-Pacific region.

**Using integrated model of marketing planning in developing international M.Sc. program in forestry.** Rekola, M. (*University of Helsinki, Finland; mika.rekola@helsinki.fi*).

The study focuses on describing the curricula development process in forestry education at the university level. There has been a rapidly growing interest within universities to launch English-Language-Taught Degree Program (ELTDP) in forestry. For example, there are more than 700 ELTDPs in Europe. Most of them are from the fields of engineering and business. However, some forestry-related programs exist. The general principles of ELTDPs are discussed. The emphasis is on strategic planning in ELTDP curricula development. In particular, it describes the use of a scientific integrated model for marketing planning in curricula development. Earlier, the model was successfully applied in numerous studies regarding forest products marketing. The case study here comes from the Finnish-Russian Cross-Border University (CBU) planning process in order to set up a joint M.Sc. degree program in Forestry.

**Changing forestry education through networking: Experiences of the Southeast Asian Network for Agroforestry Education (SEANAFAE).** Rudebjer, P.G. (*World Agroforestry Centre, ICRAF-Thailand; p.rudebjer@cgiar.org*), Jamroenprucksas, M. (*Kasetsart University, Thailand; fformtj@ku.ac.th*), Villancio, V. (*University of the Philippines Los Baños, Philippines; iaf@laguna.net*), Pipatwattanukul, D. (*Kasetsart University, Thailand; ffordap@ku.ac.th*).

Forestry education must adapt to rapidly changing biophysical and socioeconomic settings. Forestry sector boundaries blur as societies' demand for environmental services and secure livelihoods increase. Accordingly, employment patterns shift in the once government-dominated forest sector. Landscapes can no longer be divided in 'forests' and

'agriculture'; they evolve towards multifunctional agroforestry landscape mosaics. The introduction of agroforestry courses illustrates this adjustment of forestry education. The Southeast Asian Network for Agroforestry Education (SEANAFE) was established in 1999 to raise the quality of, and access to, agroforestry education. Seventy-six universities and colleges from five national networks comprise the regional network. SEANAFE is hosted by the World Agroforestry Centre, enhancing access to research outputs and other resources. Networking among disciplines and institutions has proved successful in developing tools and methods which enhance agroforestry learning. Such tools include curriculum guides, developed in a participatory mode and jointly-produced teaching materials that match the new curricula. These products are being translated to national languages. Teachers' training follows a 'trickle-down' pattern, with regional courses followed by national ones. Joint research, policy advocacy and information sharing are other features of SEANAFE, as it continues to address the need for changing forestry education.

**Russian higher education in the global education area.** Sanaev, V.G. (*Moscow State Forest University, Russian Federation; rector@mgul.ac.ru*).

In Russia, education of forest specialists with academic and vocational university degrees has a long history. Thus, in 1803, the decree of Emperor Alexander I marked the foundation of Saint-Petersburg Forest Engineering Academy. At present, 49 state educational institutions and their affiliated institutes educate students in forest specialties. The total number of forestry students is about 30,000, including 2,000 from CIS and other countries. Currently, Russian forest universities have more than 300 professors, Doctors of Sciences and over 1,500 docents, Candidates of Sciences, lecturing in forest-related subjects. Russian forest universities implement active foreign and internal educational policies. The leading institutions have cooperation agreements with institutions in Finland, USA, Iran, Great Britain, China, Austria, German, Sweden, Netherlands, Poland, Bulgaria, Slovakia etc., and successfully operate within the global areas of education and research.

### **Effective teaching with technology in higher forestry education: Foundations for success**

Organizers: Sandra Schinnerl *University of British Columbia, Canada; schinnerl@interchg.ubc.ca*, and Siegfried Lewark *University of Freiburg, Germany; Siegfried.Lewark@fobawi.uni-freiburg.de*

**Teaching technology and individual feedback in forestry education.** Brack, C.L. (*Australian National University, Australia; Cris.Brack@anu.edu.au*).

Teaching and learning technology has greatly expanded the amount of information that can be provided to students as well as increasing the number of options for the presentation or interaction with this material. Formal and informal student evaluation of teaching and learning in a number of courses at the Australian National University agree that the level of satisfaction with this material and its presentation is high, but that an ongoing problem area is timely and personal feedback to assist student learning. This presentation examines development of 'personalized' feedback to assist student learning in several forestry courses. The feedback is largely generated from patterns observed over a series of quizzes and short answer assignments (delivered and marked over web-based technology), which is then e-mailed to the students. Undergraduate classes have rated the feedback provided by this system as very good or better (5.6 on a scale of 0–7), which is at least one class higher than the mean ranking in the formal university teaching evaluation system.

**Using Personal Digital Assistants and Global Positioning Systems as a forest education and ecotourism support system in tropical forests.** Gandaseca, S. (*Universiti Putra Malaysia, Malaysia; seca@btu.upm.edu.my*), Yoshimura, T. (*Kyoto University, Japan; yoshimu@bre.soc.i.kyoto-u.ac.jp*), Abe, M. (*Kyoto University, Japan; abe@bre.soc.i.kyoto-u.ac.jp*), Sakai, T. (*Kyoto University, Japan; sakai@i.kyoto-u.ac.jp*).

The objective of this study was to establish a forest education system and to evaluate the ecotourism support system using Personal Digital Assistant (PDA) and Global Positioning System (GPS) through field tests in Indonesian tropical forests. Field test participants answered questions regarding interest, enjoyment, design, operation, GPS accuracy, navigation and mobility. More than 80% evaluated the system as excellent or good in terms of interest, enjoyment and operation. However, only 40% answered that field sites were at the indicated points—due to poor GPS reception as a result of random disturbances such as multipath and temporal signal blocking by the forest canopy. GPS receivers with higher performance should be introduced. It is known that real-time differential GPS is effective to improve GPS accuracy, and it could be realized by introducing wireless LAN to the forest. Questionnaire results were positive regarding education efficacy in the provision of information and knowledge. Furthermore, by using the system, ecotourists would have a lower environmental impact because they would stay on a predetermined route. To implement

this system, appropriate education and training of local people should be provided because nature interpretation and environmental education require professional knowledge and communication techniques.

**Research-based teaching: linking the GIS Graduate School and the Department of Forest Resource Management at the University of Helsinki.** Holopainen, M., Laasasenaho, J., Tokola, T., Nieminen, J., Mäkinen, A., Hujala, T. (*University of Helsinki, Finland; markus.holopainen@helsinki.fi; jouko.laasasenaho@helsinki.fi; timo.tokola@helsinki.fi; juhana.nieminen@helsinki.fi; antti.makinen@helsinki.fi; teppo.hujala@helsinki.fi*).

Research-based teaching has an important role in the Department of Forest Resource Management, University of Helsinki. The GIS graduate school program, established in 1998, and the introduction of new educational technology and innovative teaching methods have further enhanced the close ties between research and teaching. The aim of using a research-based teaching approach is to create a more realistic learning experience. The GIS courses strive to produce student awareness of complex issues by using concrete day-to-day research problems. The courses also require a higher level of student interactivity than in the past, leading to more flexible problem solving skills. Some GIS courses have a unique approach in using research datasets and forestry functions in teaching applications of software and basic analysis methods. Large datasets are used to demonstrate how research questions are solved using GIS. Students have an opportunity to mimic real GIS analysts when performing their analysis. The exercises use both basic principles of forestry and GIS, combining them in a problem solving environment. When given a task, the student must successfully use the common formulas and analysis techniques to derive an answer and visualize the results cartographically. The student's work is then evaluated using an instant feedback system.

**JTragic: A trainer for stand thinning.** Knauft, F.-J., Hauhs, M. (*University of Bayreuth, Germany; knauft@bitoek.uni-bayreuth.de*).

In central Europe, stand rotations usually extend over more than 100 years and silvicultural treatment of mixed stands include regular thinning operations. Every 10–20 years the competition among trees is visually assessed by locally experienced foresters. Today, this task is often delegated to the harvester operator. The difficulty of documenting this 'art-of-thinning' leads directly to problems of training novices. The time scales of the actually thinning operation and that of the subsequent growth responses in the stand, however, can easily be separated in an interactive forest growth simulator. Stand growth phases that do not require human intervention can, even in an individual-tree-based simulator, be shrunk to few seconds to minutes. The thinning intervention, however, can be carried out interactively and is supported by a realistic 3-d interface displaying a virtual stand. We introduce the web-based thinning simulator 'JTragic' with its virtual stands of mixed Norway spruce and European beech. Base-line scenarios for well-documented stands, interactively approved by experienced foresters, are kept in the background. They serve as control when forestry students interactively test their own thinning strategies and observe the growth reaction to their interventions.

**"Brewing the perfect Blend" for higher forestry education in Southern Africa.** Laengin, D.W. (*Stellenbosch University, South Africa; dwl@sun.ac.za*).

With the changing role of forestry worldwide, globalization and forestry policy shifts, especially in African countries, educational institutions have to improve course quality and equip their graduates with a variety of non-traditional skills. Blended or Hybrid Learning, offering a flexible combination of traditional face-to-face education with the advantages of online learning, is a promising and relatively new approach. Introducing computer-supported learning should never be technology driven, but should influence a rethinking process at the faculty level. It should initiate innovative education programs towards more self-directed learning. A joint research and development project between the University of Freiburg, Germany, and Stellenbosch University, South Africa, questioned how Blended Learning can be used to effectively improve higher forestry education within the specific regional situation in Southern Africa, bearing in mind that Africa still has insufficient and often unreliable internet infrastructure. The paper will discuss students' feedback on several blended learning courses presented since 2001 at the university and technikon levels, focusing on students' motivation and satisfaction, taking into consideration the different social backgrounds of students. In particular it will report on historically disadvantaged students' experiences. The paper will conclude with a perfect 'blend' for specific learning situations, offering best practice suggestions, which will add value to traditional face-to-face education.

**A new e-Learning course on gender and forestry started.** Lewark, S. (*University of Freiburg, Germany; Siegfried.Lewark.@fobawi.uni-freiburg.de*).

A new e-Learning course on gender and forestry is under preparation, to be started in September 2004 as a blended course at the Hedmark University College, Norway, and at the University of Freiburg, Germany, open for students from other institutions of higher education. The course is based on courses held at the University of Freiburg since 1999

with somewhat different focuses. It had been organized as a one week block, which according to the curriculum regulations in Freiburg meant 20 contact hours and 20 hours of self study. Two ECTS-credits are given upon successful participation. Female experts, mainly from forestry, shared their professional experience with the male and female forestry students. In a 'workshop' format, knowledge was collected on the statistics concerning women in forestry, published experiences, women's self understanding in their roles as well as on organizations of women in forestry in Germany and other countries. This course is being developed into an e-Learning course now, with face-to-face phases at the beginning and at the end, and internet based learning and teaching in between (a so-called blended course). The concept of this new course will be presented, combined with an online-demonstration.

**Video-teleconferencing as a tool for effective and economical continuing forestry education.** Moore, S.E., Bardon, R.E. (North Carolina State University, USA; [susan\\_moore@ncsu.edu](mailto:susan_moore@ncsu.edu); [robert\\_bardon@ncsu.edu](mailto:robert_bardon@ncsu.edu)).

The North Carolina State University Department of Forestry Extension and Outreach Programs developed and implemented Forestry Issues, a conference series delivered statewide via multi-point video teleconferencing. The program was developed to facilitate the continuing education needs of natural resource professionals while meeting the administrative demands and legislative edicts for cost containment and cost accountability that challenge the traditional means of engagement facilitated by extension. Each year, the series offers six to ten topics ranging from technical and policy aspects of forestry to traditional forest management issues and practices. This statewide program targets both private and public sector natural resource professionals. We have found the Forestry Issues teleconference series to be a cost effective means of providing highly relevant continuing education to this audience. The ability of participants to save money on the cost of attending conferences and to meet work schedule responsibilities have been keys to the success of the program. Four years of evaluation data are available which are analyzed to determine participants' time and cost savings, level of satisfaction, increase in knowledge and applicability to their professional forestry work. Program delivery, attendance and evaluation data will be discussed, along with implications for future continuing education programming.

**Interactive graduate student learning: A case study of a videoconference research seminar between the University of British Columbia and the University of Toronto, Canada.** Schinnerl, S. (University of British Columbia, Canada; [sandra.schinnerl@ubc.ca](mailto:sandra.schinnerl@ubc.ca)).

As a pilot project between the University of British Columbia and the University of Toronto, an interactive research seminar was launched for graduate students using videoconferencing. Faculty from both universities are involved in presentations and discussion giving students the opportunity to experience a combination of videoconference and face-to face delivery methods while having the opportunity to engage in discussion through videoconferencing technology with other graduate students. Feedback has been collected from each of the institution's participants, and students indicate ways in which interactivity can be enhanced through an iterative approach to incorporating learning technologies within the classroom.

**Virtual exams for better learning results and for students' and teachers' convenience in Namibia and in Finland.** Tahvanainen, L., Matengu, K. (University of Joensuu, Finland; [liisa.tahvanainen@joensuu.fi](mailto:liisa.tahvanainen@joensuu.fi); [kenneth.matengu@joensuu.fi](mailto:kenneth.matengu@joensuu.fi)), Otaala, B. (University of Namibia, Namibia; [botaala@unam.na](mailto:botaala@unam.na)), Tahvanainen, T. (Finnish Forest Research Institute, Finland; [timo.tahvanainen@metla.fi](mailto:timo.tahvanainen@metla.fi)), Pelkonen, P. (University of Joensuu, Finland; [paavo.pelkonen@joensuu.fi](mailto:paavo.pelkonen@joensuu.fi)).

Web-based learning environments and distance learning offer challenging opportunities for taking advantage of ICT. Universities are trying to reach a target number of graduated students and to fight against delayed studies, prolonged graduating times and non-adequate resources for teaching. Developing efficient, and at the same time user friendly, services and learning procedures such as virtual exams and automated tests, are providing an excellent competitive advantage. The effectiveness of assessment for students and teachers can be improved by using an online web-based assessment technique. Flexibility of timing means that students can take their tests anytime, while the automation of assessment marking, easily readable, and usually better outlined answers than earlier, means reduced workload, independence of location, and extra convenience for teachers. The virtual exam—the Exam Aquarium—was developed in Finland and tested at the University of Joensuu. The University of Namibia started to pilot the virtual exam in 2004 for better learning results and intensified use of learning resources. This presentation provides an overview of the Exam Aquarium, its use in teaching applications, acceptability and usefulness in two culturally different countries—Finland and Namibia.

**European Masters in Forestry: A joint master course through the SILVA Network.** Tahvanainen, L., Pelkonen, P. (University of Joensuu, Finland; [liisa.tahvanainen@joensuu.fi](mailto:liisa.tahvanainen@joensuu.fi); [paavo.pelkonen@joensuu.fi](mailto:paavo.pelkonen@joensuu.fi)).

Due to the limited policy opportunities, partnership and cooperation in higher education is of utmost importance for the future of the forest sector in the European Union. The Master's in European Forestry programme is a response by the

SILVA Network to the increasing number of issues in forest and nature management that are formulated, implemented and co-ordinated at levels above the classical nation-states, providing new challenges and demands at the European and global level. The MSc EF is an attempt to look at the broader picture; it responds to the needs of companies and organizations that require graduates with an international forestry background. The cognitive-constructivist type of learning environment is used to produce learning outcomes fostering the prerequisites of the new type of professional expertise that is now required. Providing a broader and more relevant European dimension to postgraduate education includes more international and intercultural experiences for the students as well as improved cooperation and exchange in teaching and learning skills/tools. The problem-oriented course and applied period are providing students with a realistic understanding of their job options. The new ERASMUS-Mundus programme of EU has opened an excellent funding mechanism for the students and experts from countries outside the Union to participate European study programmes.

### **Expanding the knowledge base by improving non-timber forest products (NTFP) educational opportunities**

Organizer: A.L. (Tom) Hammett *Virginia Tech., USA; himal@vt.edu*

**Documentation of ethnobotanical practices of indigenous people relative to the different forest types in the Cordillera, Philippines.** Andrada, M.G., Maddumba, H.A., Salvatera, M.E. (*Department of Environment and Natural Resources – Cordillera Administrative Region, Philippines; erds-car@mozcom.com*).

The study was conducted from 2000–2002 to document the ethnobotanical practices of the people in three forest types of the Cordillera, Philippines. Three ethnic groups in different forest types served as respondents/study sites: ‘Kalanguyas’ of the mossy forest of Benguet, Applai-Kankanaey tribe of Sagada (representing the pine forest of Mt. Province) and the Aggay tribes of San Isidro, Luna, Apayao (representing the dipterocarp forest). Focused group discussion, key informant interviews, observation and participants interviews were used in data gathering. Results showed that the indigenous peoples recognize the role and value of forests and plants in their survival and existence. Forests are sources of food, medicine and raw materials for house construction, furniture, handicraft and utensils. They also value the plants used during the ritual activities like ‘canao,’ and ‘padet’ or ‘pamanpanyang.’ However, in some of the study sites, it was observed that there was an erosion/degradation of cultures, and their dependency on forest resources were affected by introduction of modern technologies, economic status, accessibility of resources and diversity of plant resources. These ethnic groups have their own customary laws and practices in sustaining their forest resources. These customary laws and practices can be applied or integrated in the biodiversity conservation and management effort or programs of the government.

**The potential of wild edible fungi as NTFP in Scottish forests.** de Roman, M., Woodward, S. (*University of Aberdeen, Scotland; m.de.roman@abdn.ac.uk; s.woodward@abdn.ac.uk*), Boa, E. (*CABI Bioscience, UK; e.boa@cabi.org*).

At least 1154 species of wild fungi are used around the world due to their gastronomical value and/or their medicinal properties. The most significant species in terms of trade worldwide are the black truffle (*Tuber melanosporum*), which is exported from France, Italy and Spain, the matsutake (*Tricholoma matsutake*), sent to Japan from the USA, Canada and Mexico, and ceps (*Boletus* spp.), which are especially appreciated in Italy and occur in a wide range of latitudes. In order to meet the increasing demand for wild edible fungi (WEF) worldwide, there is a need to consider different countries as sources of WEF, for which local communities with little tradition in collecting WEF need to acquire specialized knowledge to become successfully involved in this flourishing trade. To achieve this aim, we are estimating the productivity of edible fungi, particularly those in the *Boletus* and *Cantharellus* groups, in Scottish forests and relating their occurrence and abundance to key environmental factors. These data will enable us to address the potential of Scottish forests as a WEF source using verifiable data, and of Scotland as a country that could play an important role in the global WEF market.

**Why domestication of medicinal and food plants? A case study from Mt. Moroto Forest Reserve, Uganda.**

Kalwany Nanyunja, R. (*Makerere University, Uganda; rhobink@yahoo.com*).

The overall aim of this study was to design a participatory biodiversity monitoring and evaluation framework for Moroto, Napak and Sango Bay Forest Reserves in Uganda. This paper focuses on the biodiversity of medicinal and food plants in Moroto Forest Reserve in the Karamoja region of northeastern Uganda. The objectives reported here are: to identify indicator species, establish their abundances, trends and uses. Participatory rural appraisal methods were used to identify and collect information on trends of medicinal and food plants from 1950 to 2001. The respondents were elders, middle aged and the young—gazetted individuals inside the reserve. In Karamoja, elders are respected for their wisdom and, in this study, they specifically provided vital historical information. Data entry and analysis were done in Microsoft Excel, by

descriptive analysis with graphical illustrations. The study found both medicinal and food plants have been significantly decreasing, due to over harvesting. Medicinal plants are very important for treatment of most diseases, while the food plants contribute a significant role in food security. With the increasing population in the forest reserve, there is a need for domestication before the plants become extinct, and to conserve biodiversity within the Moroto Forest Reserve.

**An analysis of profit margins of participants in a supply chain for non-timber forest products: from collectors in Nepal to wholesaler in India.** Maraseni, T.N., Cockfield, G., Apan, A. (*University of Southern Queensland, Australia; w0007649@mail.connect.usq.edu.au*).

Sustainable management of non-timber forest products (NTFPs) and the alleviation of NTFPs-based poverty are difficult unless collectors get an equitable share of profit margins (PM). This research paper compares the PM of collectors, village traders, Nepali wholesalers and Indian traders for two highly traded NTFPs of Nepal—asparagus and lichen. Then, it analyses the causes of inequitable PM and recommends means of increasing equity within the supply chain. Research shows that the PM of asparagus collectors was satisfactory, but due to the high transaction costs of illegal exports, PM of lichen collectors was very low. Night NTFP collectors had higher PM in comparison to day collectors, and numbers of the former were increasing annually. In four different trading chains analyzed, Nepali wholesalers and Indian traders captured most of the PM. The difference in production costs of collectors does not affect the PM of other stakeholders in the supply-chain. It is hypothesized that the inequity is exacerbated by a low level of understanding of marketing among collectors, which is supported by the low value of weighted average index (0.46) on a five point (Likert) scale analysis. It is argued that the PM of collectors could be increased by providing secured property rights, training, technical support, market and price information and other forms of institutional support.

**International education for foresters in non-timber forest products: Pilot project for internet-based learning.** Mitchell, D. (*Royal Roads University, Canada; Darcy.Mitchell@royalroads.ca*), Hammett, A.L. (*Virginia Tech, USA; himal@vt.edu*), Brigham, T. (*Royal Roads University, Canada; tbrigham@islandnet.com*).

Non-timber forest products (NTFPs) are emerging as a key forest value and an important focus of forest use and research. However, relative to other forest resources, little is known concerning the ecological and socio-economic implications of NTFPs. Forestry curricula worldwide largely neglect the management and development of these valuable forest resources. This project, funded by the International Partnership for Forestry Education and IDRC, is led by Royal Roads University's Centre for Non-Timber Resources and the College of Natural Resources, Virginia Tech in collaboration with an international steering committee from India, Nepal, Russia, the United States, Canada and Germany. A working group of the International Forestry Students Association (IFSA) has conducted a needs assessment for NTFP curriculum among IFSA members and forestry faculty throughout the world, and has found strong interest among forestry students in NTFP content and in opportunities for on-line learning. The current project builds a pilot course to be delivered on-line to forestry students on the Indian sub-continent in order to test content and delivery methods. The course is structured as a series of modules in order to facilitate creation of additional courses suitable for other regions.

## **From needs to solutions: A dialogue on core business and institutional models for effective development, marketing and implementation of science**

Organizer: Christine Hollstedt *FORREX, Canada; Chris.Hollstedt@forrex.org*, and David DeYoe *Canada*

**From broken promises to community parades: Lessons learned in a multi-agency exploration of community trust.** Davenport, M.A. (*Southern Illinois University, USA; mdaven@siu.edu*), Anderson, D.H., Leahy, J.E. (*University of Minnesota, USA; dha@umn.edu; leah0024@umn.edu*), Jakes, P.J. (*USDA Forest Service, USA; pjakes@fs.fed.us*).

Communities neighboring federally protected natural areas regularly weigh the costs and benefits of the administering agency's programs and policies. While most agencies integrate public opinion into decision making, and some encourage active collaboration, recent efforts to standardize and formalize public involvement have left many local communities feeling marginalized, spurring acrimony and opposition. A significant body of research has examined barriers to effective participation as well as strategies for relationship building in planning processes—many of which point to trust as a key factor. Trust is especially tenuous in local communities. This presentation explores trust along two fundamental components of agency-community associations: 1) the relationship or process-oriented component, and 2) the transaction or outcome-oriented component. A series of interpretive case studies were conducted at seven US federally protected natural areas and their surrounding communities. Through in-depth interviewing and focus groups with community residents and agency personnel, a conceptual model of trust was developed. Each case study

provided a unique context and detail to the issue of trust, yet several overarching themes emerged across cases. For example, an agency's capacity to follow through with decisions was significant in several communities. The studies offer several guidelines for building trust in local communities.

**Advancing the role of communications, education and capacity building in the future of forestry: Communities of practice and community-based learning.** Hollstedt, C. (*FORREX, Canada; chris.Hollstedt@forrex.org*).

The evolution from tree and stand level prescriptions over a rotation to estate and watershed level plans over many generations requires individuals and teams to understand and apply scientific, indigenous and experiential knowledge to solve complex issues. The solution must achieve the business and landscape objectives and stand up to public scrutiny, while being both practical and cost effective. Communication, education and capacity building at a community level are critical to reaching forestry solutions. Once a discipline of professional foresters, forestry is now a community of practice represented by forestry professionals. This community includes, but is not limited to, forester, engineers, biologist, ecologists, indigenous knowledge keepers, hydrologists, geologist and geomorphologists as well as economists and social scientists. Forestry professionals must be able to practically apply knowledge acquired through institutional training and education, as well as knowledge and skills acquired through practice and experience. They must be able to reach out to the knowledge sector when faced with unknowns. The knowledge sector must be able to respond as a community of practice to the demands for new science and continuous community-based learning. This paper will investigate the role of the knowledge sector in contributing to communicating science, continuous learning and capacity building in forestry professionals as well as forest-based communities.

**Evaluating best practices in forestry extension.** Johnson, J.E. (*Virginia Polytechnic Institute and State University, USA; jej@vt.edu*), Creighton, J.H. (*University of Arkansas, USA; Creighton@uamont.edu*), Norland, E.R. (*USDA Cooperative State Research, Education, and Extension Service, USA; enorland@csrees.usda.gov*).

Our changing world and the explosion of new research-based knowledge has resulted in an even more urgent need for effective knowledge transfer strategies. This trend is especially true in the fields of agriculture and forestry. The traditional way in which new research knowledge is promoted and adopted is through some form of extension endeavor. Many effective extension models are in place around the world, some within traditional governmental agencies, some in the private sector, and others functioning through non-governmental organizations. The subject of successful strategies, or 'best practices' in forestry extension, was the theme of an international conference held in Troutdale, Oregon USA in 2003. At this conference, 35 papers were presented related to this theme, representing 11 countries from around the world. We have analyzed the content of these papers and extracted a collection of 'best practices' that seem to be common at least regionally or on a continental scale. This paper will present these practices, with pertinent examples of their successful application, and a discussion of their applicable geographic scale.

**Establishing and improving links between research, education and practice.** Podrazsky, V., Viewegh, J., Pech, P., Neuhoferova, P., Karas, J. (*Czech University of Agriculture Prague, Czech Republic; podrazsky@fle.czu.cz; viewegh@fle.czu.cz; pech@fle.czu.cz; karas@fle.czu.cz; p.neuhofer@fle.czu.cz*).

Education, research, extension and practical training are among the key activities of all universities. Their proportion is a thing of great discussion amongst academic staff—dividing university bodies into research and teaching universities is a fashionable topic today. This poster documents the development of main activity fields at the Faculty of Forestry and Environment of the Czech University of Agriculture in Prague, Czech Republic. Further problems are connected with the character of particular study and activity programs: primarily scientific, primarily technical and primarily practical. To join together scientific points of view from traditional forestry, wood processing, environmental and economical disciplines within the 'engineering' approach and practical solutions is not an easy target. The first aspect is appreciated by the 'evaluation' and 'accreditation' spheres, dominated by natural scientists, the second one by the academic staff (generally originating from technical universities) and the last one by the 'consumer' (enterprises, forest owners and state administration). Problems of the applied study programs need more discussion and consideration in the future.

**The Swedish forestry education program from a gender perspective.** Staal Wästerlund, D., Wibom, M. (*Swedish University of Agricultural Sciences (SLU), Sweden; dianne.wasterlund@ssko.slu.se; marianne.wibom@adm.slu.se*).

Gender studies in forestry have shown that forestry as a professional career is still coded as masculine. The students in the MSc forestry education program in Sweden are predominately male. The average share of female students over the last five years has been 25%. A participatory study among students is being made to determine which subjects/issues/teaching methods are gender-biased in the education program and to determine how these aspects affect the students in their choice of specialization within the education program. Studies on educational settings in other male dominated education programs,

such as science and technology, documented different ways in which males uphold their dominant position in the classroom. The female forestry students experienced that it was important to observe a certain dress code to avoid comments from their male colleagues. They also acknowledged the occurrence of gender-bias in the contacts with teachers. Education programs also affect the students' identity or self-perception which may influence their focus of study. A difference was found in choice of specialization between female and male students. The distribution between study directions biology-soil science and forest management-economy-technology is for female students 35 and 65%, respectively, and for the male students 14 and 86%, respectively. Further investigations are being made to find the underlying reasons for these differences.

## **Capacity building as an objective of international development projects: Case studies from ACIAR's Asia-Pacific forestry program**

Organizer: Russell Haines *Australian Centre for International Agricultural Research (ACIAR), Australia; haines@aciarc.gov.au*

### **The Australian Centre for International Agricultural Research (ACIAR): Role of the Forestry Program in capacity building in the Asia-Pacific region.** Haines, R., Fryer, J. (*ACIAR, Australia; haines@aciarc.gov.au*).

ACIAR is an Australian Government statutory authority within the portfolio of Foreign Affairs and Trade. It contributes to Aid Program objectives of advancing Australia's national interest through poverty reduction and sustainable rural development in partner countries. The Forestry Program contributes to poverty alleviation and natural resource conservation and rehabilitation through scientific support for the establishment, management and sustainable utilization of forests, providing optimum social, economic and environmental benefits to partner countries and Australia. Building relevant capacity in partner countries is an important objective of the Program. The Program currently has active projects in Papua New Guinea, the Pacific, Indonesia, Laos, Vietnam, China and South Africa. These projects cover a broad range of species and products, and address issues that include species selection and domestication, silviculture, forest policy and management, forest protection, processing of a variety of traditional and non-traditional products and environmental values and impacts. Capacity building is a major objective of all forestry projects. ACIAR's multi-dimensional approach to capacity building includes collaborative identification of priorities and project objectives, joint planning and management of projects, formal scientific training programs (e.g. workshops and courses) and facilitation of improved access to information.

### **Development of forest health surveillance systems for South Pacific countries and Australia.** Lal, S. (*Ministry of Fisheries and Forests, Fiji; sanjana@forestryresearch.gov.fj; inoke@forestryresearch.gov.fj*).

This ACIAR-funded project has made important contributions to capacity building in the Pacific region to undertake systematized forest health surveillance for early detection of pest and disease problems. It has heightened awareness of forest health and forestry quarantine issues in the region where, until now, the primary focus has been on pests and diseases of agriculture and horticulture. Through a series of workshops and field visits, training has been provided to forestry personnel in Fiji, Vanuatu, Samoa and Tonga on surveillance methodologies, recognition of symptoms of tree disorder and specimen collection and identification. Structured surveys have been carried out in forest plantations and around ports in these countries to determine the priority pest issues that need to be addressed. Small forest health units have been established in each country with facilities for specimen rearing and storage, and a mechanism for data sharing established. Independently, local personnel in each country now conduct their own forest health surveys according to schedules set out in their Country Plan, and have organized training sessions for forestry staff in the regions and for community groups. As a result of this project stronger linkages have been created between agriculture, quarantine and forestry organizations in these countries.

### **Capacity building elements of ACIAR funded projects at Papua New Guinea Forest Research Institute, PNG.** Sam, N. (*Papua New Guinea Forest Research Institute, Papua New Guinea; nsam@fri.pngfa.gov.pg*).

The Papua New Guinea Forest Research Institute's (PNGFRI) association with ACIAR commenced in 1992. Over 12 years, the Institute has directly collaborated on 5 projects, provided input to 3 projects and received 5 fellowships. Of the five research projects, the capacity building components of 4 of them have been an integral part of project activities. Their primary objectives have been to build capacity within PNGFRI in order to undertake effectively the respective project activities. The trend has been one of increasing emphasis on human resource capacity building. The two current projects, Species Domestication (FST/1998/115) and Forest Planning (FST/1998/118) clearly demonstrate this emphasis as is highlighted in this presentation. Both of these projects, and especially the Species Domestication project, have provided much project-specific training and have extended the scope of the capacity building components beyond the boundaries of the project. The Institute



has also been the recipient of 4 John Allwright Fellowships and 1 John Dillon Fellowship. This presentation provides some highlights of the capacity building components of the projects and the impacts of this ACIAR investment.

**Capacity building in an ACIAR-funded collaborative project on improving and maintaining productivity of eucalypt plantations in India and Australia.** Sankaran, K.V., Chacko, K.C., Pandalai, R.C. (*Kerala Forest Research Institute, India; sankaran@kfri.org*), Grove, T.S., Mendham, D.S., O'Connell, A.M. (*CSIRO Forestry and Forest Products, Australia*).

The objective of this ACIAR project, implemented in 1997, was to improve productivity of eucalypt plantations in India and Australia through evaluation of options for inter-rotation site management. In Kerala, India, a set of comprehensive experiments was established at four locations in 1998 to quantify effects on tree growth of harvest residue treatments, weed control, nutrient application and legume undercropping. The experiments include the two major plantation species, *Eucalyptus tereticornis* (Et) and *E. grandis* (Eg). At age 5 years, the largest responses in tree growth in the experimental plantations were due to N and P fertilizer application and to complete weed control. Increases in volume growth ranged up to 85 m<sup>3</sup>/ha (273% increase) in Et and up to 90 m<sup>3</sup>/ha (71% increase) in Eg. A positive tree growth response to legume undercrops at one of the Et sites was evident at 5 yrs. Overall, the study demonstrated that large increases in eucalypt productivity in India can be gained at many sites through use of good quality genetic material, timely weeding and judicious application of fertilizers. The project enhanced capacity of KFRI staff through training in project planning, implementation and methodologies for measurements and preparation of scientific papers.

**Capacity building through international development projects: A case study on the Research Institute of Tropical Forestry from ACIAR's Forest Program.** Xu, D. (*Chinese Academy of Forestry, P.R. China; gzfsrd@pub.guangzhou.gd.cn*).

The ACIAR forestry project FST 97/77 'Eucalypts and groundwater: managing plantations to avoid resource depletion and environmental detriment in China and Australia' had been carried out by Australian research institutions, Research Institute of Tropical Forestry, Chinese Academy of Forestry and other Chinese research institutions from 1998 to 2003. One of important objectives of the ACIAR project was to transfer knowledge and research skills to their collaborative partners and help their collaborative institutions to build up their research capacity. During the research period of the project, 3 young scientists in our institute and 3 young scientists from Chinese collaborative research institutions were trained in Australia in tree water use measurement, plantation productivity modeling, plantation management and forest hydrology. All of the 3 young scientists who were trained in Australia were promoted in our institute after their training, one as chief research scientist, one as research scientist and one as assistant research scientist. They have taken a very important role in our institute's study on ecological impact of tree plantations and sustainable plantation management. Two postgraduates and two young scientists were trained in China during the project. Over 30 scientists and forest managers have been trained by project workshops in China.

## Interactions between science and practice

Organizer: John L. Innes *University of British Columbia, Canada; john.innes@ubc.ca*

**Visual preference research: Linking science to practice in meeting sustainable forestry objectives.** Bradley, G. (*University of Washington, USA; gbradley@u.washington.edu*).

Visual impacts related to timber harvest practices are important to consider when developing timber harvest plans or undertaking ecosystem management operations. Determining visual preferences for alternative timber harvest practices is one means of identifying the visual effects of harvest patterns. Ongoing work at Capitol State Forest, near Olympia, Washington, USA has identified visual preferences for six alternative harvest patterns by various interest groups—foresters, recreationists, environmentalists, educators and the public. Groups tend to share a common preference for patterns showing minimal disturbance, but are significantly different as the intensity of harvest practices increase. Foresters were the only group to show higher preferences for intensive forest management practices. Tree retention, harvest size, green-up and residual material are contributing factors related to preference ratings. In addition to modifying harvest practices in visually sensitive areas, information intervention is thought to be another way of addressing concerns regarding the visual impacts. The assumption is, if information is provided indicating the rationale for, or benefits of various harvest practices, people may be more understanding, and subsequently more accepting of intensive harvest practices. Preliminary findings from the Capitol Forest Study suggest that information does influence people's perceptions of timber harvest practices, however, the influence of information tends to decline as the intensity of practices increase.

**Regional partnership for connecting science and policy.** Furuberg, A.M., Larsmon, M. (*Hedmark University College, Norway; merete.furuberg@hedmark-f.kommune.no*).

Is the best connection between science and policy to establish partnership between the different actors? This poster discusses different types of partnerships: the perfect partnership, the visionary partnership, partnership like a list of projects, and partnership built on rites. Further it presents results from the forestry sector, science, and policy making, that are connected through partnerships. One example is regional partnership for forestry and equality. The county council of Hedmark in Norway discussed the strategic plan for forests and wood, and approved the following: 'the county council supports the establishment of a broad partnership to ensure that the work towards equality of the sexes in the area of forestry receives increased focus.' The partnership includes many different institutions and organizations. Exact and concrete goals were established. The main tools to reach the goals are the interaction between research, social science, policy making and action plans. The activities are followed by evaluations, which will be presented in the poster.

**Triad zoning and management on a dynamic landscape: conserving biodiversity and timber supply through holistic analysis and risk spreading.** Nitschke, C.R. (*University of British Columbia, Canada; nitschke@interchange.ubc.ca*).

Under the premise of conducting sustainable forest management (SFM), some organizations and governments have adopted forest zoning as a guiding tool for sustaining environmental, economic and social values. There are many zoning schemes but, regardless of the scheme, the same difficult questions exist—where to spatially allocate zones and how to manage within these zones? These questions become more difficult to answer when decision makers consider zoning through a framework congruent with strategic SFM planning. The objectives and long time periods associated with strategic SFM planning assure that decisions made today need to consider the dynamic nature of landscapes. Allocation decisions need to consider the influence of climate change and natural disturbance on forest management if biodiversity and timber supply are to be conserved. Triad zoning and associated management may offer forest managers with the ability to conserve both biodiversity and timber supply over the temporal scale required for SFM. The key to successful allocation is through the use of a holistic, meta-modeling analysis that examines the potential behaviour of biodiversity and timber supply under possible forest futures. A 145,000 ha landscape near Kelowna, British Columbia, Canada is used as a case study for developing a Triad allocation and management scheme that conserves both biodiversity and timber supply over a time frame congruent with SFM.

**Investigating the environmental impact of contemporary forest practices on a watershed scale: linking academic research with private industrial forest land management.** Skaugset, A. (*Oregon State University, USA; arne.skaugset@oregonstate.edu*).

The environmental impact on fish-bearing streams due to intensive forest management activities adjacent to small, non-fish-bearing, headwater streams is the focus of continuing concern on private, commercial forestland in the Pacific Northwest. A partnership between a private, industrial forest landowner, Roseburg Forest Products (RFP) and the College of Forestry at Oregon State University is allowing the investigation of these environmental impacts. RFP is continuing to manage and harvest timber on a 2,000 ha watershed, but has invited forest researchers to study how their practices impacts hydrology, water quality, stream chemistry, amphibians, aquatic invertebrates and fish in the watershed. Cutting edge technology is being used in the research such as 'passive integrated transponders' or 'PIT' tags to monitor fish movement, and turbidity is used as a surrogate measure for suspended sediment in the 'Turbidity Threshold Systems' (TSS) of stream monitoring. These data are combined in a GIS data base where the interactions between the fisheries and the hydrology of the watershed can be studied. These cutting edge technologies, combined with the willingness of the landowner to allow their use, will set a new standard for the development of new knowledge regarding forest management and environmental impacts at a watershed and landscape scale.

**The status of railway forests in Japan and the trial performance of a new management procedure.** Togari-Ohta, A., Shimamura, M., Suzuki, H. (*East Japan Railway Company, Japan; togari@jreast.co.jp; m-shimamura@jreast.co.jp; h-suzuki@jreast.co.jp*).

Railway forests were established as a belt along railroad tracks in Japan to create a natural defense and to prevent natural disasters such as avalanches and slope failures, improving safety of railway operation. These forests functioned well for one hundred years, with the both roles of such disaster prevention, and also as commercial forestry production. Presently, however, due to stand, market and labour conditions, the forests are not considered to be able to provide the necessary protection. Given the current situation, we propose a new procedure for the management of railway forests, with low cost and maintenance. The management procedure, based on the Potential Natural Vegetation Inducing Method, has been developed specifically for the vegetation rehabilitation. Trial application of the method was carried out on sites along the railway. This presentation: describes the present situation and potential problems related to

railway forests, describes the new maintenance procedure we have performed at demonstration sites along the railway and reports the data from a series of follow-up surveys.

**Forest carbon as a forest landowner incentive: protocols for the California Climate Action Registry.** Tuttle, A. (formerly California Department of Forestry and Fire Protection, USA; [atuttle@cox.net](mailto:atuttle@cox.net)).

Population growth, escalating real estate values and changing world fiber markets increasingly drive conversion of California privately-owned forestlands out of production and into residential and urban uses. Expanding regulatory costs for protection of salmon, stream courses and late seral habitats further pressure forest landowners to sell. An unusual coalition of industrial and non-industrial forest landowners, land trusts and progressive environmental groups is now forming to explore incentives to retain lands as working forests for their environmental and economic values. The California Climate Action Registry, created by statute in 2000, provides for voluntary reporting of greenhouse gas emissions. One implied purpose is that early actors will qualify to take credit for greenhouse gas reductions, should future carbon markets develop. Subsequent legislation authorized forest carbon sequestration to be included in Registry reporting and the protocols are now set for adoption. This provides new incentive opportunities for forest landowners. This paper examines the policy and technical challenges in developing workable protocols for reporting forest carbon stocks on working forestlands.

### **Linking science and practice through the Landcare approach**

Organizers: Ruth McWilliams *USDA Forest Service, USA*; [rmcwilliams@fs.fed.us](mailto:rmcwilliams@fs.fed.us), and Adela Backiel *US Department of Agriculture, USA*; [adela.backiel@usda.gov](mailto:adela.backiel@usda.gov)

**The Landcare movement: A community-based approach to sustainable natural resources management.** Backiel, A. (*US Department of Agriculture, USA*; [adela.backiel@usda.gov](mailto:adela.backiel@usda.gov)), Willcocks, C. (*Australia*; [charles.willcocks@affa.gov.au](mailto:charles.willcocks@affa.gov.au)).

Australia has developed a value-added approach to conservation that delivers the triple bottom line of environmental, social and economic benefits: Landcare. Landcare is a voluntary community group movement that works to improve conservation and natural resource management. Landcare has been highly effective in encouraging the adoption of sustainable management practices which improves productivity, profitability and the condition of natural resources. Around 4000 Landcare groups operate nationally and 87% of Australians recognize the Landcare name and logo. The Landcare partnership between communities, the private sector and government is vital to encouraging on-ground action to improve natural resource management at the local, catchment and regional levels.

**Landcare research at the grassroots: The Northern United Forestry Group** Rankin, I., Brown, M., Dyson, P. (*Northern United Forestry Group, Australia*; [ranx@inet.net.au](mailto:ranx@inet.net.au); [scarlet@bigpond.net.au](mailto:scarlet@bigpond.net.au); [pdyson@netcon.net.au](mailto:pdyson@netcon.net.au)).

In 2004, the Northern United Forestry Group (NUFG) in Victoria, Australia received the first national Telstra Country Wide Landcare Research Award. NUGF is an incorporated, community-based collection of 40 farming families committed to establishing permanent systems that bring about sustainable land use change. The Group's extensive research into suitable native trees for farm forestry is being used to establish low-rainfall farm forestry as a commercially viable enterprise that provides forest products, environmental services and community benefits. The Group's Kamarooka Project involves reclaiming salt affected land and includes a highly structured community monitoring program that is producing data that challenges the conventional understanding of acacia and eucalypt plantings and the saline environment in which they live. Future aspirations include building a critical mass of a low-rainfall farm forestry sawlog resource, attracting external investment in community-owned farm forestry, marketing the environmental services and timber products, and increasing local employment to keep youth from migrating out of the rural area.

**Growing the Landcare Movement.** Garrity, D. (*World Agroforestry Centre/ICRAF, Kenya*; [d.garrity@cgiar.org](mailto:d.garrity@cgiar.org)).

The Landcare movement is growing, branching out from the results and experience in Australia where it began. Other countries are learning from Australia and adapting it to their own realities, including a number of developing countries such as the Philippines and South Africa. The World Agroforestry Centre is working with farmers and other landowners, especially in East Africa, to foster community-based action using a Landcare approach that is grounded in both science and practice. Also, international dialogue has begun among a number of countries about how local Landcare groups and countries interested in Landcare can share experiences and learn from each other, as well as grow the Landcare movement world-wide.

**Landcare research: The New Zealand approach.** Penman, D. (*Manaaki Whenua Landcare Research, New Zealand; PenmanD@landcareresearch.co.nz*).

Landcare Research in New Zealand emphasizes collaboration among communities, end users and researchers to ensure science is relevant and recommendations are practical. Landcare Research focuses on science that benefits New Zealand using a cross-cutting theme approach to biodiversity, catchment management, invasives and more. Environmental research services include research consultancy, GIS mapping and satellite imagery, tools and products and laboratory, diagnostic and quarantine services. This includes working with indigenous people, including Maori organizations, on their issues.

**Scientist and practitioner partnerships: Making them work.** Lugo, A.E. (*USDA Forest Service International Institute of Tropical Forestry, USA; alugo@fs.fed.us; enotman@fs.fed.us*).

Landcare-like efforts exist everywhere. In Puerto Rico, a good example is Casa Pueblo, a community-based land movement that also reaps economic benefits from locally produced coffee. This paper will explore various approaches, both successes and failures, governments can use to assist these efforts. In addition, the need to learn from the experiences of existing Landcare-like groups and to encourage greater interactions among practitioners and scientists to accomplish large landscape scale improvements, particularly within the Wider Caribbean Basin, will be explored.

## **Dissemination of forest restoration and regeneration knowledge into management**

Organizers: Palle Madsen *Danish Centre for Forest, Landscape and Planning (KVL), Denmark; pam@kvl.dk*, and John Stanturf *USDA Forest Service, USA; jstanturf@fs.fed.us; drdirt\_ms@yahoo.com*

**Developing a research and demonstration project initiated by managers: The Sharkey Restoration Site.** Gardiner, E.S. (*USDA Forest Service, USA; egardiner@fs.fed.us*).

During the past 15 years, an extensive forest restoration effort in the Lower Mississippi Alluvial Valley has removed over 200,000 ha of land from agricultural production. Though basic plantation establishment techniques were available for afforestation of these former agricultural fields, managers lacked critical knowledge to implement operational-scale afforestation practices that would accommodate multiple forest restoration objectives. In 1994, managers with the U.S. Fish and Wildlife Service made an 800 ha agricultural tract available to scientists interested in partnering research and demonstrating various aspects of bottomland hardwood ecosystem restoration. Since the establishment of the Sharkey Research and Demonstration area, numerous experiments involving dozens of scientists have been installed on the site. Experimental infrastructure on the site includes a 100 ha study of various conventional and alternative afforestation practices, and a 7 ha flooding research facility to study growth and physiology of bottomland hardwood plant species. Development of this research and demonstration area has: provided a science-based resource for educating landowners and managers on afforestation techniques appropriate for restoration of bottomland hardwood forests, served as a platform for scientists and land managers to cooperate on the development of innovative approaches to forest restoration, and provided a venue for education and debate among policy makers active in the Lower Mississippi Alluvial Valley.

**Modeling as a tool of analysis on the results of natural regeneration of *Pinus sylvestris* in northern Finland.** Hyppönen, M., Alenius, V., Valkonen, S. (*Finnish Forest Research Institute, Finland; mikko.hypponen@metla.fi*).

The seed-tree method has shown great potential for cost-effective regeneration of Scots pine stands in northernmost Fennoscandia. However, large variations in results and frequent failures are characteristic. The research consisted of a survey of regeneration results in stands harvested in 1960–1993 in northern Finland, and a study on the feasibility of the modeling approach in analyzing the principal factors. Regeneration attempts had failed in 48% of the area of the stands, due mainly to unsuitable soil preparation or windblown seed trees. Models for the number of seedlings per unit area and seedling height were developed with the generalized linear mixed model method. Random parameters were involved in terms of the hierarchical data structure. Altitude, time since seed-tree cutting, interaction of site and soil treatment, stoniness, temperature sum and the presence or absence of seed trees had significantly influenced the density of the seedling stand or seedling height. It was concluded that understanding and analysis of the complicated web factors and interactions is vital in order to find ways to match soil, site, the tree stand, climate and infrastructure. The modeling approach yielded promising results in that respect.

**Dissemination of research results and its impacts in small-scale family forestry: The fluctuating intensity and success rate of natural regeneration in Finland.** Hyppönen, M., Valkonen, S. (*Finnish Forest Research Institute, Finland; Mikko.Hypponen@metla.fi*).

Forestry in Finland is based on small-scale family forestry. About 60% of forest land belongs to non-industrial private forest owners, consisting of 440,000 forest holdings. Two thirds of the industrial wood is harvested from their forests. Some basic legal restrictions are applied to forest management for safeguarding economical and ecological sustainability. On the other hand, assistance for forest management is made available through extension organizations. Research results have historically had very significant impacts on legislation and the management guidelines of companies, state forests and the extension organizations working for the private owners. Unfortunately, in the current business atmosphere, practitioners have limited time for updating their knowledge. One major shortcoming is the lack of monitoring and controlling the success of regeneration. Natural regeneration is recommended under favorable conditions. In practice, the use of natural regeneration varies, year by year, area by area and owner by owner. Its results vary accordingly. Neglect of soil treatment seems to be the most frequent cause of failure, despite conclusive evidence of its benefits. Systematic quality control, education and guidance, maintaining and strengthening the extension organizations and effective law enforcement would be the main means for improving the use of the appropriate and cost-effective methods in forest regeneration.

**Natural regeneration on burnt areas of coniferous-broadleaved mixed forests in southern Sikhote-Aline Mountain Range of Primorsky Krai, Russia.** Komarova, T.A., Sibirina, L.A. (*Russian Academy of Sciences, Russian Federation; komarova@ibss.dvo.ru, sibirina@ibss.dvo.ru*), Lee, D.K., Kang, H.-S. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr; silvi@chol.com*).

Stand development in the forests of Primorsky Krai is directly influenced by periodic disturbances by forest fire. To understand the natural regeneration and stand development on burnt areas in coniferous-deciduous mixed forests, several 50 m x 50 m permanent plots were established in 1975 and 1983, on land that was disturbed in 1973 and 1982, respectively. All individual trees were measured (DBH) and counted and classified into damaged or undamaged by fire and dead standing. Also naturally regenerated seedlings were counted in 50 m x 4 m plot in each permanent plot. The most fire-sensitive species among conifers was *Abies nephrolepis*, due to the thick bark, higher content of resin in needles, branches and stem and shallow root system, and *Picea jezoensis* was next in fire-sensitivity. *Betula costata* was the most fire-sensitive hardwood species, followed by *Acer ukurunduense*, *Acer tegmentosum*, *Betula platyphylla*, *Padus maackii*. The results, after 20–30 years, showed that successional tree species such as *Populus*, *Salix*. *Betula* regenerated immediately in the early stages of stand development and grew with a mono canopy layer and high density. Species such as *Pinus*, *Picea*, *Abies*, *Acer mono* and *Tilia taquetii*, that were distributed in the study plots before the forest fire were increasing gradually.

**Effects of forest fire or logging on forest degradation in Mongolia.** Lee, D.K., Park, Y.D. (*Seoul National University, Republic of Korea; leedk@plaza.snu.ac.kr; forest\_park@hanmail.net*), Tsogtbaatar, J. (*Institute of Geoecology, Mongolia; geoeco@magicnet.mn*), Zoyo, D. (*Institute of Botany, Mongolia*).

Mongolia is home to more than 2823 species of vascular plants. However, the country faces tremendous problems that may negatively affect its environmental condition and may severely reduce productivity of the ecosystem due to fire, improper or illegal logging, overgrazing and insects and diseases. In Siberian larch (*Larix sibirica*) forests, 51 study plots (900 m<sup>2</sup> each) with 85 quadrates (25 m<sup>2</sup> each) and 255 small quadrates (4 m<sup>2</sup> each) were established to investigate the changes in forest stand types and soil properties after forest fire or logging. Temperature and humidity in forests were significantly changed after fire or logging. Surface temperature increased by approximately 0.5–2 °C after degradation, which resulted in four types of forest vegetation such as secondary larch forest, hardwood forest dominated by birch and willow, shrubs and grass-forbs steppe vegetation. It also resulted in changes of soil properties and caused difficulty in natural regeneration.

**Water use efficiency in five different species of two-year-old seedlings grown at a field nursery in Mongolia.** Lee, D.K., Park, Y.D., Batkhoo, N.-O., Woo, S.-Y. (*University of Seoul, Republic of Korea; leedk@plaza.snu.ac.kr; forest\_park@hanmail.net; bnyamosor@yahoo.com; wsy@uos.ac.kr*).

Mongolia is a landlocked country and water is one of the factors limiting tree survival and growth in Mongolia. Thus, selecting trees for improved drought-tolerance may represent the best option to increase tree survival and growth rate for large scale rehabilitation. This study was conducted to examine the water use efficiency (WUE) in five species (two coniferous, one deciduous and two shrub species) of two-year old seedlings grown at a field nursery in Mongolia. Thirty seedlings were sampled from each of the five species (a total of 150 samples) and measured for above and below ground biomass (T/R ratio), net photosynthesis (P<sub>n</sub>) and transpiration rates (E), and carbon isotope

discrimination ( $\delta^{13}\text{C}$ ) to compare WUE of each species. Preliminary results showed that conifers have significantly higher WUE ( $p < 0.05$ ) than deciduous or shrub trees as indicated by lower T/R ratio but higher  $P_n$  values.

**Sustainable management in broadleaved forests.** Lof, M. (Swedish University of Agricultural Sciences, Sweden; [magnus.lof@ess.slu.se](mailto:magnus.lof@ess.slu.se)).

Sustainable management in broadleaved forests is a major research program (from 2003–2009) focusing on eight tree species: *Ulmus* spp., *Fraxinus excelsior*, *Carpinus betulus*, *Fagus sylvatica*, *Quercus* spp., *Prunus avium*, *Tilia cordata* and *Acer platanoides*. The Forestry faculty and external financiers are making equal investments, and the organizational structure guarantees the influence of the parties in the research. Within the program, there are several projects of interest for forest restoration and regeneration. For example, we have established, together with the regional board of forestry, six large experiments on conversion of Norway spruce to broadleaves. The experiments involve both scientific and demonstration components, with cooperative involvement of forest owners. Other research projects focus on near-natural forestry in beech forests and on management for protecting threatened beetles and lichens. Here, both the regional forestry board and the county administration are directly involved in the research to guarantee implementation of research results. Moreover, one project focuses on product innovations from wood of broadleaved tree species. Although not directly a forest restoration project, it is of interest for sustained utilization of hardwoods in the long-term and involves both companies and researchers in the same project.

**Adaptive management to restore temperate forests: Interactions between research and practice.** Madsen, P. (Forest & Landscape Denmark, Denmark; [pam@kvl.dk](mailto:pam@kvl.dk)).

Traditionally, forest research achieves and documents new and fundamental knowledge about forest ecosystems and their function, as well as silvicultural treatments and related effects on forest stands and outputs. Development of new techniques and methods are also typical elements of forest research. New findings are shared with research colleagues in scientific journals, and scientists are usually also encouraged to inform practice through popular papers in journals, lectures, excursions, web pages, leaflets etc. However, scientists increasingly need to bring their gains in knowledge and development improvements up-front and preferably ready to use for forest managers and other practitioners. This paper analyses and gives examples of various means of research and knowledge dissemination. These examples are discussed in relation to present and future needs and challenges, such as better and more direct communication and collaboration between research and practice as well as barriers for communication and knowledge transfer.

**Pre-commercial thinning in uneven-aged Douglas-fir forests to obtain stand structures for Mule Deer winter habitat.** Marshall, P., Day, K. (University of British Columbia, Canada; [peter.marshall@ubc.ca](mailto:peter.marshall@ubc.ca); [ken.day@ubc.ca](mailto:ken.day@ubc.ca)), Dobson, D. (JD Forestry Services, Canada).

Forests in the dry, cool Interior Douglas-fir biogeoclimatic subzone of central British Columbia, Canada are often dominated by stands of uneven-aged Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Mirb.) Franco). This type of forest covers a large portion of the Knife Creek Block of the University of British Columbia's Alex Fraser Research Forest. In the 1960s, diameter limit logging resulted in residual Douglas-fir stands with few large trees. Subsequent recruitment of trees was primarily through the release of abundant advanced regeneration, leading to dense stands dominated by poorly formed saplings and poles with low growth rates. Management objectives today emphasize production and maintenance of mule deer (*Odocoileus hemionus hemionus* (Raf.)) winter habitat to provide snow interception cover and winter forage. This is achieved via producing and maintaining uneven-aged, primarily Douglas-fir stands, containing a number of large trees with wide deep crowns, larger diameters and clumped spatial arrangements. Pre-commercial thinning was applied to reduce stand densities, focusing on removing the poorly formed trees and retaining the best-formed and most vigorous individuals. A study of treated stands was initiated in 1998 to evaluate growth of trees and stands following thinning and the ability of these treated stands to meet mule deer winter habitat requirements.

**Seedling regeneration, growth and density of *Eucalyptus obliqua* following variable retention harvesting in wet eucalypt forests in Tasmania, Australia.** Neyland, M.G. (Forestry Tasmania, Australia; [mark.neyland@forestrytas.com.au](mailto:mark.neyland@forestrytas.com.au)).

The Warra silvicultural systems trial is being established to compare clearfell, burn and sow silviculture with five alternative treatments suitable for use in lowland wet eucalypt forests. These alternatives include: 1) clearfell, burn and sow with understorey islands, 2) stripfell/patchfell, 3) dispersed retention at 10% of the original overstorey, 4) aggregated retention at 30%, and 5) single tree/small group selection. The influence on seedling regeneration, growth and density of *Eucalyptus obliqua*, of silvicultural treatment, seedbed type and light availability within each treatment

has been monitored for three years across four treatments and for one year within one treatment. At age three years, clearfell, burn and sow coupes have a higher stocking of faster growing seedlings than the alternative treatments. However with the exception of the single tree/small group selection coupe, the alternative treatments are all fully stocked with eucalypt seedlings and the retained trees are having no significant effect on seedling growth at this stage.

**Understorey islands as a means of conserving structural and plant diversity within harvested wet eucalypt forests in Tasmania.** Neyland, M.G. (*Forestry Tasmania, Australia; mark.neyland@forestrytas.com.au*).

Clearfell, burn and sow silviculture can reduce post-harvesting diversity through the loss of vegetatively reproducing and/or late successional species, and through structural simplification. A study involving understorey islands—areas where harvesting machinery is excluded but from within which commercial wood may be harvested—was undertaken in two coupes within the Warra silvicultural systems trial in southern Tasmania. Three years after completion of harvesting and burning, results from this study show that even where burnt, understorey islands have the potential to retain both species and structural elements that would otherwise be lost during routine clearfell, burn and sow operations.

**The changes and challenges of natural regeneration of European beech stands in Romania: A case study.**

Nicolescu, N.-V. (*University “Transylvania” of Brasov, Romania; nvnicolescu@unitbv.ro*), Stancioiu, P.-T. (*National Forest Administration ROMSILVA, Romania; tudorstancioiu@yahoo.com*), Petritan, I.-C., Vasilescu, M.-M. (*University “Transylvania of Brasov, Romania; catalinp24@yahoo.com; vasilescum2001@yahoo.com*).

The regeneration process of European beech *Fagus sylvatica* L., the most important forest species in Romania, was examined from different standpoints. Since the onset of professional forestry in Romania (end of 19<sup>th</sup> century), pure and mixed European beech stands have been regenerated either under shelterwood systems (uniform, but also group and irregular) or selection systems, depending on species composition, existing or targeted stand structure, as well as functions to play. After the fall of communism in 1989, due to the major changes of ownership structure as a result of restitution of forestland to the former owners, the regeneration process of European beech stands has faced major changes and challenges. The shelterwood systems, owing especially to financial constraints, have involved fewer regeneration cuttings and a shorter regeneration period followed by less silvicultural interventions in the seedling and sapling stages. Such approach has led to regular and overly dense stands, with many defective and slender trees, prone to snow bending and/or breakage. Under such circumstances, scientists and professional foresters should play an increasing role in creating research and development strategies, and demonstrating and implementing old successful regeneration methods, as well as new ones, in all forests regardless of their ownership status.

**Individual tree release and enrichment planting to enhance the proportion and growth of desired species in natural stands.** Robison, D.J., Schuler, J., Malone, M., Collazo, J. (*North Carolina State University, USA; dan\_robison@ncsu.edu*).

The regeneration of natural forests often results in species composition that is not fully desirable. Changes in land use history and management, introduction of exotic-invasive insects, diseases and plant pests and constraints on the use of some silvicultural tools can reduce the representation and growth rates of preferred species. These species need to be promoted and/or restored to forest systems to achieve land use objectives. Enrichment planting and individual tree release provide opportunities to accomplish this, without resorting to more intensive planting alternatives. Examples from work with oaks (*Quercus* spp.) in the southern US and Puerto Rican royal palm (*Roystonea borinquena*) in Puerto Rico will be discussed.

**Propagation and silviculture of two forest trees, *Shorea robusta* and *Dipterocarpus turbinatus*, for restoration of a sustainable forest ecosystem.** Sinha, P., Roy, S.K. (*Jahangirnagar University, Bangladesh; pinakiju@yahoo.com*).

*Shorea robusta* and *Dipterocarpus turbinatus* of the family Dipterocarpaceae, two tree species of the rain forests in south- and southeast Asia, are of great economic importance for timber. They are generally propagated by seed that are recalcitrant and lose their viability within a few days of maturity. Moreover, the survival rate of seedlings planted in the open spaces of degraded forests is very low. Propagation methods by seed germination, cutting and layering, and *in vitro* micropropagation was compared. The results showed that, for large scale planting materials in these two species, seed collection at proper maturation time is the best, ensuring 75% healthy seedlings. For high percentage survival of the planted plantlets, silvicultural methods were tested. One year old plantlets were transplanted in open spaces and on the shady floor of three-year old *Acacia auriculiformis* stands. Plantlets on the shady forest floor had a 100% survival rate. After two years when five-year old *Acacia auriculiformis* were cut, no mortality of dipterocarps were found. The methodology is detailed in this paper and feasibility of restoration of degraded dipterocarp forests is discussed.

**Hybrid aspen plantations in boreal conditions: Research, development and implementation.** Tullus, A., Tullus, H., Vares, A. (*Estonian Agricultural University, Estonia; arvo@eau.ee; htullus@eau.ee; avares@eau.ee*), Kanal, A. (*Tartu University, Estonia; akanal@ut.ee*), Karoles, K. (*Centre of Forest Protection and Silviculture, Estonia; mmk@metsad.ee*).

During the last decade, 25–30% of agricultural lands have been abandoned in Estonia. One possible way to exploit those lands in a profitable way is afforestation with fast growing deciduous tree species. The establishment of hybrid aspen plantations (*Populus x wettsteinii* Hämet-Ahti) began in 1999 and, up to the present, 600 ha have been cultivated. The purpose of the research was to measure and evaluate the early growth of hybrid aspen stands on different soils in an Estonian climate, and compare the results with similar data from Scandinavia. An evaluation of the environmental interaction of hybrid aspen in Estonia was carried out; the potential influence of hybrid aspen plantations on the local environment is considered to be quite low. The network of experimental plots was created for future research work on rotation period and yield of hybrid aspen clones at different sites. Fifty experimental plots have been established in 26 hybrid aspen plantations, and data on basic tree measurements and soil type have been collected. Samples of foliage, timber and soil were taken for chemical analyses. Suggestions for choosing the most suitable site types are given for the benefit of landowners. Hybrid aspen shows better growth on podzoluvisols, leptic podzols and planosols.



## General Sessions

### General Posters: Silviculture

Organizer: Björn Hånell *Swedish University of Agricultural Sciences, Sweden*; [bjorn.hanell@ssko.slu.se](mailto:bjorn.hanell@ssko.slu.se), and John Parrotta *USDA Forest Service, USA*; [jparrotta@fs.fed.us](mailto:jparrotta@fs.fed.us)

**Height growth and growth intercepts for estimating site quality for young jack pine plantations in Northern Ontario.** Guo, J. (*Shanxi Agricultural University, P.R. China*), Wang, J.R. (*Lakehead University, Canada*); [jian.wang@lakeheadu.ca](mailto:jian.wang@lakeheadu.ca).

Sixty-five jack pine plantations (<50 years age) were sampled to develop height growth and variable growth intercept (GI) models for jack pine plantation in northern Ontario, Canada. These models were compared with site index models developed for natural jack pine stands (stand aged 50 to 157 years) from the same geographic region. The main objective of this study was to determine if jack pine plantations have a higher site quality (site index) and if we can use the same site index from natural stands to predict growth and yield of jack pine plantations. These growth intercept models will be used in forest management planning and other applications.

**Long-term effects of site preparation on water-retention characteristics of forest soil in Finnish Lapland.**

Heiskanen, J., Mäkitalo, K., Hyvönen, J. (*Finnish Forest Research Institute, Finland*; [juha.heiskanen@metla.fi](mailto:juha.heiskanen@metla.fi); [kari.makitalo@metla.fi](mailto:kari.makitalo@metla.fi); [juha.hyvonen@metla.fi](mailto:juha.hyvonen@metla.fi)).

Site preparation is commonly used with reforestation in Finnish Lapland since it reduces high soil moisture and increases low soil temperature in planting spots and thus improves reforestation prerequisites. However, environmental aspects of site preparation, such as possible changes in surface-water runoff as well as in soil density and aeration, are often addressed. Heavy site-preparation machines may cause soil alterations also in untreated intermediate areas. The present paper studied effects of site preparation on water-retention characteristics of till soils on 96 plots in 8 experimental sites 21 years after site preparation and reforestation. Water-retention characteristics were studied, using a function that was fitted to measured water-retention data. The results showed no long-term effect of heavy machines on the water-retention characteristics. These characteristics in untreated intermediate areas of patch-scarified, disk-trenched and ploughed plots (scarified by a bulldozer) did not differ from prescribed-burned plots (scarified manually). In ploughed ridges, however, saturated water content and air-filled porosity at field capacity were significantly higher and bulk density lower than in the untreated intermediate areas, which suggests that alterations in soil composition and organic matter content may affect soil-water regime until 21 years after site preparation.

**Early growth and survival in planted seedlings of several tree species beneath Norway spruce stands in southern**

**Sweden.** Löf, M., Karlsson, M., Sonesson, K. (*Swedish University of Agricultural Sciences, Sweden*; [magnus.lof@ess.slu.se](mailto:magnus.lof@ess.slu.se); [matts.karlsson@ess.slu.se](mailto:matts.karlsson@ess.slu.se); [kerstin.sonesson@ess.slu.se](mailto:kerstin.sonesson@ess.slu.se)), Collet, C. (*INRA, France*; [collet@nancy.inra.fr](mailto:collet@nancy.inra.fr)).

In Europe, conversion of Norway spruce stands to more natural broadleaved stands has become increasingly common. In this field-experiment, the influence of different overstory removal and light environments on survival and growth in seedlings were examined. Four overstory treatments with middle aged Norway spruce were applied. Seedlings of the following seven tree species were planted in each of the four blocks: *Acer platanoides* L., *Fagus sylvatica* L., *Fraxinus excelsior* L., *Picea abies* L. (Karst.), *Prunus avium* L., *Quercus robur* L. and *Tilia cordata* (Mill.). The seedlings were monitored through the 2001–2004 growing seasons and light environments were estimated through analysis of hemispherical images. Highest survival was found among seedlings planted in approx. 18–25 % relative light, whereas best diameter growth in seedlings was found in the small clear-cut with approx. 70 % relative light. Survival and growth curves in relation to relative light are presented for all species.

**Effect of site preparation and soil-water characteristics on the long-term performance of Scots pine plantations in Finnish Lapland.** Mäkitalo, K., Alenius, V., Heiskanen, J., Hallikainen, V. (*Finnish Forest Research Institute, Finland*; [kari.makitalo@metla.fi](mailto:kari.makitalo@metla.fi); [virpi.alenius@metla.fi](mailto:virpi.alenius@metla.fi); [juha.heiskanen@metla.fi](mailto:juha.heiskanen@metla.fi); [ville.hallikainen@metla.fi](mailto:ville.hallikainen@metla.fi)).

High soil water content and low temperature have been considered to be the main causes of severe dieback of Scots pine (*Pinus sylvestris* L.) plantations in Finnish Lapland. The effects of site preparation, and soil texture, water-retention characteristics, water content and air-filled porosity on the long-term performance of planted Scots pines were studied on 96 plots of eight reforestation experiment areas 25 years after site preparation and planting. The site preparation methods were prescribed burning, patch scarification, disk trenching and ploughing. Mixed models were

used in the data analysis. The results showed that site preparation had a significant effect on the survival and total volume of the pines, but no effect on mean height. Soil parameter  $\alpha$  in untreated intermediate areas, inverse of which is often referred to as the soil air-entry value, showed a significant positive effect on survival and total volume. Air-filled porosity had a significant positive relationship with mean height. The results suggest that, in addition to site preparation, the soil hydraulic properties in the untreated intermediate areas affect the long-term performance of Scots pine plantations in northern boreal forests.

**Is N<sub>2</sub>-fixation by woody legumes limited by soil phosphorus supply in secondary vegetation on degraded pastures of Eastern Amazonia?**

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The effect of nitrogen or phosphorus fertilization on nutrient use in eight prominent woody legume and non-legume species was studied in 10-year-old, legume-poor secondary re-growth on degraded pasture in a former rainforest area in Pará, Brazil. Concentrations of carbon, nitrogen, phosphorus and natural abundance of <sup>15</sup>N in soil, litter, leaves and specific leaf areas were determined three years after last fertilization. In spite of contrasting foliar N concentrations between some species, leaves of putative N<sub>2</sub>-fixers and non-fixers did not differ in N concentrations. Across all treatments, foliar δ<sup>15</sup>N of putative N<sub>2</sub>-fixers were, on average, 3.7 ‰ lower than those of non-fixers. In P-fertilized plots, the most prominent putative N<sub>2</sub>-fixers, i.e. naturally regenerating, exotic *Acacia mangium* and native *Stryphnodendron adstringens*, showed lower foliar δ<sup>15</sup>N than in unfertilized controls. Foliar δ<sup>15</sup>N values of the most abundant legume vine at the site, *Senna chrysoarpa*, suggest it is not N<sub>2</sub>-fixing, supporting published records for this genus. The results suggest that N<sub>2</sub>-fixation by legumes at this site is stimulated by relaxing the P-availability constraint widespread throughout strongly weathered tropical soils. Thus, the ecosystem is limited by nitrogen not only due to the low abundance of potential N<sub>2</sub>-fixers, but also due to P-limitation of symbiotic N<sub>2</sub>-fixation.

**General posters: Physiology and genetics**

Organizer: Eric Teissier du Cros *INRA, France; eric.teissierducros@avignon.inra.fr*, and Bob Luxmoore, *Oak Ridge National Laboratory, USA; luxmoorerj@ornl.gov*

**The multiple leader growth formation of *Acacia* genotypes.** Ab. Shukor, N.A., Awang, K. (*Universiti Putra Malaysia, Malaysia; anishukor@yahoo.com*), Eldoma, A. (*University of Khartoum, Sudan; ahmedeldouma@hotmail.com*), Ng, F. (*Forest Research Institute, Malaysia; fng@pc.jaring.my*), Hassan, A., Mat, S. (*Universiti Putra Malaysia; aishah@agri.upm.edu.my; sapari\_bae@hotmail.com*).

Some *Acacia* genotypes have shown promising potentials for timber production in short rotations. However, this proposition was partially restrained by the multiple leader (ML) formation. This study investigated the causes of ML formation and its variation between genotypes of selected *Acacia* species and concurrently, assessed their growth performance and examined the patterns of shoot growth traits through a progeny and burnt/unburned trials and related greenhouse experiments. Results showed that ML 2 (tree with two stems) is the most dominant class for ML formation in both trials. The trend showed that the number of ML trees decreased with increasing number of stems in most genotypes. ML occurrence between species showed that *A. aulacocarpa* recorded the highest number of trees followed by *A. auriculiformis*, *A. crassicaarpa* and *A. mangium*. Provenances from Papua New Guinea of these species showed higher number of ML formation than the ones from Queensland except for *A. crassicaarpa*. Approximately half (49.1%) of the trees grown at the burnt site developed ML whereas the unburned site produced only 4.52%. ANOVA results confirmed that burning causes ML formation in the *Acacia* genotypes investigated. However, the causes of the ML formation could not be further identified in the greenhouse experiments.

**Cell wall polysaccharides during early-wood and late-wood formation in *Larix sibirica* Ldb.** Antonova, G.F., Chaplignina, I.A. (*Russian Academy of Sciences, Russian Federation; institute@forest.akadem.ru*).

The deposition of hemicellulose of the groups A and B, soluble in 4 and 24 % KOH, pectin and arabinogalactans at different stages of differentiation of early- and late-wood tracheids during annual ring wood formation in *Larix sibirica* stems were studied. The xylem with different stages of tracheid development, starting from the zones of cambium,

radial cell expansion, secondary wall development before lignification, two consecutive layers of lignifying cell of early-wood and three consecutive ones of lignifying latewood tracheids, as well as mature xylem cells were obtained from the stem cuttings of 20-year-old larch trees. The amounts of polymer carbohydrates deposited at each of differentiation stages were calculated per dry weight and per cell. At each of the differentiation stages of early- and late-wood tracheids the accumulation of pectin, arabinogalactan, A and B hemicelluloses, bound and unbound with cellulose, occurred with individual dynamics according functional role of each from compounds in the creation of structure of tracheid walls. The changes in the amounts and structure of hemicellulose, especially xyloglucan, pectin, arabinogalactans and arabinogalactan-proteins are considered as the base for differences in radial diameters and secondary wall thickness of early- and late-wood tracheids.

**Long-range dispersal of tree seeds.** Avissar, R., Bohrer, G. (*Duke University, USA; avissar@duke.edu*).

One of the key challenges to quantify long-distance wind dispersal of seed is describing the complex and three-dimensional eddy motion inside and above canopies. The Large-Eddy Simulations (LES) option of the Regional Atmospheric Modeling System (RAMS), a state-of-the-art, three-dimensional, non-hydrostatic atmospheric numerical model was modified to simulate atmospheric turbulence within and above tree canopies. The primary modification included a new coordinate system designed to contour the shape of trees, permitting a more accurate descriptor of the interaction between canopy morphology and the 'energetic' eddies. A detailed energy balance of the tree canopy was also introduced in the model. The model was designed to simulate turbulence within a second-growth 180-year-old hardwood stand at Duke Forest, with a mean canopy height of 30 m and a maximum leaf area index of 6. The LES was initialized with measured hourly mean wind speed, temperature and humidity profiles near a 45 m tower. The various statistical moments needed to drive seed trajectories were compared with the corresponding moments measured at the tower. A Lagrangian Dispersion Particle Model (LDPM) driven with the turbulent flow simulated with the RAMS-LES was then used to quantify seed dispersal at that site. The combined RAMS-LES and LDPM simulations adequately matched the patterns of seed dispersal as quantified by observations conducted near the tower.

**Seed rain and phenology of a semi deciduous seasonal forest fragment in Botucatu, southeastern Brazil.** Caes, B.R.M., Engel, V.L., Rua, D.R. (*UNESP/FCA, Brazil; brmcaes@fca.unesp.br; veralex@fca.unesp.br; daniele@imaflora.org*).

Phenological processes are fundamental for understanding the ecosystem dynamics of tropical forests, reproductive biology of its species and ecological interactions in the community. The objective of this research project was to investigate the community phenodynamics of a semi-deciduous seasonal tropical forest, to verify possible inter-annual differences in its phenological patterns and to determine propagule availability for forest regeneration. In a one ha plot, 338 individual mature trees were marked and observed fortnightly for the presence and intensity of flower buds, flowers, fruits, new leaves, mature leaves and leaf-fall phenophases, in 2002–2003 and 2004–2005. Seed rain was collected monthly in 28, 50 x 50 cm traps, for subsequent quantification and identification. The results indicated that the forest is highly seasonal, with the majority of propagules being dispersed at the end of the dry season, most of them belonging to anemochoric vines and tree taxa. There were some differences among phenological patterns among years, attributable to species' individual phenorhythms and climatic abnormalities. Community phenological patterns are consistent with a disturbed secondary forest.

**Overcoming biological barriers to hybrid seed production in *Eucalyptus* (subgenus *Symphyomyrtus*).** Horsley, T., Stanger, T. (*Sappi Forests Research, South Africa; tasmien.horsley@sappi.com; terry.stanger@sappi.com*), Johnson, S. (*University of KwaZulu-Natal, South Africa; johnsonsd@ukzn.ac.za*).

The greatest challenge in *Eucalyptus* breeding programs is the use of efficient strategies to produce individuals with high growth potential and desirable wood qualities. Hybrids are appealing because of the potential to create genotypes with special combinations of properties, especially those of economic importance. However, a major limitation preventing hybrid deployment is the inability to mass-produce them cost-efficiently due to low fertility, poor rooting and the inability to produce new hybrids, especially across taxonomic sections. The present study sought to understand biological barriers to seed set following various genetic combinations of six species belonging to the subgenus *Symphyomyrtus*. The aim was to find a suitable protocol for their controlled cross-pollination. Three controlled pollination methods were compared, namely Conventional One Stop Pollination(OSP), and Artificially-Induced-Protogyny (AIP), with the latter found to be the most cost-efficient. The decline in pollen viability during storage was also addressed. Pollen was found to retain high viability for up to a year when stored at -10 °C. An optimal viability-testing medium contained 30% sucrose and 150 ppm boric acid. Barriers to fertilization were studied using epifluorescent microscopy, and species were found to be partially self-incompatible. Pollen tubes grew slower in styles and less seed was obtained following selfing than following outcrossing.

**The asexual reproduction of *Oplonax elatus* by rooted cuttings.** Kim, C.-W., Yi, J.-S. (Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr).

This research was carried out to establish a high-efficiency propagation system using hard-wood cuttings for *Oplonax elatus*, one threatened tree species in Korea. In August, 2002 stems treated without and with 2000 mg/L NAA showed 100% rooting and other treatments treated with NAA (>300 mg/L) showed more than 70% rooting, when a mixture of sand and peatmoss (1:1 v/v) was used. When considering root number and length in addition to economic efficiency, the control treatment was recommendable. In April 2003, three kinds of soil were used in the experiment: soil A was sand, soil B was a 1:1 sand and peatmoss mixture, and soil C was a 1:1:1:1 mixture of sand, vermiculite, peatmoss and perlite. In soil A, B and C, rooting rates were 30, 32 and 8%, respectively. At the same date, IAA (500 mg/L) showed 10% rooting rate and other treatments showed 0% using soil B. In all things considered above, it appeared that the time of cutting is critical for the rooting success and that soil B was effective for rooting and growth of hard-wood cuttings.

**Provenance variation in bud flush of *Pinus densiflora* in Korea.** Kim, I.-S., Ryu, K.-O., Kang, K.-S. (Korea Forest Research Institute, Republic of Korea; kimis02@foa.go.kr; koryu95@foa.go.kr; kangks@foa.go.kr).

This study was conducted to investigate the climatic factors affecting bud flush of *Pinus densiflora* provenances. Data were collected from plantations in Jungsun, Chungju, Naju and Jeju. The plantations were part of the 11 provenance trials established by KFRI in 1996. Thirty-six provenances were included in this study, conducted between 33° 30' – 38° 08' lat. and 126° 30' – 129° 20' long. Bud flush of the provenances was investigated from March to May according to a grading system that ranged between 0 (dormant bud) to 5 (elongation flush). Fifteen climatic factors and ecological distance values between provenance and plantation were used in this analysis. In test plantation, annual mean temperature, extremely low temperature (March–October) and annual mean growing days were mainly affected to bud flush—bud flush was faster at the plantation with higher temperature (March–October) and longer growing days. Mean temperature (Nov.–Feb.) and extremely low temperature (Dec.–Feb.) of seed origin also affected the bud flush—the seed origin with lower winter temperature showed the faster bud flush.

**Genetic variation of *Daphne pseudomezereum* var. *koreana* based on AFLP and RAPD analysis.** Kim, J.H., Yi, J.-S., Kim, N.-S. (Kangwon National University, Republic of Korea; ojijk2000@mail.kangwon.ac.kr; jasonyi@kangwon.ac.kr; kinnamsu@kangwon.ac.kr).

Genetic variation and relationship in the native populations of *Daphne pseudomezereum* var. *koreana* were analyzed with AFLP and RAPD markers. Analysis of 117 accessions derived from 5 populations of *D. pseudomezereum* var. *koreana* revealed 81 polymorphic AFLP fragments, 10 polymorphic RAPD fragments with four AFLP primer combinations and ten RAPD primers. By UPGMA cluster analysis with molecular markers, the 117 accessions were grouped into two major clusters at 78% genetic similarity. The geographic locations of most accessions derived from five populations that did not seem to be corresponded to their positions in the UPGM cluster dendrogram, except for eight accessions in population V. The genetic similarity among five populations measured by the molecular markers ranged from 0.66–1.00. Population V showed the highest GS with means of 0.99, while population III showed the lowest GS with means of 0.93. This result will be useful for designing the strategy of conservation in the native populations of *D. pseudomezereum* var. *koreana*.

**Development of microsatellite markers in an important timber species *Koompassia malaccensis* (Leguminosae): Preliminary results.** Lee, C.-T., Lee, S.-L. (Forest Research Institute Malaysia, Malaysia; leechait@frim.gov.my; leesl@frim.gov.my), Faridah, Q.Z., Siraj, S.S. (University Putra Malaysia, Malaysia; fqz@putra.upm.edu.my; shapor@fsas.upm.edu.my), Norlia, B., Ng, K.K.-S., Norwati, A., Norwati, M. (Forest Research Institute Malaysia, Malaysia; norlia@frim.gov.my; kevin@frim.gov.my; norwatia@frim.gov.my; norwati@frim.gov.my).

We report the preliminary results of microsatellite isolation and characterization in *Koompassia malaccensis*, an important timber species in Malaysia from the family Leguminosae. As its previous genetic assessment based on allozymes yielded very limited number of loci, development of microsatellite markers is essential in order to generate genetic data that could provide more comprehensive suggestions for the genetic resource management of this particular timber species. The approach adopted for microsatellites isolation is selective hybridization using biotinylated repeat oligo (CT)<sub>15</sub> bound to streptavidin coated magnetic beads. Enriched fragments were ligated to Plasmid pUC118 BamH1/BAP and cloned. Approximately 200 putative clones were extracted and 55 clones sequenced. Preliminary analysis showed that out of the 55 clones, 32 (58%) contain microsatellite (dinucleotide) sequences with the maximum of 23 repeats. Two compound microsatellite sequences were found: (AG)<sub>7</sub>G(GA)<sub>6</sub> and (AG)<sub>10</sub>AA(AG)<sub>6</sub>. The remaining clones will be sequenced and thereafter, primers will be designed from the flanking regions of unique microsatellite sequences.

**Identification of isolated compounds from seed extracts of *Amorpha fruticosa* L. and their physiological activity assay.** Lee, H.-J. (*Korea Forest Research Institute, Republic of Korea; LEEHJ99@foa.go.kr*), Kwon, Y.-H. (*National Arboretum, Republic of Korea*), Kang, H.-Y., Choi, D.-H. (*Korea Forest Research Institute, Republic of Korea*), Lee, M.-K. (*Chungbuk National University, Republic of Korea*), Paik, K.-H. (*Korea University, Republic of Korea*).

Interests in isolation and identification of new natural compounds are increasing to find their possible applications for medical purposes. *Amorpha fruticosa* (Leguminosae) is a shrub originally from North America that was introduced to Korea in the 1930s. This plant is approximately three-meters tall and flowers in May–June. Its seed ripens in September, and usually has one seed per fruit. This study was carried out to examine the constituents of *A. fruticosa*. Dried and ground seed of *A. fruticosa* was extracted with methanol and then concentrated to give the crude extracts. The crude extracts were successively fractionated with organic solvents, such as n-hexane, dichloromethane, ethyl acetate and butanol. Seven compounds were isolated from the seeds of *A. fruticosa* and identified using spectroscopic methods such as mass spectroscopy and nuclear magnetic resonance. The structures of these compounds were determined as: kaempferol 7-O- $\alpha$ -L-rhamnopyranoside, methyl 3,4,5-trihydroxybenzoate, tephrosin, dalbinol, gallic acid, 2',4',5',7-tetramethoxyisoflavone and dalbinol 2'-O- $\beta$ -D-glucopyranoside. In addition, treatment of PC12 cells (rat pheochromocytoma) with methyl gallate increased dopamine content in a dose-dependent manner (120.6% inhibition at 5 mg/ml for 24 hr).

**Two-year growth performance of progeny trials of *Acacia crassicaarpa*.** Maelim, S., Lee, D.K. (*Seoul National University, Republic of Korea; smaelim@yahoo.com; leedk@plaza.snu.ac.kr*).

The progeny trials of 80 *Acacia crassicaarpa* families in Chachoengsao Province, Thailand, were assessed for their survival and growth two-years after planting. Those families were originated from seven provenances: three from Gubam village, Papua New Guinea (PNG), three from Samlleberr Iran Jaya, Indonesia, four from Oliver River, Queensland (QLD), 18 from Claudie River, QLD, 14 from Oriomo, PNG, 15 from Bimadebum, PNG, and 23 from Bensbach, PNG. The experiment consisted of a row-column design with eight replications, each one subdivided into 80 plots with four trees per plot. All families showed good survival and growth performance. No significant growth differences in survival, diameter, or height were found among the families or among the provenances. Diameter growth varied from 4.68–6.53 cm, while height growth ranged from 4.7–6.5 m.

**The mating system of natural populations of canafistula.** Mori, E.S. (*São Paulo State University, Brazil; esmori@fca.unesp.br*), Sebbenn, A.M., Zimback, L. (*Instituto Florestal, Brazil; amsebbenn@bol.com.br; nativas@fca.unesp.br*), Guries, R.P. (*University of Wisconsin, USA; rpguries@facstaff.wisc.edu*).

The multiloci models for mixed mating systems and correlated matings were used for analysis of four natural populations of canafistula, *Peltophorum dubium* (Sprengel) Taubert, from Brazil. We used isoenzymes from 19–33 open pollinated progenies for population. The comparisons of allele frequencies, either pollen and ovules, have shown significant differences at least in 50% of loci, indicating strong deviations on random matings, possibly due to biparental crossings, selfings and/or mating between relatives. The estimates of multiloci rates ( $\alpha$ ) were from 0.557–0.924, showing the species has a mixed mating system. The differences between multiloci and uniloci rates ( $\alpha$ ) were positives and statistically different from zero for all populations (0.092 to 0.111), suggesting a spatial genetic structuration of populations, and because of crossings among relatives. The comparison of fixation index of maternal trees (0.009–0.285) with their progenies (0.127–0.364) suggests selection against homozygous from seedling to adult phases. The correlation ( $r$ ) of biparental crossings (0.046–0.123), demonstrated that in some populations, part of progenies are full sibs. The mean coefficient of co-ancestry ( $f$ ) estimated between plants within progenies (0.147–0.251), confirmed the progenies are a pool of different degrees of relatedness.

**Assessing and managing the risk of gene flow between plantations and native eucalypts in Australia.**

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With the large increase in eucalypt plantations in Australia over the last decade for environmental, farm and industrial purposes, there is concern that native eucalypt gene pools may be contaminated by pollen flow from locally exotic species or provenances. Australia is the custodian of the majority of the world's native eucalypt forest and management of hybridisation and gene flow is one of the many sustainability issues that need to be addressed by forest and land managers. Hybridisation between planted and native eucalypt species has already been reported. This talk will outline the framework used to assess the risk and consequences of such gene flow and discuss a case study involving the introduced plantation species, *Eucalyptus nitens*, on the island of Tasmania.

**Influence of water stress on lesion expansion in the xylem of *Cryptomeria japonica* seedlings inoculated with a canker fungus *Guignardia cryptomeriae* revealed by neutron radiography.** Yamada, T., Yamato, M., Nakanishi, T.M. (University of Tokyo, Japan; [yamari@uf.a.u-tokyo.ac.jp](mailto:yamari@uf.a.u-tokyo.ac.jp); [banri@fr.a.u-tokyo.ac.jp](mailto:banri@fr.a.u-tokyo.ac.jp); [atomoko@mail.ecc.u-tokyo.ac.jp](mailto:atomoko@mail.ecc.u-tokyo.ac.jp)).

Influence of water stress on xylem lesion (discolored wood and dry zone) expansion in *Cryptomeria japonica* seedlings inoculated with a canker fungus *Guignardia cryptomeriae* was investigated by neutron radiography. Two-year-old seedlings, planted in the pots, were wound inoculated with virulent isolate MA7 and avirulent isolate MA21 of the fungus. Moisture content of soil (vermiculite and perlite) was adjusted to 300% or 150%. Seedlings were irradiated with neutron beam one and seven days after inoculation, and radiography images were obtained with imaging plates. Water potential of seedlings was clearly different between the two soil water regimes at the time of inoculation. No difference was observed in xylem lesion size between the two regimes one day after inoculation. Xylem lesion expanded with time after inoculation in dry soil conditions. In moist conditions, however, xylem lesion hardly expanded, even in the seedlings inoculated with virulent isolate. These results indicated that water stress accelerated the lesion expansion. On the 2<sup>nd</sup> day of inoculation, xylem lesion was larger in the combination of avirulent fungus-dry condition than that of virulent fungus-moist condition, suggesting that host-pathogen interaction was a more important factor affecting lesion expansion than physical force causing air invasion under water stress.

## General posters: Forest operations

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**Forest road design with soil sediment evaluation using a high resolution DEM.** Aruga, K. (Utsunomiya University, Japan; [aruga@cc.utsunomiya-u.ac.jp](mailto:aruga@cc.utsunomiya-u.ac.jp)), Sessions, J. (Oregon State University, USA; [john.sessions@oregonstate.edu](mailto:john.sessions@oregonstate.edu)), Miyata, E.S. (University of Washington, USA; [esm@u.washington.edu](mailto:esm@u.washington.edu)).

In this study, we developed a forest road design program based on a high-resolution DEM from LIDAR. After a designer locates the intersection points on a horizontal plane, the model first generates the horizontal alignment and the ground profile. The model precisely generates cross sections and accurately calculates earthwork volumes using a high-resolution DEM. The program optimizes horizontal and vertical alignments of forest roads simultaneously based on total construction and maintenance costs. Because the program precisely generates forest road alignments using a high resolution DEM, it can calculate factors for standard methodology to predict soil sediments delivered to streams. We applied the program to a part of Capitol State Forest in Washington State and optimized horizontal and vertical alignments while estimating soil sediments from roads to streams. We examined the effects of road materials, up-slope culvert distances to streams and out-sloped road configurations. As a result, placing up-slope culverts 15 m upstream and out-sloped road configurations reduced total road costs and soil sediments. As the accuracy of a high-resolution DEM from LIDAR increases, the model would be useful tool for a forest road designer by eliminating or at least reducing the time-consuming process of road survey.

**Environmental management improves efficiency in forestry operations.** Berg, S. (Forestry Research Institute of Sweden; [staffan.berg@skogforsk.se](mailto:staffan.berg@skogforsk.se)).

Current fears about a scarcity of resources and energy influence investment and development work. Many certification schemes guide investors to branches which promise efficient use of resources. The Earth Summit 1992 (UNCED) brought forward many ways (ISO) to describe the impact resulting from the management of natural resources and energy usage. Samset and Sundberg chose energy use as a standard for measuring the economy and efficiency of forestry operations. In Sweden, these operations have a high level of mechanization and a low cost per cubic metre. Recent studies on Swedish forestry have also demonstrated an efficient use of energy and a low environmental impact. The deployment of modern engines, fuels and IT could well bring about further improvements. The forestry sector is remarkable in that its activities are based on a renewable raw material that is also an energy carrier. If synthetic fuels from wood fibre are used in forestry, much of the wood chain will have virtually no impact on global warming—and a reduced impact on other environmental impact categories.

**Productivity, soil compaction and residual stand damage associated with four harvesting systems.** Bustos, O. (University of Maine, USA; [oscar.bustos@umit.maine.edu](mailto:oscar.bustos@umit.maine.edu)).

The use of small harvesting equipment can make the harvest of limited volumes from small acreages more economical and feasible for loggers and landowners. However, these operations can adversely affect the stand by (1) disturbing or compacting the soil, and (2) injuring residual trees. Both lower land productivity and could affect future timber growth

and prevent sustainable forest management. The present research investigated the productivity effects and economical issues of different forest harvesting systems, such as rubber-tired skidder, farm tractor, forwarder and bulldozer. The study considered an area of 16 ha. (1-hectare) treatment blocks on the University of Maine's Forest, which was inventoried and marked for partial harvest. Each block was randomly assigned one of four yarding treatments, resulting in four replicates for each treatment. Results indicate significant differences between areas with and without traffic in the block. Yarding treatments produced a certain degree of compaction on skid trails, but there were no significant differences among the treatments. In terms of productivity, the forwarder showed cheaper production costs compared to the bulldozer. The study indicated that the forwarder was the better harvesting system. It resulted in minimum soil impact and damage to residual stands, and was associated with the highest productivity.

**Selection of forest harvesting systems of low impact on the soil using multicriteria evaluation techniques.** Bustos, O., Baltra, R. (*University of Talca, Chile; oscar.bustos@umit.maine.edu*).

Harvest operations planning traditionally considers productivity and efficiency related to engineering and economic features. However, forest harvesting activities are considering more the protection of environmental factors, especially the effects on the soil. The objective of this study was to formulate a methodology for the selection of machinery and harvest systems, according to economic, productivity and environmental considerations. It is important to choose machines that have the least impacts on soils because they are essential for the development of productive *Pinus radiata* D. Don plantations. By means of a database selected from several research and terrain evaluations of the different harvest systems, it was possible to identify the main soil variables that were associated with low impact machines and least environmental damage. The integration of this database was made by means of the Multicriteria Evaluation Techniques. The results confirmed that cutting by chainsaw, yarding by aerial cables, bucking with chainsaw and using a front loader caused less damage to the soils.

**Topographic indices of the erosion potential of forest-road networks: A case study from south-east Brazil.**

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In managed forested watersheds, unpaved roads erosion is regarded as the major source of sediment production. For a given area with its soil type, topography and rain erosivity, one main factor controlling the erosion potential is the length and steepness of the road ramps ('LS-factor'). This index is not automatically given by common GIS. Using the open source GRASS-GIS, an algorithm to differentiate distinct hydraulic ramps of the road networks from road vectors, digital elevation models were developed. In one part of our test site, 315 km of roads in a 12,000 ha plantation area in southeast Brazil were studied. The roads were distributed in a regular-grid and a terrain-adapted plan. Despite higher terrain roughness in the terrain-adapted road area, the LS-factor per road length was only 0.58 of the LS-factor of the grid-like roads and by the adapted roads their LS factor per ha was 0.7 of the grid-like roads. Our results show, that erosion indices of road networks, which can be calculated from commonly available data, may be an important contribution to environmental certification and road planning.

**Documentation and evaluation of vehicle movements in the forest.** Hamberger, J. (*Bavarian State Institute of Forestry, Germany; jhh@lwf.uni-muenchen.de*).

In the last 10 years the mechanized wood harvesting increased rapidly. More and more heavy machines, with high axle loads are moving on forest soils. The impact of their weight and wheels leads to compressions or plastic deformation of the soils. By driving on skidding lines, the damage can be concentrated on these lines but it can not be avoided. However, these lines are often not visible in the forest. Using the existing methods of quality assurance, it was expensive to guide the movement of machinery on the productive areas and the information collected was imprecise. Therefore, software was developed to record the movement of harvesting vehicles. On the basis of the results of the analysis of the system and the GPS-Navigation, a concept for documenting vehicle movements was developed. This concept includes ecological navigation when the harvesting equipment is in operation and an evaluation after harvesting is completed.

**Work safety on timber harvesting operations at thinning sites in Japan.** Imatomi, Y. (*Forestry and Forest Products Research Institute, Japan; tomy@ffpri.affrc.go.jp*).

Although forest resources are growing every year, thinning of man-made forests is inadequate in Japan. Thinning is indispensable to keep man-made forests healthy and vigorous and to improve the various functions of forests for public benefit. The use of swing-yarders for harvesting operations at thinning sites is recently increasing. However, measures to

prevent labour accidents in yarding operations with the swing-yarders are still insufficient. The objective of this study was to find the risk factors of accidents in the swing-yarder operations. A questionnaire was used to collect data on the risk factors and near-miss incidents of swing-yarder operators. The results of the analysis showed yarding directions, sizes of swing-yarders and yarding methods were related to work safety. Near-miss incidents occurred frequently when an excessive tension is generated in the wire rope and lateral yarding is done. It turned out that a proper wire rope tension and safe positioning of the person setting the choker were necessary to prevent labour accidents in logging with swing-yarders.

**Development of the rail type logging machine for steep terrain.** Jinkawa, M., Yamaguchi, H. (*Forestry and Forest Products Research Institute, Japan; jin@ffpri.affrc.go.jp; hiroy@ffpri.affrc.go.jp*), Furukawa, K. (*Gifu Prefecture Forest Science Research Institute, Japan; furu@forest.rd.pref.gifu.jp*), Satake, T. (*FUJII DENKO CO., Ltd., Japan; tsatake@fujii-denko.co.jp*).

We developed a rail type base machine to mechanize forest work on steep slopes. This machine runs on conventional railway tracks as well as monorail. The composition is two vehicles, consisting of a power truck and a work truck. The power truck can run safely on a slope with the inclination of  $\pm 45^\circ$  by the oil pressure drive. The running speed was 28–35 m/min (30–40°). The work truck is equipped with four-legged type outriggers, which operate by a remote control device called the crane-tilt mechanism. This mechanism is able to adjust the angle of the central pillar of the crane within the range of  $\pm 35^\circ$  and the grapple crane (8 m) with the winch (50 m) for the logging and wood-loading work. It can work also on ground at an inclination of 30°. Based on results of a logging trial, the work efficiency was 5.4 m<sup>3</sup>/day. In the future, we will be able to mechanize forest work on steeply sloping ground by applying this machine and technology.

**Analysis of ergonomic factors in the furniture industries of Uba, Minas Gerais.** Minette, L.J., Souza, A.P., Machado, C.C. (*Federal University of Viçosa, Brazil; minetti@ufv.br; amaurySouza@ufv.br; machado@ufv.br*), Silva, K.R. (*Grupo Orsa Florestal, Brazil*).

Ergonomic factors in a cluster of furniture industries of Ubá were examined for improving health, safety and well-being of the workers. Data on human factors and working conditions were obtained by means of questionnaires (interviews) and measurements. The noise levels were found to be high for most of the activities, surpassing the Brazilian legislation recommended limit of 84.3 dBA, for a 9-hour work shift. The average values WBGT (wet bulb globe temperature) were below the maximum limit allowed by the Brazilian norm (NR 15, Annex 3). Luminosity was insufficient for most of the workplaces in the furniture finishing sector. The anthropometric data indicated that workplace dimensions were not within the recommended values. The values for biomechanics variables used in furniture making activities were below the risk limits for damaging the vertebral column (L5-S1 disc). The activities related to stapling the superior and inferior parts of wardrobes, as well as door mounting, presented elbow articulation risks.

**The potential of improved working condition to enhance competitiveness of sustainably working timber enterprises in the Brazilian Amazon.** Mühlsiegl, R., Pokorny, B. (*University of Freiburg, Germany; reiner.muehlsiegl@fobawi.uni-freiburg.de; benno.pokorny@waldbau.uni-freiburg.de*).

Timber enterprises in the Brazilian Amazon working with Reduced Impact Logging have difficulty in competing financially with conventional loggers. One reason is that they have to train their own staff, due to a lack of qualified labour. To partly compensate for these investments, the enterprises hesitate to pay higher salaries. As a consequence, many enterprises suffer from high employee turnover rates. As shown by recent studies from developed countries, improved working conditions present a promising option for these enterprises to hold qualified workers, while avoiding additional payments. To get first insights into this option, we studied the working situation of forest workers of a timber enterprise in the Brazilian Eastern Amazon by applying the Job Diagnostic Survey. The study revealed that poorly qualified forest workers, especially, evaluated positively, the extremely hierarchical organization of forest operations. They identified financial incentives and adequate strategies to minimize separation from their families as most critical for their motivation. The study showed a wide gap between the working situation of Amazonian forest workers and that in developed countries. Methodologies that successfully analyze working conditions and motivation in developed countries need to be adapted to the Amazonian context.

**Development of a wood charcoal production system with the potential of high yield and low cycle time.** Muti Lin, J.C., Tsai, M.-H. (*National Chinyi Institute of Technology, Chinese Taipei; mutilin@mail.ncit.edu.tw; tsaimh@mail.ncit.edu.tw*), Wu, L.-J. (*Industry of Technology Research Institute, Chinese Taipei; LJWu@itri.org.tw*).

A prototype of a biomass charcoal production system with the potential of high charcoal/fix carbon yield and low cycle time was developed in the current study. The system is comprised of a solid biomass heat conversion unit, a carbonizer and a connecting pipe. The heat conversion unit is an updraft fixed bed gasifier with an embedded



combustor fueled by solid biomass for generating high temperature flue gas. The carbonizer is a variation of the Brazilian beehive charcoal kiln. The connecting pipe transports the hot and oxygen free flue gas from the gasifier to the carbonizer. The flue gas is radially distributed in the floor of the Brazilian beehive kiln through many small openings on the surface of a ring pipe. In the current study the syngas generated from the updraft fixed bed gasifier is fully burnt in the embedded combustor. This design results in very high temperatures and virtually oxygen-free flue gas from solid biomass. The hot and reductive flue gas is forced to circulate in the kiln to carbonize the biomass charge. Temperature distribution in the carbonizer is found to be much more uniform than any conventional charcoal kiln. Charcoal yield is increased and carbonization time is decreased, considerably.

**Accurate estimation and control on operation of efficiency and effects through forest utilization.** Nitami, T. (*University of Tokyo, Japan; Nitami@fr.a.u-tokyo.ac.jp*).

In order to keep forest operations under environmental tolerance, accurate estimation and control of the system and method are necessary. System Dynamics (SD), representation was useful to show the operational system and the interaction between that and the surrounding environment. It was also used to estimate productivity and showed how to harmonize the operation disturbance with the environment. Through those processes, feasible operational controls were designed. A field harvesting operation was modeled by the SD method and used to find an optimum level of operation for the equipment. The intensity of thinning and layout spacing of forest roads were developed. Interactive and iterative methods of the SD model were useful in developing the structure of the operational system and devise a way to modify the system to use it at a more efficient level.

**The driver's influence on the productivity of the harvester. Sample design, partio-autonome time studies, productivity model.** Purfürst, T. (*Germany; thomas.purfuerst@forst.tu-dresden.de*).

Productivity models indicate the performance that can be expected with a specific procedure, under specific conditions. In systems theory, the performance of a technical forest production system depends on various independent factors, which have already been tested in many studies. The individual performance of a collaborator, which is seen as decisive in manual or motor-manual activities, is disregarded in machine work. Practical experience, however, indicates that the machine driver is a decisive factor for the system's performance, so that all productivity models that do not allow for this fact, include an error not yet quantifiable. In order to compare drivers under similar conditions and to be able to deduce a performance standard, test persons were examined in four different ways: 1) in the stand, with several working turns, 2) on an 'ideal' surface performing a specific task, 3) in the simulator with identical test courses, and 4) with the assistance of a certified expert who evaluates the performance standard. With these data and under the assumption that the performance of the machine conductor follows a log-normal distribution, it is possible to classify the performance of the driver. Therefore, a modular model should be proposed to explain the performance of machine drivers.

**Navigation beside public roads. NavLog, a German wide initiative for digitizing the forest road system to optimize the wood logistic chain.** Stoecker, M. (*University of Muenster, Germany; mstoeck@uni-muenster.de*).

In Germany, 33 Mio tonnes per year of timber are transported by trucks out of the forests. The transport generates approximately 2.6 Mio transport kilometres for the trucks. By looking at the length of stay of the timber trucks in the forest, one observes that approximately 31% of the time is necessary to find and reach the timber stack. For the way back to the public roads, the trucks need around 9% of the total time inside the forest. By applying a continuous navigation system from public roads to forest roads the German timber and forest industry calculates with savings up to \$12.1 million annually. Due to this in 2003 the German-wide federation of timber and forest industries launched an initiative called NavLog. The members of NavLog (Federations, companies and universities) developed a concept for collecting, distributing and actualizing the relevant forest road data. The realization started in April 2004. The forest road data will be distributed by a 'non profit' organization, called NavLog GmbH carried by the timber and forest industries. This presentation will show the state of the art of the NavLog Initiative, future plans and realizable potentials.

**Organic planting media produced from paper mill bio-solids.** Wan Ab Kadir, W.R., Ahmad, R., Abdullah, R. (*Forest Research Institute Malaysia; rashidah@frim.gov.my; rozita@frim.gov.my; rosazlin@frim.gov.my*).

Trials were carried out in FRIM to convert paper mill biosolids into organic planting media via composting. Raw paper mill biosolids, foul-smelling and containing 75% moisture, was tested as composting material in three treatments, 1) biosolids alone, 2) biosolids plus palm oil bunch residues in a 75:25 ratio, and 3) biosolids plus palm oil bunch residues in a 50:50 ratio. As the first two treatments did not show any increase in pile temperature, we decided to work with only the 50:50 mixture ratio. Compost piles of oil palm residues mixed with biosolids reached only 29 °C after 3 days, with the help of mesophilic microorganisms. Chemical analysis showed significant increases in acidity, due to the

formation of organic acids. Total nitrogen decreased due to dilution from EFB fibres and to volatilization, and total P declined due to dilution. The increase in total K is attributed to the high K content in the plant residue. The material that resulted from composting has a soil-like structure with the colour of organic soil; it was friable and had the odour of fresh soil. The composted material was found to promote seed germination and root development.

**Bundling, a way to improve the procurement of forest fuel.** Wästerlund, I. (SLU, Sweden; [Iwan.wasterlund@ssko.slu.se](mailto:Iwan.wasterlund@ssko.slu.se)).

Present procurement of logging residues from stand to combustion can be improved. From a logistic point of view, the losses in the supply chain during passive storage and bad utilization of transport vehicles are disturbing. Roughly only 50% of the potential energy left after clear felling reaches combustion. Bundling can be a way to improve the supply chain and production of bundles using WoodPac bundling machine as well as storing and shave off of fine material during bundling was followed. About 29 MWH was produced per effective hour, 10% losses at 9-month storage but on the other hand 20% of the nutrients in the slash was returned to the stand as shave offs. The machines used only 1% of the energy amount in the material delivered at roadside. With bundling the amount reaching combustion may raise to 65–70%. Still the bundling may be improved with higher efficiency and CRLs with better sizes fitting to the supply chain.

**Efficient terrain transport – money versus soil damage?** Wästerlund, I. (SLU, Sweden; [Iwan.wasterlund@ssko.slu.se](mailto:Iwan.wasterlund@ssko.slu.se)).

Different time studies indicate that a bigger forwarder will produce more timber at road side per hour and in a cheaper way than a small one. However, present big forwarders (mass > 34 Mg loaded) may influence soil in the deep layers and may cause severe soil compaction down to 40 cm depth. Experiments with bogey tracks showed that good bogey tracks may reduce rutting in the soil and even reduce rolling resistance. Different measures to avoid soil disturbance at extraction are discussed in the paper and some new results presented. Finally, a draft for practical assessments of soil damage is presented and discussed.

**Forestry contractors: The ignored link in the wood chain.** Westermayer, T. (Albert-Ludwigs-University, Freiburg, Germany; [till.westermayer@pluto.uni-freiburg.de](mailto:till.westermayer@pluto.uni-freiburg.de)), Kastenholz, E. (Office for Occupational Safety and Work Organisation, Germany; [edgar.kastenholz@enfe.net](mailto:edgar.kastenholz@enfe.net)), Lewark, S. (Albert-Ludwigs-University, Freiburg, Germany; [siegfried.lewark@fobawi.uni-freiburg.de](mailto:siegfried.lewark@fobawi.uni-freiburg.de)).

The interdisciplinary research project WALD focuses on contractors in the wood chain and their contribution to employment in rural areas. While contract labour gains increasing importance throughout Europe, heralded by technical, economic and political developments as well as by rural social change, there is still a lack of knowledge about the social and economic situation of contracting enterprises. Using qualitative methodology, and integrating statistical data, the position of contractors in the wood chain in Germany has been investigated. Their position between forest owners and wood processing industries – both demanding flexibility and low costs – is rather weak. Market conditions, political regulations and the predominance of micro-enterprises in this sector (employing less than ten persons) with weak political representation lead to a situation that is economically precarious and is generally non-innovative. Several strategies for contractors to cope with these issues and with structural change were identified. Informal co-operations and personal networks are particularly important. The results of the WALD project help not only to establish new ways of accessing this clientele, they also demonstrate how political and economical settings influence the role of contractors (and the wood chain as a whole) can play in sustainable regional development.

## **General posters: Forest assessment, modeling and management**

Organizer: Lauri Valsta *University of Helsinki, Finland; [lauri.valsta@helsinki.fi](mailto:lauri.valsta@helsinki.fi)*

**Forest inventory by means of digital aerial photographs and laser-relascope based field measurements.** Melkas, T., Holopainen, M., Mäkinen, A., Leino, O., Norjamäki, I. (University of Helsinki, Finland; [timo.melkas@helsinki.fi](mailto:timo.melkas@helsinki.fi), [markus.holopainen@helsinki.fi](mailto:markus.holopainen@helsinki.fi), [antti.makinen@helsinki.fi](mailto:antti.makinen@helsinki.fi), [olli.pt.leino@helsinki.fi](mailto:olli.pt.leino@helsinki.fi), [ilkka.norjamaki@helsinki.fi](mailto:ilkka.norjamaki@helsinki.fi)).

A major factor affecting the accuracy of numerical image interpretation is the accuracy of the ground-truth data used. The standard error of stand data derived from compartment-wise inventories, commonly used as ground-truth data, has turned out to be as high as 25%, which naturally is transferred also to the interpretation accuracy. Ground-truth errors may in fact be even larger than the actual interpretation errors. It is therefore important to improve the accuracy of

ground-truth data. Modern measuring equipment provides a means for improving the efficiency and accuracy of field measurements. Today field measurements are carried out with the aid of field computers and satellite positioning systems with which measured forest data can be transferred directly to forest databases attached with accurate positioning data. Devices for improving the efficiency and accuracy of stock measurements have also been developed. The Helsinki University Dept. of Forest Management has developed a new stock measurement device called the laser-relascope that is based on laser measurements of angles and distances. The device can be used to measure tree heights and tree diameters at arbitrary heights from plot centers without actually visiting the trees. All measurements are further positioned using GPS. The objective of this study was to evaluate possibilities and accuracy of laser-relascope measurements as ground-truth data in numerical photo interpretation of digital aerial photographs.

**Developing analytical tools for the analysis of ecological balance using the general land classification: Forestlands and alienable and disposable lands.** Odsey, M.S. (*DENR-CAR, Philippines; msodsey@yahoo.com*).

Two analytical tools were developed to mainstream population into the analysis of forest and land resources as follows: 1) land:man development ratio, and 2) land:man ecological ratio. The first is the land:man development ratio, so-called to indicate that the ratio involves the computation of how much area of alienable and disposable lands are available for development needs (for example, residential land needs, agricultural land needs) of a person in a municipality, province, or region. The second is the land:man ecological ratio, so-called to indicate that the ratio involves the measurement of how much area of forestlands are sustaining the ecological needs of each person in a certain municipality, province, or region. An analytical framework was also developed that linked the land:man development ratio and the land:man ecological ratio in the analysis of land classification relative to ecological balance. The framework identified four categories that showed the state of ecological balance and remedial measures that should be taken by local or the state governments in each identified category.

**Adaptive cluster sampling.** Pelz, D.R., Yue, C. (*University of Freiburg, Germany; pelz@biom.uni-freiburg.de*).

Adaptive cluster sampling is a highly efficient sampling method for clustered populations. A study was performed on the inventory of ant nests in a forest area to study the efficiency of adaptive cluster sampling compared with random sampling. The efficiency of the method was tested for alternative grid widths, sampling intensities and clustering indices. It could be shown that the adaptive cluster design was more efficient, resulting in a smaller optimal sample size.

**Tree general volume equations for *Nothofagus betuloides* in Chilean Patagonia forests.** Promis, A., Cruz, G., Schmidt, H., Caprile, R., Caldenty, J. (*Universidad de Chile, Chile; gcruz@uchile.cl*).

*Nothofagus betuloides* is one of the most important tree species of Chilean Patagonia forests. Tree volume estimation of this species is only based on local volumetric equations. General volume functions were generated to estimate the total volume of *N. betuloides* trees growing under virgin and logged old-growth forests. A total of 125 trees were measured from five geographical locations (Continental Magallanes and Tierra del Fuego). Trees with stump diameters (DSH) from 12–69 cm, diameters at breast height (DBH) from 11–62 cm, heights (H) from 9–25 m and site qualities (S) range from 16–27 m were selected. The site quality was expressed as the height of the 10 highest mature trees within one hectare. Allometric equations were developed as a function of DSH and S, DSH and H, DBH and S, and DBH and H.

## General Posters: Forest products

Organizer: Howard Rosen *USDA Forest Service, USA; hrosen@fs.fed.us*

**Visualization of shrinkage behaviour of tracheid by CLSM technique.** Arikawa, J., Matsumura, J., Sakagami, H., Hasegawa, M., Oda, K. (*Kyushu University, Japan*).

Confocal Laser Scanning Microscopy (CLSM) was applied as a new method of observing shrinkage and its anisotropy. These new techniques allow observation of water containing specimens. Sugi and Akamatsu were used in this study. Sequential images of transverse faces from the saturated condition to the dried condition were acquired. The shrinkage of tracheid cells was also determined by measuring tangential diameter of tracheid and lumen, radial diameter of tracheid and lumen, thickness of tangential wall and radial wall. As a result, it was found that the CLSM technique is an effective method of observing shrinkage of tracheid cells with desorption.

**Relation between analytic parameters from signal processing, wood anatomy and perceptive classification of xylophone bar materials.** Brancheriau, L., Baillères, H., Détienne, P. (CIRAD, France; loic.brancheriau@cirad.fr).

Wood is an essential material for the manufacture of musical instruments. Evaluating its acoustic qualities falls within the pooling of several fields of competence; the instrument maker brings a very invaluable empirical knowledge which allows the choice of the best species. In addition, knowledge in mechanics and anatomy of wood allows a better comprehension of the origin of these qualities. In parallel, research in musical synthesis associated with the problems of psychoacoustics elucidates the perceptive attributes, which make the acoustic quality of a given species. The study relates to sixty tropical wood species and is limited to the percussion instruments such as xylophone. Two classifications are carried out and put in parallel, that of the instrument maker and that given by the signal analysis, in order to identify the parameters of the signal and the wood anatomy which are determined from the point of view of the acoustic quality of material.

**Microwave treatment accelerates solar wood drying.** Brodie, G. (University of Melbourne, Australia; grahamb@unimelb.edu.au).

The rate at which wood dries depends on board thickness, air temperature and humidity, speed of air flow over the wood surface and the moisture permeability of the wood. Solar power is a convenient and cheap source of energy that can be easily harnessed to control air temperature and humidity; however other techniques are needed to manipulate moisture permeability. Microwave heating rapidly generates steam inside moist wood. The resulting internal pressure selectively ruptures the wood structure creating radial pathways through which moisture may readily move. In an experiment, microwave treated *Eucalyptus regnans* samples dried in 33% less time than untreated samples dried in a solar kiln, which was specifically designed for this research. There was no significant difference in the macroscopic quality of boards in either treatment; however micro-fractures were observed in the microwave treated samples. This reduction in drying time is attributable to a combination of wood structure modification and the initial moisture loss associated with microwave treatment. The energy requirements for microwave treatment were approximately 104 kWh/m<sup>3</sup>, which costs about \$15.08/m<sup>3</sup>. In conclusion, microwave treatment significantly reduced solar wood drying time without affecting visible appearance.

**Derivation of furfural from the low-temperature catalysed fast pyrolysis of lignocellulose.** Butt, D. (University of Melbourne, Australia; davidb@unimelb.edu.au).

Pyrolysis is a promising technique for the derivation of a wide range of chemicals from renewable lignocellulosic resources, although the extreme complexity and chemical instability of 'pyrolysis oil' has frustrated most efforts to develop viable thermochemical conversion technologies for the derivation of specific chemicals. Furfural is one such chemical and is currently prepared industrially from the acid hydrolysis of pentosan rich materials, such as oat hulls or corn cobs. The low temperature, Lewis acid catalysed fast pyrolysis of pentosan rich lignocellulose was investigated in order to maximize furfural yield and purity. Three such acids were investigated, zinc (II) chloride, Iron (III) chloride and Co (II) Chloride. Fast pyrolysis was achieved by use of an electrically heated bench-scale fluidized-bed reactor. The temperatures investigated ranged between 240–380 °C. It was found that incorporation of such acids under fast pyrolysis conditions resulted in furfural yields in excess of 10% m/m, or up to 60% of the theoretical yield. These results are comparable to the furfural yields obtained through current industrial processes.

**Impact of curve sawing on southern pine dimension lumber volume and value yields.** Carino, H.F. (Auburn University, USA; carinhf@auburn.edu), Blanche, C.A. (USDA Cooperative State Research, Education & Extension Service, USA; cblanche@csrees.usda.gov).

This paper discusses the impact of curve sawing on southern pine dimension lumber manufacturing, particularly in terms of lumber product volume and value yields from tree-length log inputs with varying severity of sweep. The study mill had been processing southern pine tree-length logs with an average diameter-at-breast-height (inside bark) of 32.5 cm, average length of 14.3 m, and with sweep severity that varied by 10.2 cm. Lumber recovery studies were conducted on 340 tree-length log sections. It was determined that with curve sawing, the study mill could produce about 0.0024 m<sup>3</sup> (7.5 board feet) of dimension lumber valued at \$3.28 per cubic foot of log input, i.e., a weighted average improvement of about 8.7% over that of the conventional (i.e., no curve sawing) sawing method. It was established that lumber volume and value yield improvement due to curve sawing increased with input log sweep severity. On average, such improvements could be up to 5.6%, 15.4%, 25.0% and 47.1% from logs with 2.54 cm (1-inch), 5.08 cm (2-inch), 7.62 cm (3-inch), and 10.16 cm (4-inch) sweeps, respectively. Evidently, given the same input log volume, sawmills with curve sawing technology like the study mill could benefit further economically by increasing the procurement (or proportion) of input logs with sweep.

**Effect of outdoor exposure on the properties of wood particle-plastic composites and using for interior flooring material.** Chen, H.-C. (*Shu-Te University, Chinese Taipei*), Chen, T.-Y., Hsu, C.-H. (*National Chung-Hsing University, Chinese Taipei*; [tychen@dragon.nchu.edu.tw](mailto:tychen@dragon.nchu.edu.tw)).

This study used flat pressing to make wood particle-plastic composites, which were tested with outdoor exposure. Strength of the composites decreased after 48 weeks of outdoor exposure. When the proportion of wood particles increased, the strength of the composites decreased more obviously. Retention of bending strength after 48 weeks exposure was 71% and 65% for composites that had wood:plastic ratios of 50:50 and 75:25, respectively. The bending strength of composite W50P50 retained 86% of its value following treatment with boiling water for 2 hours and this magnitude of decrease was similar to that obtained after 36 weeks of exposure. In comparison, the bending strength of composites W75P25 retained 67% of its value after 48 weeks. In another study, veneer laminated W50P50 composites were subjected to a flooring test in environments of different humidity levels and their dimensional stability was measured. Results showed that size stability of the wood particle-plastic composite was better than either the solid wood floor or the plywood laminated veneer floor. Swelling of the wood particle-plastic composite was 25~33% of that of the plywood laminated veneer floor.

**Study on utilizing mobile DIY (Do-It-Yourself) woodworking education promoting a forest products culture.** Hsu, C.-H., Chen, T.-Y., Shiau, R.-J., Tsai, T.-Y. (*National Chung-Hsing University, Chinese Taipei*; [tychen@dragon.nchu.edu.tw](mailto:tychen@dragon.nchu.edu.tw)).

This poster shows the results of a study to determine how mobile DIY woodworking education programs, developed to help the forest production industry, effect consumer behaviour and communication strategy. There were 313 questionnaires administered to find the promotional value of using DIY woodworking education. For example; in education, responders agreed to use woodworking programs for school teaching materials of environmental protection; for leisure, responders expressed a desire to join woodworking programs; for material use; responders agreed to consider wood for its usefulness and price. We suggest that the promotion of woodworking programs be based on leisure experience and education. The promotional point of this study is to transmit to the consumer the appropriate utilization of wood by education programs. The communication strategy was to push learning attitude, which could reinforce woodworking education programs.

**Improvement of the acoustic properties of Sitka spruce with chemical treatment.** Cho, C.-L., Wu, S.-Y., Yeh, S.-U. (*National Ilan University, Chinese Taipei*; [clcho@niu.edu.tw](mailto:clcho@niu.edu.tw); [sywu@niu.edu.tw](mailto:sywu@niu.edu.tw)).

Improvement of the acoustic properties of low quality wood for musical instruments is very important. This would solve a problem originating in the short supply and expensive cost of high quality wood for musical instruments. This study investigated acoustic properties of quarter-sawn Sitka spruce plates treated with three kinds of low molecular weight phenol resin (LPR) concentrations by non-pressure process. Resonant frequencies of modes (1,1), (0,2) and (2,0) were measured by the Chladin plate vibration method to evaluate acoustic properties. Results indicated that moisture contents of chemically treated specimens in equilibrium with 20 °C temperature and 65% relative humidity were 4.6% ~7.0% lower than those of untreated specimens. The hygroscopic ability was reduced considerably. Resonant frequencies of different modes, modulus of elasticity and shear modulus were increased significantly after treatment. The amounts of improvement were better for modulus of elasticity in the radial direction and shear modulus than those in the longitudinal direction. Consequently, the anisotropy to the ratio of Young's modulus to shear modulus were reduced. Specific modulus of elasticity in the longitudinal and radial direction and specific shear modulus, usually used as important parameters for acoustic assessment of stringed instruments, were increased about 6%, 22% and 54% respectively.

**Creep of microwave-modified timber: Predicting creep deflection of microwave-modified radiata pine (*Pinus radiata*).** Dien, D.L., Ozarska, B. (*University of Melbourne, Australia*; [l.dang@pgrad.unimelb.edu.au](mailto:l.dang@pgrad.unimelb.edu.au); [b.ozarska@land-food.unimelb.edu.au](mailto:b.ozarska@land-food.unimelb.edu.au)), Murray, M.H. (*Queensland University of Technology, Australia*; [m.murray@qut.edu.au](mailto:m.murray@qut.edu.au)).

'Vintorg' is a new innovative wood composite product developed by CRC Wood Innovations by resin impregnation of microwave-treated timber. The product is intended for a wide range of applications including structural engineering members. This study is being undertaken to obtain experimental data on the creep performance and long-term behaviour of the new product. In the experiment, samples of untreated radiata pine and Vintorg (treated with MUF resin and Isocyanate resin) were loaded in four-point bending at 30% of the matched samples' failing stress, in a protected external environment in Brisbane, Australia, for a period of nine months. The Vintorg samples have produced lower relative creep deformations than the untreated samples. The samples treated with MUF resin showed better creep resistance than the samples treated with Isocyanate resin. Data from the first 90 days were used to obtain parameters for the two chosen models: the power law model and the 5-parameter model. While both models provided good fitting for the data, the 5-element model was found to possess better extrapolation capacity beyond the regression period. An increase in the period of regression data from 90 to 150 days significantly lowered the errors in both of the models.

**Effect of chemical component of wood on wood forming products for a high-density charcoal production.**

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To manufacture a high-density charcoal from forest resources, as a substitute for coke, is expected not only as an effective utilization of unused biological resources but as a way of saving fossil fuel resources. Milled wood, such as sawdust, can be formed by heating and pressurization, without adhesives. It is known from experience that a form of forming wood is maintained after pressure release, following compression with heating. It is theorized that some chemical components of wood cause fixation of formed wood by heating. Therefore, we investigated the effect of heating and compression on chemical components of milled wood. Each chemical component, separately and as mixtures, was formed by compression with heating and carbonized at 1000 °C, after which the specific gravity was measured. Cellulose and holocellulose were fixed by compression with heating but lignin was not. Other cellulose materials such as waste paper and absorbent cotton were also formed by compression with heating and the formed products had high density. The density of these carbonized products varied with their lignin content.

**Study on mechanism of carbonization for thinning wood of Chinese fir and application of its carbonized materials in environmental protection.** Huang, B., Chen, X.-R., Jiang, M.-S., Tang, X.-P. (*Fujian Agriculture and Forestry University, P.R. China; bhuang@public.fz.fj.cn*), Gao, S.-Y. (*Nanjing Forestry University, P.R. China*).

The study of wood charcoal utilization and the development of advanced carbon materials from wood charcoals has become widespread. Pyrolysis experiments on Chinese fir thinnings, one of the fastest growing tree species in Southern China, have been undertaken using two-step carbonization, namely capped and uncapped carbonization, with carbon dioxide, nitrogen, oxygen, air and their mixture. The experiment focused on the basic pyrolysis process of saw dust and the laws governing carbonized materials under different carbonization conditions. With Raman, XRD, XPS and other analytical methods, research and characterization on chemical structure, surface functional group, pore size distribution, as well as specific surface area and microcrystalline structure of carbonized material were conducted. By means of SEM, HRTEM and nanophase carbon tubes, onion-like graphitic particles in a diamond structure were first found in wood charcoal of Chinese Fir. Furthermore, the experiments revealed that the critical temperature where the qualitative change of carbonized material occurs is 700 °C.

**Mechanical performance of wood bending following microwave softening.** Juniper, L., Ozarska, B., Burvill, C., Worsey, M. (*University of Melbourne, Australia; ljuniper@pgrad.unimelb.edu.au; bo@unimelb.edu.au; colb@unimelb.edu.au; mworsey@unimelb.edu.au*).

The research explores the experimental stresses, strains and external forces generated in microwave heated wood, *Eucalyptus regnans*, as it is being bent to shape – with the main intent of this research directed towards quantitative determination of these variables allowing optimization of the wood bending process. The data from the experimental stage is used to form empirical relationships between the forces and bending angle. These models will allow comparison between other wood species tested, and will provide validation data for theoretical work. Furthermore, the internal strains imposed on the wood, which include; longitudinal tension and compression, shear and transverse tension and compression, are measured. This will provide information indicating which strains are significant to the bending process. Identifying and managing these strains to optimum levels by controlling external forces will promote improved bending performance of the wood. The theoretical part of the study involves the development of a mathematical model for the wood bending process using a computer generated finite element analysis (FEA) procedure. This model will be a template for assessing bending characteristics of plantation and re-growth species. A prototype wood bending machine has been designed and manufactured and testing is underway to provide research results for future commercial applications.

**The effects of supersonic treatment on the structure and components of oak wood.** Konovalova, N.T., Konovalov, N.T., Bazhenov, A.N., Parshov, S.M. (*SLR “OST-ALKO”, Russian Federation*), Stasova, V.V., Antonova, G.F. (*Russian Academy of Sciences, Russian Federation; institute@forest.akadem.ru*).

Changes in the structure of oak (*Quercus robur*) wood and its components after supersonic treatment were studied. The influence of acoustic waves on oak wood in such media as air, water and water-alcohol solution was investigated by anatomical and chemical analysis, gel-filtration and IR-spectroscopy. The principal changes in wood structure after supersonic treatment were observed in cell walls of libriform and its porosity. The effects of acoustic waves on cell wall structure during 15 and 35 minutes in air were similar, whereas the treatment in water resulted mainly in structural changes of the middle lamella. Supersonic treatment of oak wood produced structural changes in lignin, increased the amount of its alcohol-soluble fraction, especially after treatment of wood in water, and water-alcohol media. After treatment with acoustic waves, gel-filtration analysis showed considerable change in the molecular weight of lignin,

especially its alcohol-insoluble fraction. Infrared spectroscopy and histochemical tests showed that it is mainly the siringylpropanoid part of oak wood lignin that is destroyed by supersonic treatment. Supersonic treatment influenced the yield of carbohydrates, phenols and catechin after treatment with water only, or a 65% water-alcohol solution.

**Analyzing evolved species and estimating combustion emissions of four types of commercial adhesives.** Lin, H.C. (NCYU, Chinese Taipei; alexhlin@mail.ncyu.edu.tw), Shiah, T.-C. (TFRI, Chinese Taipei; ccshiah@serv.tfri.gov.tw).

Four types of commercial adhesives, urea formaldehyde resin adhesives (UF), melamine-urea formaldehyde copolymer resin adhesives (MUF), phenol formaldehyde resin adhesives (PF) and diphenylmethane diisocyanate adhesives (MDI) were studied by two methods. The first used TGA-IR to analyze the kinds of evolved species under thermogravimetric analysis, and the second used CEM technology, one of the main waste processes in Taiwan, to monitor the effectiveness of the emission gas temperature, as well as the emitted gases (O<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub> and SO<sub>2</sub>). Results obtained from the IR response of all adhesives in the TGA-IR tests showed that the absorbance of UF, MUF and MDI was higher than that of PF. From the results of CEM combustion emissions, the SO<sub>2</sub> was not produced in the emission gas during the combustion of various adhesives. These results, when examined with TGA-IR and CEM, enabled us identify the kinds of evolved species and emission contents. It has been suggested that PF is the most environmentally friendly adhesive, because it has the least environmental impact. Using TGA-IR, to analyze four types of adhesives, in combination with CEM, has produced useful results, involving the identification of evolved and emitted products.

**Displacement of imported bleached softwood pulp with bamboo kraft pulp for making newsprint.** Resalati, H., Moosavy, S.A. (Gorgan University of Agricultural Sciences and Natural Resources, Iran; hnresalati@yahoo.com).

Hardwood CMP pulp is not strong enough to make newsprint, especially in high speed machines. In this respect, up to 20% of softwood chemical pulp is used as reinforcement. Lack of softwood species and deficient foreign currency for importing long fiber pulp is a challenge for pulp and paper industries in developing countries. In northern Iran, a few species of bamboo grow naturally, although in a limited area. Based on worldwide experience, the possibility of using local bamboo kraft pulp in place of imported long fiber for making newsprint was investigated at the laboratory scale. Bamboo kraft pulp at kappa number of 20 was made in the laboratory and has been semi-bleached by using oxygen delignification and hydrogen peroxide bleaching sequences, to 73% ISO brightness. The results of the comparative study of reinforcing the CMP pulp by either imported long fiber or bamboo kraft pulp have shown that the fiber furnished by 75% hardwood CMP + 25% bamboo kraft pulp had even better opacity with similar strength. Compared with the reference fiber of 83% CMP + 17% imported long fiber, whenever tear strength is a limiting factor, the fiber furnish of 25% kraft bamboo + 75% hardwood CMP + 5% imported long fiber, is recommended, based on laboratory experiment.

**Withdrawal properties of dovetail joint.** Su, W.-C., Wang, Y. (National Chiayi University, Chinese Taipei; wencsu@mail.ncyu.edu.tw; woody@mail.ncyu.edu.tw), Ku, C.-W. (National Chiayi Industrial Vocational School, Chinese Taipei).

T-type dovetail joints were designed to conduct withdrawal tests for hard maple and Japanese cedar. The effects of tenon sizes (length, width and thickness), application of glue, tail angles and fitness were studied. The result showed that hard maple was significantly greater than Japanese cedar in withdrawal strength. It was also found that there was no significant difference in the withdrawal strength among the tenon sizes (width, length and thickness), except for the group of C-W30L15T15. No significant effects of tail angles, application of glue and fitness on the withdrawal strength of the dovetail joint were observed. The failure modes of hard maple joint contained (A) the longitudinal split in the mortise, (B) the shear off in the tenon tip, (C) the mixed mode of mode A and B and (D) the compression of the tenon tip. The most frequent mode was mode A, followed by mode C. For Japanese cedar, only mode B and mode C were observed and mode C was found more often. Thus, the findings showed that the failure modes of dovetail joints for the two wood species all resulted from the failure of the materials rather than the joint.

**Carbon dioxide emission from log production process: Evaluation using life cycle assessment method.** Suzuki, H., Yamaguchi, S., Umeda, S., Ohkawabata, O. (Forestry and Forest Products Research Institute, Japan; hidesuzu@ffpri.affrc.go.jp).

Wood is regarded as a zero emission material for carbon dioxide (CO<sub>2</sub>) because, when it is discarded, it releases the same amount of CO<sub>2</sub> as it absorbed in growth. However, machines such as excavators, chain saws and trucks are used for forest road construction, felling and transporting, and much CO<sub>2</sub> is released during log production. This study calculated the amount of CO<sub>2</sub> emission from log production, using the life-cycle assessment method. One of the CO<sub>2</sub> emission sources is the manufacturing activity of products and machines for forestry and this was defined as embodied emission. The operating time for each activity is a small fraction of the total for an individual machine, and we calculated the embodied emission of machines from the rate of depreciation by those operations. The other main

emission source is fuel consumption by the machines. As a result, it was found that much CO<sub>2</sub> is emitted from road construction and the emission from a road of 5m width is 72kg C per 1m length.

**Evaluation of production lines of jambs and garrisons through linear programming.** Uliana, L.R., Garcia, J.N., Nolasco, A.M. (*Universidade de São Paulo, Brazil; (lruliana@esalq.usp.br; jngarcia@esalq.usp.br; amnolasc@esalq.usp.br)*).

The concern with the efficiency in the allocation of scarce resources has been stimulating the development of mathematical models for optimization of production systems. Optimization technology has become a key component of modern-day decision-making in financial, biotechnological, aerospace, agriculture, energy, telecommunications and internet areas. In this work, linear programming was used to create, establish and consolidate assistant mechanisms for the non-subjective evaluation of production efficiency of jambs and garrisons in a joinery industry, considering the generation and allocation of wood residues from mechanical processing. It was verified that the maximum gross income is obtained in the manufacture of some products only, and this may be changed due to market restrictions and price fluctuation. More important yet, is the fact of having verified that some products, in determined market conditions, present negative income contribution, that is, contribute for the reduction of the global gross income, when produced and commercialized.

**Potential for the utilization of roundwood and wood raw materials in relation to the wood product markets.** Verkasalo, E., Enroth, R.-R. (*Finnish Forest Research Institute, Finland; (erkki.verkasalo@metla.fi; raija-riitta.enroth@metla.fi)*).

One of the key challenges facing roundwood producers and wood product companies in Finland will be to ensure the demand of domestic wood and wood-based products. The Finnish Forest Research Institute is carrying out an extensive research programme during the years 2002–2006, aiming to diversify and develop wood utilization in relation to the wood product markets. This multi-disciplinary programme brings together researchers from various research organizations in the fields of wood science, wood and forest technology, forest products marketing, silviculture and forest pathology. The programme focuses on technical properties, quality and value of wood and timber of Scots pine, European birch and aspens, novel upgraded wood products, procurement of wood raw materials in relation to timber quality, value formation of timber stands and modern timber scaling. The studies aim, in particular, to the diversification of wood utilization and to the competitive advantage of Finnish wood in wood product markets. The results show that wood product industries have opportunities to diversify the use of wood, for example by utilizing small-diameter thinning wood and by developing the use of birch. However, the profitability of production requires individually tailored solutions for companies based on market analyses and specific raw materials.

**Bending properties of dovetail joint.** Wang, Y., Su, W.-C. (*National Chiayi University, Chinese Taipei; (woody@mail.ncyu.edu.tw; wencsu@mail.ncyu.edu.tw)*), Ku, C.-W. (*National Chiayi Industrial Vocational School, Chinese Taipei*).

Joint strength, efficiency of rigidity and failure conditions were examined for dovetail joints under bending tests. Hard maple was significantly greater than Japanese cedar in the bending moment. However, no significant difference in the efficiency of joint rigidity was found between the two wood species. The bending moment became greater with the increase in tenon length. The moment changes with the degree of fit, following the descending order of interference fit, transitional fit and clearance fit. No significant influence on the bending moment was found among the tenon widths, the tenon thickness and the application of glue. The efficiencies of rigidity increased with the increase of the tenon width and the tenon thickness. Moreover, the efficiency of rigidity was significantly correlated with the adhesives. Both the joint with UF resin and that without glue were superior to that with modified PVAc in the rigidity efficiency. The failure modes contained (A) the longitudinal split in the mortise, (B) the shear off in the tenon tip and (C) mixed mode of mode A and B. Mode A and C consisted of 96% of the failed specimens.

## **General posters: Social, economic, information and policy sciences**

Organizer: Niels Elers Koch *Danish Centre for Forest, Landscape and Planning, KVL, Denmark; nek@kvl.dk*

**Evaluation of activities in Kampung Seri Tanjung homestay program, Masjid Tanah, Melaka, Malaysia.**

Abdullah, N.M.H., Yaman, T.H.A.R., Jusof, K. (*Universiti Putra Malaysia; Malaysia; (nurmastura@putra.upm.edu.my; mas\_along80@yahoo.com; kamaruz@aeroscan.biz)*).

Homestay program—living, experiencing and learning about rural area or villagers' lifestyle and culture—is one of the community-based eco-tourism products. The objective of this study is to evaluate the participation characteristics of



visitors in Kampung Seri Tanjung Homestay Program in Melaka. Questionnaires were distributed to 50 visitors who visited the homestay program during the period of study. Descriptive and Kruskal-Wallis tests were used to determine the mean and percentage of the trip characteristics, activities and reasons for satisfaction and dissatisfaction. Results indicated that all the visitors only spent two days under the homestay program. Desire to be close and learn about local culture (88%), was the major purpose to participate in the homestay program, while some of the visitors (24%) had chosen to relax and experience living in the countryside. Of 11 programs offered, only five activities are preferred most by the visitors—welcoming ceremony (199 pts), learning to make handicrafts (102 pts), visit to beach/ recreational areas (77 pts), coconut plucking demonstration by monkeys (76 pts), and enjoying Malay meals and traditional food (75 pts). This study hopefully can help the management of the homestay program or the agency to improve and enhance the quality of present and future activities.

**Trends and goals in Israel's tree protection laws.** Avni, Z. (*KKL Forest Department, Israel; tzvika@kkl.org.il*).

Two laws exist whereby Protected Trees are defined in Israel: The Forest Ordinance (1926 in the British Mandate of Palestine) including the regulations arising from it, and the regulations based on the Law of National Parks, Nature Reserves, National Monuments and Memorial Monuments (1998) decreeing which trees and wooded plants are included in the definition of Protected Natural Assets. In addition, all trees growing in the protected Forests Lands and Nature Reserves are protected based on growing location. A review of all decrees concerning tree and shrub protection, since 1926, can teach us about the changes in the trends and goals of decision makers throughout this period. The first trend was agricultural economic stand protecting fruit trees. At the same time, a trend of preserving native Mediterranean trees and preventing soil erosion existed. Later, a trend to protect introduced forest trees was added. After the founding of the State of Israel, many wild trees species were added to the Protected Trees lists. In the last list (1997), the prominent change in the trends and goals of tree protection is one of the protecting ornamental planted trees.

**Policy and technological regimes in the evolution of the Engineered Trees in Forestry Innovation System in Europe.** Battistel, G.A. (*AQA-IASMA, Italy; battistel@iasma.it*), La Porta, N. (*IASMA, Italy; nicola.laporta@mail.isma.it*).

The use of genetic engineering in forestry is matter of science as well as technology policy. Engineered trees—poplars, aspen, birch, eucalyptus, pine and spruce—are already under field trials in Europe, but plantation into forest has not been done so far. The issues raise a complex mix of environmental and socio-economic concerns. Information is likely to be required by public if they are to support introduction of GMOs in forestry. In EU, a set of institutional arrangements and policy-makers actions, accompanied by a set of expectations by interested parties, have provided stringent legislation and labeling policies. Moreover, certification initiatives of sustainable forest management do not touch comprehensively on this topic, even though the call by MCPFE for strengthening of I&E in the forestry sector. Point of view and contribution of forest land-owners and wood customers is underestimated, and much of the information is provided by of the same timber companies that are developing the engineered trees. This paper examines the evolution of interplay between 'policy regimes' and 'technological regimes' on genetic engineering in sustainable management of forests, within a context of a sustainable rural development. Regulatory interventions as well as different solutions over time and across European countries, are discussed.

**Gender analysis of the reforestation component of the CHARM project in three provinces of the Cordillera Administrative Region.** Costales, A.B., Exconde, L.M., Maddumba, H.A., Odsey, M.S. (*Department of Environment and Natural Resources (DENR), Cordillera Administrative Region, Philippines; erds-car@mozcom.com*).

Gender sensitive process documentation and operations analysis of the reforestation component of the DENR-CHARM Project was undertaken from November 20, 2002 to December 2003 in selected project sites within the provinces of Benguet, Abra, and Mt. Province, Philippines. This study was intended to assess gender sensitivity of training programs conducted and document gender roles in the planning and implementation of reforestation projects. Results showed that the training conducted was gender-sensitive at two project sites (Benguet and Mt. Province). Findings showed that equal chances to attend training were given to male and female participants, venues selected for training were accessible to both sexes and the time/schedule of training was considerate to female participants. Other findings indicate that contributions and opinions of women were entertained and sharing of ideas of both men and women were encouraged during training. Training programs in Abra were not gender-sensitive because of gender role stereotyping and other reasons. Questionnaires on gender roles in the planning and implementation of projects were distributed among the male and female participants both in the People's Organizations (PO) and the DENR implementers. The inhibiting and facilitating factors identified, as well as the lessons learned documented in this study may serve as useful inputs to other community-based reforestation project or similar projects currently being implemented by the DENR.

**Medicinal plants of the Himalayas: Their antibacterial activity and contribution to livelihood.** Dutta, I.C. (Tribhuvan University, Nepal; [icdutta@fewanet.com.np](mailto:icdutta@fewanet.com.np)).

The Himalayas of Nepal are rich in high-value medicinal plants. Three important commercially and locally used medicinal plants—*Parmelia nepalensis*, *Microsorium membranaceum* and *Bergenia ciliate*—were collected from the high hills. The contribution of these plants to local livelihood and their relation to the antibacterial activity was been examined. The data were collected by using PRA tools (wealth ranking, preference ranking, group meetings, household visits, interviews, etc.). The analysis was done using ANOVA, mean, percentage, IRR and logical reasoning. Crude ethanol extract was tested for the antibacterial activity of these plants. The agar-diffusion test determined ZOI and serial-dilution technique MIC of the plant extract. The ZOI of different dilutions (80, 125 and 500 mg/ml) of plant extracts were tested for the bacteria: *Staphylococcus aureus*, *Salmonella typhi*, *Pseudomonas aeruginosa* and *Escherichia coli*. The phytochemical screening of extracts was also done. *Microsorium* contributed highest to the local livelihoods, followed by *Parmelia* and *Bergenia* spp. The antibacterial activity of *Microsorium* and *Parmelia*, against these bacteria was strong. These findings have implications in promoting species, which show strong activity as well as high contribution to livelihood. This study indicates the relationship between traditional use and technology.

**Making and utilizing sequential video archives recorded with long-term fixed video cameras.** Fujiwara, A., Saito, K. (University of Tokyo, Japan; [akio@uf.a.u-tokyo.ac.jp](mailto:akio@uf.a.u-tokyo.ac.jp); [kaoru@nenv.k.u-tokyo.ac.jp](mailto:kaoru@nenv.k.u-tokyo.ac.jp)).

Information technology involving video recording, editing, browsing, etc., have become possible to use easily in a digital format on a personal computers. It is necessary to develop archiving and processing technique of videos as well as of conventional measurement data. We developed the robot camera (automatic forest monitoring system) in 1996 which takes daily videos of trees, landscape, as well as 'soundscape' of the Tokyo University Forest, Japan. The still images derived from these video archives are used to produce the calendar. The 'How-To' is not stated in this calendar to make it fully user-oriented. People have different ways to enjoy and analyze the sequential images, and so people become interested in and can visualize what is happening on the other side of earth, and even what happened in past. This is important especially for the forest sector in which is not easy to imagine and feel real. The original video images are contained in DVD which would be distributed while the author presents the poster.

**Human health and forests.** Furuberg, A.M., Larsmon, M. (Hedmark University College, Norway; [merete.furuberg@hedmark-f.kommune.no](mailto:merete.furuberg@hedmark-f.kommune.no)).

When discussing human health we must define the culture and standard of living. Worldwide we know that poverty is the main cause of health problems. Even in 'rich' countries there is a health gradient through the population relating socio-economic status and well known individual health risk factors. Psychological well-being is of great importance for our health. Using trees and forests in health care is part off 'mass strategy' to influence the population in general. The objective/goal is to lower the total risk factor. Most of us do have a positive relation and feelings to outdoor activities. Therefore forests are an important means of informing and creating motivation, and thereby influencing people to choose a healthier alternative. Forests, trees and nature represent a huge potential in general health work. Another benefit here is the low-cost level of this kind of effort. But we need well skilled motivators to 'guide' patients and clients for outdoor activities. We must be aware of that the young people of today are not so familiar with forests and farms because most of the population in Scandinavia and the rest of Europe live in the cities. Some results from Norwegian activities within Human Health and Forests will be presented, together with experiences in developing student courses in this field.

**Village Forest Committees: Empowering people constitutionally, economically and technically for managing local forest resources.** Gangadharappa, N.R., Ibrahim, S., Nagesha, G., Ganesamoorthi (University of Agricultural Sciences, Bangalore; [nrganga@yahoo.co.in](mailto:nrganga@yahoo.co.in); [simal12002@yahoo.com](mailto:simal12002@yahoo.com); [nagesha22@yahoo.co.in](mailto:nagesha22@yahoo.co.in); [ganeshextension@yahoo.co.in](mailto:ganeshextension@yahoo.co.in)).

The research paper discusses the sustainable strategy of people's participation in forest management through the inception of village forest committees (VFC) as a means of management turnover introduced by the Joint Forest Planning and Management Program in Karnataka, India. The status of VFCs was studied with respect to processes they delivered, the outcomes fetched, and the dimensions of forest and people development issues tackled. The cat-mice relationship that existed between the villagers and forest officials has now changed to a healthy working relationship, and people have imbibed the need for participating in sustainable forest management. VFC members were knowledgeable of the afforestation measures taken both in community and individual holdings, and protected them from grazing, fire, theft and other threats. Fuel wood requirements did not change, while sourcing of fuel wood has. Significant change was observed both in fodder requirement and getting the same due to the efforts of VFCs. Women in the VFCs were enthusiastic about the compulsory reservation ensured for them. Women and resource-poor

individuals were able to improve their living conditions by forming self-help-groups through beedi, rope, leaf-plate and broomstick making, and by utilizing the lops and tops, grasses, pruned materials and non-timber forest products.

**Indicators for Sacred Forest management by local communities in the Western Ghats, India.** Garcia, C., Pain-Orcet, M. (*CIRAD Forêt, France; claude.garcia@cirad.fr*), Murali, K.S. (*French Institute of Pondicherry, India*), Konerira, N., Kushalappa, C.G. (*University of Agricultural Sciences, India*), Depommier, D. (*CIRAD Forêt, France*), Seen, D.L. (*French Institute of Pondicherry, India*), Nasi, R. (*CIFOR, Indonesia*).

The district of Kodagu, in the Western Ghats of India, harbours more than one thousand sacred forests (devarakadus), small fragments of tropical rain forest surrounded by agricultural land, formerly managed by the Karnataka Forest Department. In December 2001, the Government of Karnataka adopted the Joint Forest Management Plan for the devarakadus, thus creating Management Committees (MCs) at the village level, in charge of the management. These MCs, lacking in resources, knowledge and practical skills for forest ecosystem management, yet having responsibilities over them, provided an opportunity for developing an indicator-based information system to enable informed decision making. We proposed a low cost, low tech toolbox based on three components: 1) indicators of state that convey information on resource status, 2) indicators of flow that enable better control of user activities, and 3) indicators of management that provide MCs with reflexive and critical feedback on their actions. The final proposal relies on knowledge of the local communities, validated by scientific expertise to achieve balance between ecological and social relevance and is adapted to the available human, material and organizational resources. The co-construction process conforms to a modification of institutional order, with newly formed institutions that wish to legitimize their activities. Viewed from this perspective, the information system is much more than just a mere tool for data collection.

**A national decision-support for forest owners on the Internet.** Hannerz, M., Johansson, S. (*Skogforsk, Sweden; mats.hannerz@skogforsk.se; sverker.johansson@skogforsk.se*), Palmér, C.-H. (*Areca, Sweden; chp@areca.se*).

More than 50% of the forest land in Sweden is owned and managed by 330,000 private forest owners. This diverse group, which is constantly changing, has to maintain sufficient competence to meet increasingly strict management demands on their forests. Since most forest owners now have access to the Internet, it has become an important tool for knowledge transfer. Since 1998, Skogforsk has been developing a web-based forest management knowledge system, which now contains over 500 web-pages with information and interactive exercises on topics such as regeneration, pre-commercial thinning, thinning and final felling. The system is mainly targeted at private forest owners, so it is constantly evaluated and revised to meet their requirements. The advisory service is easy to use, and users should be able to find answers to any questions they may have on the different stages of development of their stands, and to calculate the economic consequences of various management actions. The users interact with the system through various exercises where they can put their new knowledge into practice, partly by adding information about their own stands and getting management advice adjusted to their specific cases. Experiences, decision support tools and evaluation results will be presented at the conference.

**The World Forestry Center's Discovery Museum.** Hartshorn, G.S. (*World Forestry Center, USA; ghartshorn@worldforestry.org*).

The World Forestry Center's Discovery Museum recently reopened with all-new exhibits, bringing the famous museum into the 21<sup>st</sup> century with many highly interactive exhibits. Sustainability of the world's forests is the museum's overarching theme. Two-thirds of the new exhibits focus on the Pacific Northwest, complemented by four global forest exhibits representing exotic locales—tropical Brazil, subtropical South Africa, temperate China and boreal Russia. Museum visitors hear from local people about their concerns and issues. The museum's exhibits offer clear educational messages about the importance of forests and forestry. The Pacific Northwest exhibits focus on a dynamic forest stand from below-ground ecology to canopy biology. Complementary exhibits feature forest science, natural forces affecting forests, recreational uses, timberland ownership, water quality, forest management options, timber harvesting technologies, wood qualities and uses, high-tech wood processing and the environmentally sound choices of using wood. The museum visitor is able to simulate precision landing by a smokejumper, ride a hoist into the forest canopy, sample a canopy walkway, take a virtual ride on a white-water river and practice tree harvesting in a Timberjack simulator. Check out the new Discovery Museum on your next visit to the Pacific Northwest!

**Public relations with simulated deer browsing.** Knauft, F.-J., Hauhs, M., Daenner, M. (*University of Bayreuth, Germany; knauft@bitoek.uni-bayreuth.de*).

Objectives of forest owners, hunters and forest visitors in central Europe are often in conflict. The re-growth of Norway spruce (*Picea abies*, Karst.), the commercially most important species, is often hampered by exceptionally high roe deer (*Capreolus capreolus* Lin.) populations. Even when a local agreement with respect to priorities of

ecosystem management has been reached, the operational implementation remains poorly documented and poorly assessed. Here we demonstrate an interactive growth simulator which is able to visualize the qualitative and quantitative impact of browsing by roe deer under various hunting regimes. It can be parameterized according to the perceptions of the specific interest group, and thereby support a more objective communication.

**Influence of the disposition of private forests on sustainable forest management in Hokkaido, Japan.** Komaki, T. (*Forestry and Forest Products Research Institute, Japan; komaki@ffpri.affrc.go.jp*).

Since private forest management is under severe economic stress, some absentee owners of forestlands in Hokkaido wish to sell their holdings. Due to the decline of timber prices, landowners are unwilling to sustain forests, and the future of forestry is at risk. Absentee small-scale forest holders of less than 20 ha are inclined to sell their holdings. Local landowners who want to increase their forest area are the primary buyers of forestlands. The age of the transacted forest is mainly 50 years old and includes man-made Japanese larch forests or old natural hardwood forests. The land is currently being sold for slightly less than \$5,000 per hectare. On the other hand, in approximately half of the forest sites that have been clear-cut, reforestation is either delayed or not practiced at all. This is a significant impediment to sustainable management of forests. Japan's government and local authorities should consider provisions to prevent such situations.

**Gender issues in forestry curricula: Updated results from surveys in 2002 and 2004.** Lewark, S. (*University of Freiburg, Germany; Siegfried.Lewark@fobawi.uni-freiburg.de*).

As forestry is a gendered business, a thorough understanding of gender issues is considered to be part of the qualification of forestry graduates. A first survey on gender issues in forestry curricula was carried out in 2002 by the IUFRO unit Gender, Education and Forestry, as there was little information. The main results are: 17 courses have been named from 11 different countries, which implicitly or explicitly include gender issues into compulsory and elective courses, most are given regularly. These results seem to be incomplete, being based on less than forty responses from more than 800 colleagues from within IUFRO mailing lists, who received the enquiry. For that reason an update was initiated in the summer of 2004, for which answers are still coming in. The preliminary evaluation indicates that the trends identified in 2002 are being confirmed: it was concluded, that teaching gender issues seems to be something special, often considered as women's business. Prerequisites are supporting structures, committed teachers, responding students and knowledge from available research. The information collected through these enquiries is intended to serve as a basis for exchange of experience of the organizers and for improvement of the quality of courses.

**The role and position of women in the Taiwan Forestry Bureau.** Lo, S.-L. (*National ChungHsing University, Chinese Taipei; sllo@dragon.nchu.edu.tw*), Tornng, C.-S. (*Taichung Healthcare and Management University, Chinese Taipei; tcstcs@ms50.url.com.tw*).

The Forestry Bureau of Taiwan has been historically dominated by men, particularly in its professional and leadership ranks. This has recently changed, with women performing many critical administrative and management functions—the result of a rapid growth in the employment of women and the transformation of management mission, though some male foresters think these roles could not be done well by women. To identify the importance of women in the Agency, this study focused on three aspects to examine the role and position of female foresters in forestry: 1) to identify the influence factors on career development for women foresters, 2) to explore the promotion process and barriers between genders, and 3) to discuss what women are competent to do by job analysis. The study revealed that social support, organization authority and interrelationship have positive effects on career development. By contrast, sex stereotype, occupation stereotype, role stress and fear of success have negative effects. The average promotion rate of male foresters is not higher than female, but a 'glass ceiling' or an invisible barrier still exists in higher leadership ranks. Competency was classified into four categories (from competence to incompetence for female foresters) according to qualification, disposition, task environment and ability with reference to employment and recruitment.

**Backward vertical integration: Importance of timberland ownership for pulp and paper companies.** Lönnstedt, L. (*Swedish University of Agricultural Sciences, Sweden; Lars.Lonnstedt@spm.slu.se*), Månsson, J. (*Växjö University, Sweden; jonas.mansson@ehv.vxu.se*).

The purpose of this research is to determine if timberland ownership for pulp and paper companies has an impact on return on capital. Pulp and paper companies in Japan, Sweden and the USA are studied. The hypothesis is that return on capital can be explained by mill size, productivity, production line, financial data, control and use of wood resources. Return on capital is measured as income before tax related to stockholders' equity. This dependent variable is split into profit margin and asset utilization rate. A statistical analysis of Japanese pulp and paper companies indicates that the best model fit is found when using capital turnover as dependent variable. Significant variables are

labour productivity, capital productivity, paper production as a share of total paper and board production, and solidity. As could be expected, labour productivity and solidity are positively correlated with capital turnover. It is of interest to note, even if it is not significant, that pulp production as share of total paper and board production, and average pulp mill size are positively correlated with capital turnover. This may indicate that there is profitability in pulp production (mill size and production line) but not in paper and paperboard production (mill size and production line).

**Gender and forestry: a bibliography.** Lyrén, L. (*SLU, Sweden; lillemor@lyren.se*).

The aim of this bibliography is to make gender issues in the forestry sector more visible and accessible for people studying gender issues in forestry. The result of searches in 19 different databases and library catalogues are compiled in this bibliography of gender and forestry. It contains 927 references. The terms used in the searches were forest, forest management, masculinity, gender, sex and women, in different combinations. The bibliography is organized in a scheme with different headings: author (editors), title, language, source, database, type of publication, country/region and type of study. The authors or editors are listed in alphabetical order, the title is the material that was found in the databases, language refers to the language of the document (in some cases with English summaries), source holding the information of the publisher, year, number if it is a serial, database is where the title has been located, type of publication is the document type, country/region is the geographical area described in the document, and type of study gives information about the study. This bibliography is a first step toward establishing a database in the research field of gender and forestry. New references will be added to the bibliography. The bibliography is available at: <http://www.bib.slu.se/bibliotek/skogs/genus/genderandfor.pdf>.

**A campaign model based on community communication in the upper watershed area of the Motatán River, Venezuela.** Ramos G., Y.T., Jaimes C., E.J., Mendoza M., J.G. (*Los Andes University, Venezuela; yalitzar3@hotmail.com; edgarja@cantv.net; josegmm@hotmail.com*).

The definition of a campaign based on the communication system that is used daily by the communities is important in order to improve the flow of information generated in productive social relationships, and also to contribute to the education of the citizens with regard to the sustainable agro-ecological management of a watershed. This presentation aims at determining the key elements needed for defining a campaign model that is both efficient and effective in the process of social interaction required for the agro-ecological and environmental management of the watershed of the Motatán river in the State of Mérida, Venezuela. The methodological instrument used to this end is that of action/participation and production of ideas by means of a logical frame. This methodology is based on holistic investigation. On the basis of the results obtained, a Community Campaign Model was developed that concentrates on three communication processes to create—awareness, understanding and sensitivity—and one non-communicative process—recognition. The latter is characterized as a socio-political and ideological trend immanent with the communities themselves, which allows the model to adapt to new information technologies and acts as a suitable multiplier of important social communication in the integral self-sustaining development of the watershed that is subject of the study.

**Basic survey analysis and promotion plan direction of mountain villages in Korea.** Seo, J.-W., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; knight01@foa.go.kr; salixkim@empal.com*), Yoo, B.I. (*Center for International Forestry Research[CIFOR], Indonesia; b.i.yoo@cgiar.org*), Ryu, K.S. (*Korea Forest Service, Republic of Korea; R436@foa.go.kr*), Kim, E.-G. (*Gyeongsang National University, Republic of Korea; egkim@nongae.gsnu.ac.kr*).

According to results of the 2003 basic survey of mountain villages, the forests of mountain villages in Korea covered 82.2% for 3,705,000 ha. In addition, the results showed that the productive forested land accounted for 66.8%, and that the natural forests covering 2,794,000 ha (75.4% of the total area) reached the stage of afforestation, in which the forest pilot project (tending, intermediate harvesting and pruning) at age class III or lower (64.1% of the total area) should be energetically carried out. Also, they revealed that the mountain villages in Korea centered upon agriculture/forestry and the wholesale retail business, and that there were income differences between regions. In terms of industrial basis, tourism, exchange basis, living conditions and medical facilities, there was also a difference between regions. In particular, the results identified the need for a policy on population maintenance for young and senior people. Accordingly, in order to establish the plan, a discussion and consideration should be undertaken with respect to: the promotion strategy for the basic plan on the national mountain villages, the function and role of each of the municipalities and provinces, the basic system of the city-county unit, and the integration and link among the project units in terms of plan establishment.

**A financial performance of the Korean pulp and paper industry.** Seok, H.D., Shon, C.H. (*Korea Rural Economic Institute, Republic of Korea; hdseok@krei.re.kr*).

This paper is an analysis of the financial performance of the Korean packaging, paper and pulp industry. All 29 firms on the Korean stock exchange market were selected for the analysis—a comparison between 2002 and 2002

performance. Relevant indicators of financial performances from the raw data of each firm's financial statement were employed. Total production was increased by 3.4%, while exports increased only 1.2%. The difference was absorbed by domestic consumption. Annual sales decreased by 1.7%, meaning that prices had decreased more than production increased. Return on equity, a main indicator of return on investment, decreased by 12%. This means the profitability over assets had degraded. Earning per share, also represents the profitability, decreased 78%. Both results showed the profitability had been degraded by a significant amount. Debt to equity, considered as the main indicator of the leverage ratio indicating risk of insolvency, showed that the Korean pulp and paper industry was much less leveraged with a 38% decrease. The combined results indicate that the industry became less risky in terms of insolvency, while their profitability was considerably downsized.

**The development of forest land accounts in Japan.** Yamamoto, N. (*Forestry and Forest Products Research Institute, Japan; n.yamamoto@affrc.go.jp*).

Land use is dependent on the land's natural conditions and the socio-economic conditions of each geographical region. Land cover is determined under the impacts of land use and based on the land's natural conditions. The state of land in any one region is therefore determined by the combination of its natural and socio-economic conditions. This shows the great importance of starting by building a statistical system that relates these various kinds of information organically and continues to collect information while maintaining its consistency. In doing so, the concept of natural resource accounts is useful. Natural resource accounting is a consistent and comprehensive system for representing natural resource and environmental information. It is an integral component of the broader framework of the System of National Accounts. Various accounts are included in natural resource accounts and their accounts have structural relationship. The forest land account is one of natural resource accounts, and links two systems of forest resource accounts and land accounts. This presentation explains the characteristics of forest land accounts and provides thoughts about the possibility of implementing the concept in Japan.

## General posters: Forest health

Organizer: Michael Wingfield *University of Pretoria, South Africa; mike.wingfield@fab.up.ac.za*

**Application of nematode-trapping fungus *Arthrobotrys adstyloides* on the control of root-knot disease of *Paulownia × taiwania*.** Chen, Y.-N., Liu, Y.-Y., Lee, M.-J. (*National Chiayi University, Chinese Taipei; s0921393@mail.ncyu.edu.tw; s0921357@mail.ncyu.edu.tw; mjlee@mail.ncyu.edu.tw*).

This study is aimed at the application of the nematode-trapping fungus, *Arthrobotrys dactyloides*, to the control of root-knot disease of *Paulownia × taiwaniana* (Taiwan paulownia). *A. dactyloides* was cultured and used to inoculate Taiwan paulownia seedlings. Two weeks later, 3rd-stage larvae of the root-knot nematode (*Meloidogyne incognita*) were used to inoculate Taiwan paulownia seedlings, already inoculated with *A. dactyloides*. After six months, height growth, root collar diameter, biomass and leaf area of Taiwan paulownia seedlings were measured and analyzed. The seedlings inoculated with *A. dactyloides* and *Meloidogyne incognita* had an average net height growth of  $46.67 \pm 6.51$  cm, and a net root collar diameter growth of  $9.87 \pm 2.31$  cm. Growth was significantly higher than that of the controls, which averaged  $34.67 \pm 2.31$  cm for height and  $7.47 \pm 0.38$  cm for root collar diameter. This study demonstrates that *A. dactyloides* can trap the larvae of the root-knot nematode, and hence inhibit its population. Thus, *A. dactyloides* could increase the resistance of Taiwan paulownia against root-knot nematode, and has great value for biological control.

**Chemical composition and mosquito larvicidal activity of essential oils from leaf of *Cryptomeria japonica* D. Don.** Cheng, S.-S., Chua, M.-T., Chang, S.-T., Tsai, K.-H. (*National Taiwan University, Chinese Taipei; d89625006@ntu.edu.tw; r93625035@ntu.edu.tw; peter@ntu.edu.tw; tsaikunhsien@seed.net.tw*), Chen, W.-J. (*Chang Gung University, Chinese Taipei; wen\_yuan@mail.ttv.com.tw*).

The essential oil of *Cryptomeria japonica* D. leaf and its effective constituents were evaluated for larvicidal activity against two mosquito species, *Aedes aegypti* and *Aedes albopictus*. The LC<sub>50</sub> values of *C. japonica* leaf essential oil against *A. aegypti* and *A. albopictus* larvae in 24 h were 28.4 Bg/mL (LC<sub>90</sub> = 111.8 Bg/mL) and 251.2 Bg/mL (LC<sub>90</sub> = 178.0 Bg/mL). Results of the 24-h mosquito larvicidal assay also showed that the effective constituents in essential oil of the leaf were 3-carene,  $\alpha$ -terpinene,  $\gamma$ -terpinene and *p*-cymene. Among these constituents, 3-carene demonstrated the best *A. aegypti* larvicidal activity, with an LC<sub>50</sub> value of 10.7 Bg/mL (LC<sub>90</sub> = 34.2 Bg/mL) in 24 h and  $\alpha$ -terpinene had an excellent inhibitory effect against *A. albopictus* larvae, with an LC<sub>50</sub> value of 25.2 Bg/mL (LC<sub>90</sub> = 53.2 Bg/mL) in 24 h. The results obtained shows that the leaf essential oil and its effective constituents could be considered as a natural larvicide.

**Types of ectomycorrhizae on beech trees fumigated with ozone.** Grebenc, T. (*Slovenian Forestry Institute, Slovenia*); Blaschke, H. (*TUM München, Germany*; [blaschke@wzw.tum.de](mailto:blaschke@wzw.tum.de)), Jurc, D. (*Slovenian Forestry Institute, Slovenia*; [dusan.jurc@gozdis.si](mailto:dusan.jurc@gozdis.si)), Kraigher, H. (*Slovenian Forestry Institute, Slovenia*; [hojka.kraigher@gozdis.si](mailto:hojka.kraigher@gozdis.si)).

In Kranzberg forest near Freising (Germany), a novel 'Free-Air Canopy O<sub>3</sub> exposure' system has been employed for analyzing O<sub>3</sub>-induced responses that are relevant for carbon balance and CO<sub>2</sub> demand of the beech trees. The belowground ectomycorrhizal community was studied in 2xO<sub>3</sub>-fumigated 60 years old trees (five cores per sampling), in ambient 1 x O<sub>3</sub>-trees (two cores per sampling) and outside the experimental set-up (two cores per sampling). Throughout the vegetation season in 2003, five samplings were done with 270 ml soil cores (0–18cm below ground). All roots were carefully washed and separated into non-mycorrhizal roots, vital-, and non-vital ectomycorrhizae. Types of ectomycorrhizae were determined after anatomical and molecular characteristics (ITS-RFLP database and GenBank comparisons) and counted. Twenty types of ectomycorrhizae were determined in 45 soil cores containing altogether 21,180 mycorrhizal root tips (less than 1% were nonmycorrhizal), representing 19% of 110,562 vital and non-vital roots. *Cenococcum geophilum* was present in all soil cores at all sampling times (26% of all vital roots). It was also more frequent in samples from plots with doubled O<sub>3</sub> concentration. Other relatively frequent types belonged to 7 spp. from the genus *Russula* and 5 from the genus *Lactarius*.

**Managing intensively grown, irrigated hybrid poplars based on clonal susceptibility to Poplar/Willow Borer *Cryptorhynchus lapathi* (Curculionidae).** Hannon, E.R., Kittelson, N.T., Brown, J.J. (*Washington State University, Washington, USA*; [hannon@mail.wsu.edu](mailto:hannon@mail.wsu.edu); [nealk@wsu.edu](mailto:nealk@wsu.edu); [brownjj@wsu.edu](mailto:brownjj@wsu.edu)).

The Poplar/Willow Borer (PWB) *Cryptorhynchus lapathi* (L.) is a wood-boring pest of economic importance in irrigated hybrid poplars grown in eastern Washington and Oregon, USA. The larvae damage trees when they burrow into the sapwood; which discolors wood, allows entry of pathogens and contributes to trees breaking in high wind. This damage translates into a loss of revenue. Presently, there is no practical insecticide control tactic against either the larval or adult stage of the PWB. Anecdotal evidence led us to believe there is variability amongst *Populus* hybrid clones to PWB attack. To assess putative clonal susceptibility to PWB we implemented a large-scale damage survey in 2004. In 120 planting blocks our survey sampled 13 clonal types within the following four hybrid crosses: *Populus deltoides* x *P. trichocarpa* (DxT); *P. trichocarpa* x *P. nigra* (TxN); TxD; and DxN. Our results indicate DxT hybrid crosses are the most susceptible while DxN crosses are least susceptible. Concurrent with this study we have implemented a small no-choice screening trial that will evaluate future clone selection against known susceptible and resistant clones. Results of the survey and screening trials have given growers the option to choose less susceptible varieties.

**Quantitative detection of wood rot fungi using genetic marker.** Horisawa, S. (*Kochi University of Technology, Japan*; [horisawa.sakae@kochi-tech.ac.jp](mailto:horisawa.sakae@kochi-tech.ac.jp)), Sakuma, Y. (*JIRCAS, Japan*; [sakuma@jircas.affrc.go.jp](mailto:sakuma@jircas.affrc.go.jp)), Doi, S. (*Akita Prefectural University, Japan*; [doi@iwt.akita-pu.ac.jp](mailto:doi@iwt.akita-pu.ac.jp)).

The detection of wood-rot fungi in wood is important from the viewpoint of developing a detection method and studying the mechanism of wood degradation. Recently, the method for detecting biomolecules of wood-rot fungi received attention as a highly sensitive detection method. We have examined how to use species-specific sequences of nucleic acid for identifying wood-rot fungi. Nucleic acid can be detected at high sensitivity by amplification using PCR, and nucleic acid sequences facilitate species identification at high precision. Of note is the fact that species-specific DNA sequences can detect wood rot fungi and identify the fungal species at the same time. Moreover, the fungal biomass could be evaluated, using quantitative PCR of the species-specific sequence. In this study, we developed species-specific primers for *Serpula lacrymans*, *Coniophora puteana*, *Gloeophyllum sepiarium*, *G. trabeum*, *Trametes versicolor* and checked their effectiveness for biomass determination.

**Occurrence of root rot disease on *Acacia mangium* caused by *Ganoderma* spp. in Indonesia.** Ito, S.-I. (*Mie University, Japan*; [ito-s@bio.mie-u.ac.jp](mailto:ito-s@bio.mie-u.ac.jp)), Fiani, A., Hidayati, N. (*Center of Biotechnology and Forest Tree Improvement Research and Development in Indonesia, Indonesia*), Yamaguchi, K. (*Tree Breeding Center Kansai Regional Breeding Office, Japan*).

*Acacia mangium* Willd. is one of the most promising species for tree planting programs and has been planted over wide areas in the humid tropics. The success of *A. mangium* is due primarily to its rapid growth rate and broad range of uses. Now it is being planted over wide areas throughout tropical Asia, Africa and the Americas. Recently, a mass mortality of *A. mangium* was found at several plantations in Indonesia. To ascertain the cause of this mortality, a survey was conducted at a seedling seed orchard at Wonogiri in Central Java. The first symptoms of this disease are yellowing of leaves and leaf fall, and in the plantation, many trees that showed the earliest symptoms, were located next to dead trees. On the stem of those trees, many fruiting bodies of *Ganoderma* sp. were produced. Since abnormal trees grew next to dead trees, it was thought that they were infected by the dead trees by root contact. There were also fallen trees and those roots have already been

rotted by the fungus. Average disease incidence was 12.8 % and differed among provenances and families. These results suggest strongly that this mortality on *A. mangium* is caused by root rot disease (*Ganoderma* spp.).

**Examination of the thinning effect of snow damage of Japan cedar stands using a new risk index of the damage.**

Kato, A. (*Toyama Forestry and Forest Product Research Center, Japan; kato-a@fes.pref.toyama.jp*).

The effect of thinning from snow damage of Japan cedar was examined using simulations and field surveys. The risk to the damage on individual trees was estimated by a new index called a critical snowfall. This index is expressed with snowfall when a tree breaks. The growth of a Japan cedar was predicted by using a system yield table. The results showed that the risk of snow damage was smaller in stands thinned from small diameter classes than in stands thinned from large diameter classes and in stands thinned equally from each diameter class, under the condition of constant thinning intensity. In addition, the risk of snow damage tended to decrease with thinning intensity, and if thinning was done earlier in the year, assuming thinning methods were the same.

**Impact of forest cover degradation on diversity and pest status of grasshoppers in Africa.**

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The economic exploitation of timber and the practice of slash and burn agriculture are the major causes of the transformation of the forest landscape in tropical Africa. This paper reviewed the consequences of deforestation on the diversity and status of grasshoppers. In addition, the threat to food security was discussed. It is known that, globally, grasshopper infestation is most likely to affect countries with drier climates. Because of transformation of the forest landscape, forest zones will likely become vulnerable in the future. The substitution of trees by herbaceous plants supports the reduction of grasshopper diversity, but the increase of herbaceous fallow can enhance the environment for locusts. The damage from grasshoppers significantly decreases agricultural output and constitutes an important threat to food security. To reduce the risks related to this deforestation, it is important that the forest policies of each affected country should emphasize strategies that focus on a) reinforcement of artificial forest regeneration, and b) research on the effects of short fallow stabilization.

**The anatomical observation on Hinoki (*Chamaecyparis obtusa*) and Leyland cypress ( $\times$  *Cupressocyparis leylandii*) inoculated by *Seiridium unicorne*.**

Kimoto, M. (*Oji Paper Company Limited, Japan; mai-kimoto@ojipaper.co.jp*), Yada, Y. (*Ishikawa Forest Experimental Station., Japan*), Ito, S. (*Mie University, Japan*).

$\times$  *Cupressocyparis leylandii* (Leyland cypress) is the hybrid between *Cupressus macrocarpa* (Monterey cypress) and *Chamaecyparis nootkatensis* (Nootka cypress) and widely planted as a hedge and screen tree in Great Britain. It was particularly favored for seaside planting because of its resistance to wind and salt spray. In Japan,  $\times$  *C. leylandii* was planted for experimental use at the seaside in Ishikawa Prefecture. It was found that the stems of the trees developed cankers and heavy resin flow. From each diseased part, *Seiridium unicorne*, mainly, was isolated and this fungus showed clear pathogenicity to Leyland cypress. These results suggest that this disease is caused by *S. unicorne*. However, this symptom caused by *Seiridium* canker disease has not been recorded, previously, on Hinoki (*Ch. obtusa*) in Japan. In this study, we inoculated *S. unicorne* against Leyland cypress and Hinoki to observe defense reactions of both species. Seven days after inoculation, Hinoki formed a wound periderm around the inoculated inner bark and it blocked fungus spread. Leyland cypress did not form a wound periderm after inoculation. These results suggest that the wound periderm formation is a defense reaction and Leyland cypress is susceptible to this disease.

**Resistant *Meloidogone incognita* via *Agrobacterium*-mediated transformation of *Paulownia*  $\times$  *taiwania* Hu et**

**Chang.** Liu, Y.-Y., Ho, S.-L., Lee, M.-J. (*National Chiayi University, Chinese Taipei; s0921357@mail.ncyu.edu.tw; slho@mail.ncyu.edu.tw; mjlee@mail.ncyu.edu.tw*).

*Paulownia*  $\times$  *taiwania* (Taiwan paulownia), the hybrid of *P. fortunei* and *P. kawakamii*, is a fast-growing tree species with excellent wood quality, and is ideal for furniture and instrument production. However, root-knot disease has resulted in slow growth and even death of Taiwan paulownia seedlings. This study cultured explants from internode sections of sterile Taiwan paulownia seedlings, and found that treatment with an MS-basic medium supplemented with 0.5 ppm 2,4-D, 0.1 ppm BA/0.5 ppm NAA, and 0.1 ppm BA resulted in the best induction of the callus. The MS-basic medium supplemented with 0.2 ppm NAA and 2 ppm BA induced bud formation. Roots were induced from the buds by 1/2 or 1/4 MS basic medium. The regeneration system was established, and provided sufficient materials for transformation. In this study, the expression vector pChiada containing a root-knot nematode resistant gene, *Mi-1.2*, and the transgenic reporter gene, *gusA*, was co-transformed into the Taiwan paulownia calli mediated by *Agrobacterium* gene transformation. Several of the



putative transformed calli were selected and used for plant regeneration. Further study will focus on the relative expression levels of *Mi-1.2* versus nematode resistance in the transgenic plants.

**Comparison of discolored sapwood size and non-conducting water area among six Fagaceae species inoculated with *Raffaelea quercivora*.** Murata, M. (*Mie University, Japan; ob30232@cc.mie-u.ac.jp*), Yamada, T. (*University of Tokyo, Japan*), Ito, S. (*Mie University, Japan*).

Mass mortality of oak trees has been occurring in Japan since the late 1980s. Most trunks of the dead or wilting trees were attacked exclusively by ambrosia beetle, *Platypus quercivorus*. Since *Raffaelea quercivora* was frequently isolated from discolored sapwood in the dead or wilting trees and from the surface of the beetles, this fungus might be closely associated with the mortality of oak trees. Results of the inoculation suggest that, among oak species, *Quercus crispula* and *Q. serrata* are very susceptible to this fungus. The wilting resulted from the disruption of water conduction as the discoloration of the xylem spreads over the cross-section of the trunk. To reveal the major factor associated with the susceptibility, seedlings of six Fagaceae species inoculated with *R. quercivora* were sampled 56 days after inoculation, and the size of both the axial and transverse sections of discolored sapwood were measured. The size of transverse sapwood and the water area in *Quercus crispula* and *Q. serrata* were larger than those in the other species and therefore would be the major factors associated with the susceptibility of this fungus.

**Population structure of the fungal pathogen *Cryphonectria eucalypti* from Australia and South Africa.**

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*Cryphonectria eucalypti* is a fungal pathogen of *Eucalyptus* species in South Africa and Australia. In South Africa it is considered opportunistic whereas in Australia it has been associated with occasional serious disease problems. The population biology and origin of *C. eucalypti* are still to be ascertained. The aim of this study was to determine the population structure of a South African population of *C. eucalypti* and to compare this to an Australian population. Isolates (72) from South Africa and South Western Australia (65) were amplified using eight pairs of microsatellite markers developed for *C. eucalypti*. Nei's gene diversity (H) showed that the Western Australian population is more diverse than the South African population with a value of 0.5218 compared to 0.1030. The maximum genotypic diversity for the Australian population was 68%, and 17% for the South African population. The high genetic diversity in the Australian population suggests that *C. eucalypti* might be native to the Australian continent from which it has spread to South Africa.

**Monitoring of the forest damaged by the salt-winds and the gale of typhoon (II).** Nakashima, T. (*Kyoto University, Japan; tnakashi@kais.kyoto-u.ac.jp*).

We have several typhoons every year in Japan. In order to study the influence of these typhoons on the forest, a typhoon-damaged forest was monitored. The forest is situated near Tokuyama Experimental Forest of Kyoto University, in Yamaguchi Pref., Japan. This forest was heavily damaged by winds from Typhoon No.19 in 1991. This area was attacked again by Typhoon No.18 in 1999 and Typhoon No.18 in 2005. According to the results of monitoring for 13 years, about 20% of initial stands were dead in 1995. Comparing the growth before and after Typhoon No.19 in 1991, stem diameter and height were 50–75% and 32–55% of growth before the typhoon. A tree with a damaged top grew into a forked tree. About 30% of the initial stands were dead in 2005, and many seedlings were found in sunny parts of the forested area.

**Sensitivity of *Populus deltoides* cuttings to gamma rays.** Singh, S.S. (*Guru Ghasidas University, India; sssingh\_ggu@rediffmail.com*), Chauhan, P.S. (*HNB Garhwal University Campus, India*).

The D-121 clones of *Populus deltoides* have been selected for the present experiment because it has wide adaptability in northern India. Cuttings, 18 cm long and of three ages (young age – 6 months, middle age – 12 months, and old age – 24 months) were used to investigate their regeneration sensitivity to different continuous and fractionated doses of gamma rays. Following gamma irradiation at the 500 R, 1, 2, and 4 KR dose level, they were treated with different growth regulators and monitored for sprouting. At all ages, sprouting was enhanced by gamma irradiation of the cuttings, but the combination of irradiation and growth regulators had an antagonistic effect on sprouting. Continuous irradiation enhanced lateral shoot growth and leaf number per cutting at all ages, but leaf area was highest in middle-aged cuttings, followed by young- and old-aged cuttings. Mortality of sprouted seedlings was least at 500R-F radiation in young cuttings and greatest with a 2KR-C dose in old cuttings. Continuous doses of radiation enhanced primary root number per cutting and their subsequent growth in young age cuttings. Middle age cuttings showed maximum primary root formation per cutting with a dose of 2 KR-C radiation.

**Role of *Phytophthora* spp. in decline of alder and black walnut stands.** Szabó, I. (University of West Hungary, Hungary; szaboi@emk.nyme.hu).

Decline of *Alnus glutinosa* and *Juglans nigra* occurred in some stands in peatland and flood areas in Hungary. Collar symptoms specific to *Phytophthora* as well as unspecific decline signs were observed on both tree species. The isolation of *Phytophthora* was carried out from soil samples by baiting with *Prunus laurocerasus* leaves on selective medium, PARPNH. The isolates were identified based on the cultural and morphological features. Several types of isolates were obtained from at least five morphological species in the case of alder and two in the case of black nut stands, respectively. Work on the molecular identification of the isolates is in progress. The pathogenicity was tested by wound inoculation of the stem of seedlings. The inoculations resulted mostly in small, well-delimited bark necrosis. The role of *Phytophthora* spp. in decline of the trees was deduced indirectly also because of the lack of *Phytophthora* spp. in the control soil samples taken from healthy stands without decline symptoms.

**The identification of viruses and phytoplasmas infecting woody plants in China.** Tian, G.-Z., Li, Y., Piao, C.-G. (Chinese Academy of Forestry, P.R. China; tiangz@forestry.ac.cn), Liang, W.-X., Huang, J.-G., Li, H.-F., Fan, Z.-F. (China Agricultural University, P.R. China).

There are more than 60 woody plant diseases associated with plant viruses and 50 diseases related to phytoplasmas reported in China. Some of them cause very severe problems in pomiculture, forestry and horticulture. So far, only some of the pathogens have been confirmed completely, or partially studied; others remain to be identified. Recently, several new woody plant viruses and phytoplasmas were identified, based mainly on their molecular characterization. The Wisteria vein mosaic virus (WVMV) in the ornamental wisteria was first reported in China according to biological property, serological relatedness and 3'-partial nucleotide sequence. Sequencing of the whole genome of WVMV was also completed. The tomato mosaic virus (ToMV) and tobacco mosaic virus (TMV) were isolated and identified from *Hibiscus rosa-sinensis*. Several phytoplasmas causing Chinaberry (*Melia azedarach*) witches' broom in Jiangxi province, periwinkle (*Catharanthus roseus*) phyllody and several other tropical plant diseases in Hainan island were identified, based on 16Sr DNA sequence and other molecular analyses.

**Association of occurrence of Chinese jujube (*Zizyphus jujuba* Mill) witches' broom disease caused by phytoplasma with the wild jujube (*Z. spinosa* Hu) infection resources.** Tian, G.-Z., Li, Y., Piao, C.-G. (Chinese Academy of Forestry, P.R. China; tiangz@forestry.ac.cn), Wen, X.-J., Guo, X.-J. (Hebei Academy of Forestry, P.R. China), Li, Z.-Q. (Puyang Institute of Forestry, P.R. China).

Field survey, phytoplasmal detection, and molecular characterization were used to compare jujube growing in regions with witches' broom infestation with cultivated Chinese jujube (*Zizyphus jujuba* Mill), and wild jujube (*Z. spinosa* Hu). The results showed a high incidence of disease in wild jujubes near disease-susceptible Chinese jujube orchards. Wild jujube had a higher resistance against phytoplasmas than most of the Chinese jujube cultivars. Healthy grafted plants were kept on hand in case stock was needed for grafts on to tree seedlings. Susceptible scions, when grafted onto symptomless but phytoplasmas-carrying wild jujube stocks, were likely to develop witches' broom symptoms in the field months later. The nested-PCR detection results indicated that the percentages of symptomless phytoplasmas-carrying trees surrounding diseased tree were 10% at wild jujube, 33% at cultivated jujube and 32% at grafted tree between above both. According to the results of heteroduplex mobility assay of 16SrDNA as well as 16SrDNA and rp gene sequencing, we theorize that the phytoplasmas infecting both jujubes might be the same pathogen sorted into 16SrDNA group and the wild jujube would be one of the major natural host for Chinese jujube witches' broom-phytoplasmas and an important infection source.

**Decisive inoculation term of ambrosia fungi *Raffaelea quercivora* on disturbance of sap flow of *Quercus crispula*.** Yamato, M., Suzuki, K. (University of Tokyo, Japan; banri@fr.a.u-tokyo.ac.jp; k-suz@fr.a.u-tokyo.ac.jp).

Mass mortality of oaks (*Quercus crispula* and *Q. serrata*) has been prominent in Japan since the 1980s. Mature oaks wilt during summer following attack of the pinhole-borer *Platypus quercivorus*, which is a vector for ambrosia fungus *Raffaelea quercivora*. Previous research showed that the time of inoculation is critical for susceptibility of *Q. crispula* to *R. quercivora*. The fungus blocks sap flow in oak sapwood, and thereby induces water stress in the tree. In order to confirm whether the extent of sap flow disturbance changed with time of inoculation, *Q. crispula* branches were inoculated on July 9th and August 19th, and sap flow disturbance was checked with a dye infusion technique. July-inoculated branches showed a larger axial dye-disturbed area (10–23 cm) than those inoculated in August (6–17 cm), but the horizontal dye disturbed area showed no difference. Tyloses formed from three days after the inoculation and were more extensive on inoculated branches than control with sterile media inoculation. Histochemical studies showed the accumulation of phenolic- and lignin-like compounds on fiber and tracheids by seven days after the inoculation. The extent of axial sap flow disturbance was related to the change in susceptibility at the time of inoculation.

***Ophiostoma* spp. associated with the bark beetle, *Ips grandicollis*, on native and exotic *Pinus* spp.** Zhou, X.D., de Beer, Z.W., Wingfield, M.J. (University of Pretoria, South Africa; [xu.zhou@fabi.up.ac.za](mailto:xu.zhou@fabi.up.ac.za); [wilhelm.debeer@fabi.up.ac.za](mailto:wilhelm.debeer@fabi.up.ac.za); [mike.wingfield@fabi.up.ac.za](mailto:mike.wingfield@fabi.up.ac.za)); Carnegie, A.J. (NSW Department of Primary Industries, Australia; [angusc@sf.nsw.gov.au](mailto:angusc@sf.nsw.gov.au)); Portales, J.M. (Agencia de Medio Ambiente, Cuba; [julio.mena@infomed.sld.cu](mailto:julio.mena@infomed.sld.cu)); Klepzig, K. (Forest Insect Research, USA; [kklepzig@fs.fed.us](mailto:kklepzig@fs.fed.us)).

Conifer-infesting bark beetles are known as vectors of *Ophiostoma* and their anamorphs. *Ips grandicollis* is native to North America and has been accidentally introduced into exotic pine plantations in Australia. Very little is known regarding differences in the fungal associates of this bark beetle in its native and introduced environments. The aim of this study was thus to compare *Ophiostoma* spp. associated with *I. grandicollis* collected from pine trees in the United States (Louisiana), Cuba (Havana) and Australia (NSW). Fungi were isolated directly from beetles and their galleries, and cultures were purified and grouped based on morphological characteristics. More than 500 fungal isolates were collected, including seven morphological groups from USA, five from Cuba, and four from Australia. Comparisons of ITS sequences of the rRNA operon were used to confirm fungal identities. *Ophiostoma ips* was the most common associate in all areas surveyed. *O. pluriannulatum* and two unidentified *Sporothrix* spp. were obtained from the USA, *Pesotum fragrans* and a third *Sporothrix* sp. from Cuba. *Ceratocystiopsis minuta*, *P. fragrans* and one of the unidentified *Sporothrix* spp. were also present in Australia. These comparisons of fungi associated with *I. grandicollis* in native and exotic situations illustrate that components of the mycoflora were introduced with the insect.

## General Posters: Forest environment

Organizer: Alex Mosseler *Natural Resources Canada, Canada*; [Alex.Mosseler@nrcan-rncan.gc.ca](mailto:Alex.Mosseler@nrcan-rncan.gc.ca)

**A new approach to the environmental risk assessment of forest road systems: Mitigating the risk of stream deterioration.** Farabi, H., James, R. (Australian National University, Australia; [houshang.farabi@anu.edu.au](mailto:houshang.farabi@anu.edu.au); [H.Farabi@csiro.au](mailto:H.Farabi@csiro.au); [ryde.james@anu.edu.au](mailto:ryde.james@anu.edu.au)).

Unsealed forest roads are the main source of sedimentation in streams. This risk is highest during road construction and when maintenance is poor. Identifying problem locations, analyzing and ranking the risks can be useful when managing the road to mitigate harmful impacts to stream water quality. The aim of this study was to develop a method for assessing the risk for existing unsealed forest roads. Field data and information were gathered from a case study area (Stromlo Forest, ACT, Australia) using DGPS, and then transferred and stored as a GIS database in layers. Terrain attributes data and maps were derived from a digital elevation model. The most important variables to the risk of forest roads affecting the initiation and expansion of rills and gullies on the surface of the roads and at the outlets of drainage systems were then determined using logistic regression analysis. The effective variables were then overlaid using ArcView, ArcGIS and IDRISI to create a 'risk map of the study area'. The results show that slope, contribution area, CTI, and distance between roads and streams are the most important factors affecting the elements at risk (soil and water). These results will help decision-makers to more effectively manage their roads by identifying specific road locations where problems are likely to occur. This method can also be used as a framework for evaluating environmental risks of unsealed forest roads.

**Floristic diversity of woody species in trans-Himalayan dry-temperate areas of the northwest Himalayas, India.** Gupta, H.K., Dasgupta, S. (Forest Survey of India, India; [ghemant\\_sml@hotmail.com](mailto:ghemant_sml@hotmail.com); [saibaldasgupta@hotmail.com](mailto:saibaldasgupta@hotmail.com)).

The paper is based on a study of floristic diversity of woody species in trans-Himalayan dry-temperate areas in the northwest Himalayas. Trans-Himalayan area is chiefly represented by mountainous tracts of dry-temperate and cold deserts of Kinnaur, Lahaul and Spiti and Chamba districts in Himachal Pradesh, India. The biodiversity of trans-Himalayas is facing serious threat due to habitat loss, degradation and fragmentation of ecological niches mainly due to over grazing, fuelwood needs and road construction activities. Species diversity comprising  $\alpha$ -diversity, importance value index (IVI) and importance value (IV%), structural parameters of the dominant tree species with respect to abiotic and biotic factors,  $\beta$ -diversity and inter-specific associations were recorded. The species richness (S) for trees varied greatly from 1.00 to 6.97 corresponding to the values of Shannon Index (HT) for plant diversity. Community diversity (both tree and shrub strata) of species dominance was determined on the basis of maximum IVI and IV%. The tree and shrub layers were studied as two distinct communities—the trend of dominance by different tree species remained the same, however, different shrub communities showed different dominants. Community participation along with appropriate management intervention, integrated with income generating activities for the dependent population is suggested for sustainable biodiversity conservation.

**Water quality in Latvian forest ecosystems.** Indriksons, A., Zalitis, P. (*Latvian State Forestry Research Institute "Silava", Latvia; indrikso@silava.lv; zalitis@silava.lv*).

The models constructed from long-term (since 1963) data collection in several forested catchments have been used to characterize water quality in the forest ecosystems of Latvia. Data for precipitation, soil groundwater, confined aquifer water, and surface runoff in watercourses have been analyzed. The yearly input of nitrogen, phosphorus and potassium exceed the output, but output of calcium and magnesium via ditch runoff is several times higher than input by precipitation. For each of the 215 rivers in Latvia, the output of total nitrogen and phosphorus from the forests has been calculated. The runoff models, in the form of linear regressions, have been used to calculate the output from different forest site type groups (dry forests, forests on hydromorphic mineral soils and peat soils). The output of nitrogen and phosphorus from the forests average 2.92 and 0.099 kg/ha/yr, respectively, and are smaller in comparison to that of agricultural areas. However, in several river basins the amount of nitrogen and phosphorous output reaches 6.00 and 0.22 kg/ha/yr, respectively. The output rates are higher in the swampy forest site types.

**Assessing leakage costs from activity, demand and supply displacements and investment crowding in Clean Development Mechanism tree biomass based 1 MW power projects in Tamilnadu, India.** Kant, P. (*Indian Council of Forestry Research and Education, India; promodekant@yahoo.com*), Wu, S. (*Chinese Academy of Forestry, P.R. China; wushr2000@263.net*).

The Clean Development Mechanism (CDM) rules make the accounting of all negative leakages mandatory for earning carbon credits. Leakages can take place in the shape of activity displacement, demand displacement, supply displacement, or investment crowding. Activity displacement would occur when an activity on a land taken up for carbon sequestration shifts to another land, causes carbon loss there. Demand displacement occurs when demands for forest products being met from a land taken up for carbon sequestration are fulfilled from another accessible land. Supply displacement is when cheaper forest products from a CDM supported plantation makes costlier products from existing forests unviable and puts economic pressures for land use change. Investment crowding could occur when the incentives to invest in plantations for carbon sequestration are so high that the funds meant for other carbon-friendly economic activities are also diverted for the former. This paper assesses the total economic value of leakages likely to be caused by the proposed 1 MW tree biomass gassifier-based power generation project near Tiruchirapalli in Tamilnadu, India.

**Changes of plant species diversity over the last five years in *Larix kaempferi* plantations and abandoned coppice forests in central Japan.** Nagaike, T., Hayashi, A., Kubo, M. (*Yamanashi Forest Research Institute, Japan; nagaike-zty@pref.yamanashi.lg.jp*), Takahashi, K. (*University of Tokyo, Japan*), Abe, M. (*Akita Prefectural University, Japan*), Arai, N. (*Niigata University, Japan*).

To examine the species colonization and extinction at the local scale, with special reference to different forest management systems, we studied plant species diversity in the understory of *Larix kaempferi* plantations and abandoned coppice forests in central Japan, and compared the data collected in 1999 and 2004. Species diversity measures ( $H'$  and  $J'$ ) in both forest types and both layers (forest floor plants and tree flora) were relatively stable, although the number of species per unit area has decreased. Net change in the number of forest floor species in each plot decreased in both forest types, while a decrease in the tree flora was only observed in plantations. Numbers of gained and lost species were higher in forest floor plants than in tree flora, showing that species replacement in forest floor plants was greater than tree flora. These results showed that the competition in the canopy layer and the effects on species diversity were different between stand types. It is recommended that each forest type should be managed differently to maintain species diversity.

**Wild boar and biodiversity in southern Sweden: What habitat do they prefer and where do they influence at most?** Sjöberg, K., Åhlén, P.-E. (*Swedish University of Agricultural Sciences, Sweden; Kjell.Sjoberg@szoek.slu.se; Per-Arne.Ahlen@szoek.slu.se*).

The wild boar (*Sus scrofa*) is a re-introduced animal species in Sweden. In a project conducted in the southernmost part of the country, the spatial and temporal distribution of wild boars is measured in a mosaic landscape with broad-leaved forests and conifer plantations, mixed with different proportions of agricultural land. In different family units of wild boars, adult females, preferable the leading sows, are tagged with GPS/GSM transmitter collars. In this way, movements in the landscape of the whole unit of animals could be followed in detail, in real-time without disturbing them. The GPS positions are automatically sent to a computer via sms messages. The wild boar is known to be able to influence the biodiversity in forests as a consequence of their searching for food. However, to be able to predict the degree of influence this re-introduced animal will have, it is important to know their habitat preferences in the landscape, up till now un-influenced by the wild boars. In this project, with the GPS technique, we are studying in detail the utilization of the landscape at a scale almost down to a tree-level. The first-year results are presented.

**Assessing and reducing transaction costs in a Clean Development Mechanism afforestation project at the Miyun Reservoir Watershed, China.** Wu, S. (*Chinese Academy of Forestry, P.R. China; wushr2000@263.net*), Kant, P. (*Indian Council of Forestry Research & Education, India; promodekant@yahoo.com*).

Transaction costs are the costs incurred in reaching a product to the consumer except the production and transportation costs. In a typical Clean Development Mechanism (CDM) project these include the search costs, negotiation costs, verification and certification costs, monitoring costs, enforcement costs and the insurance costs. Search costs are incurred as the investors and hosts seek partners for mutual benefits, and negotiation costs are incurred, after the search is over, in reaching an agreement over the terms of partnership. Verification and certification costs are incurred when the negotiated contract parameters require the approval of an accredited agency. The implementation costs refer to the costs incurred in implementing the provisions of the negotiated contract. Monitoring costs are the amounts expended to measure the intermediate and final achievements and test them against the project forecasts. Enforcement costs are incurred when monitoring reveals deviation from the agreed terms of the contract. Insurance costs arise from the risks that the ventures face. This paper makes an assessment of the likely total transaction costs in the proposed CDM afforestation project at Miyun Reservoir watershed of China, and analyzes the possibilities of reducing these costs.

**Ecological analysis of *Populus euphratica* forest in the Ejina oasis, Inner-Mongolia, China.** Yoshikawa, K., Monda, Y., Naoko, M. (*Okayama University, Japan; kenchan@cc.okayama-u.ac.jp*), Kubota, J. (*RIHN, Japan*).

The Ejina oasis, located in the western part of Inner-Mongolia, is supported by the Heihe River flowing from the Qilian Mountains in the south of the Hexi Corridor, Inner-Mongolia. Due to irrigation withdrawals in the middle reaches, the amount of inflowing water has decreased during the last decade. To clarify the effect of changes in moisture condition on the vegetation in Ejina oasis, species composition of typical vegetations and ecological characteristic of the dominant tree species, *Populus euphratica*, were investigated. Fifty-seven species were identified in 11 experimental sites. Through cluster analysis, these sites were classified into four groups: 1) pure forest of *P. euphratica* on good soils, 2) dry forests of *P. euphratica* neighboring pure poplar forests, 3) dry bush composed of psammophytes, and 4) wet meadows extended over frequently flooded areas. In most of the poplar forests, the 3/2 power rule was detected. The maximum height of *P. euphratica* estimated by D-Hmax relations was approximately 17 m. However, the tallest trees in each forest were seldom over 12 m. Die-back phenomenon of big trees observed throughout the Ejina oasis suggests a severe water stress effect on height growth. From analysis of the frequency distribution of tree sizes, the regeneration strategy of *P. euphratica* will be discussed.

Index of authors

- Aamlid, D., 37  
 Ab. Shukor, N.A., 66, 369  
 Abarquez, A., 156  
 Abd. Rahman, K., 26, 28, 29, 30, 243  
 Abdul Rahim, N., 28  
 Abdullah, M.Z., 66  
 Abdullah, N.M.H., 383  
 Abdullah, R., 376  
 Abe, M., 353, 395  
 Abedini, W., 53  
 Abedini, W.I., 53  
 Ablan, M., 206  
 Abraham, E.R.G., 94  
 Abrudan, I.V., 111  
 Abundio R., E., 27  
 Abwe Wa Masabo, M., 85  
 Acharya, A.P., 226  
 Acharya, K.P., 226, 314  
 Acharya, U., 346  
 Ackerman, P., 179  
 Adams, M., 317  
 Adams, M.A., 96, 256  
 Adams, P., 133  
 Adamson, D.G., 83  
 Addison, J.A., 245  
 Adeli, E., 238  
 Adesina, A.A., 44, 349  
 Adijaya, 331  
 Adilo, M., 67  
 Adiova, J.M., 37  
 Agnoletti, M., 250  
 Aguiar, A.M., 61  
 Åhlén, P.-E., 395  
 Ahmad Zuhaidi, Y., 27  
 Ahmad, F., 183  
 Ahmad, M., 127, 172  
 Ahmad, R., 376  
 Ahmed, R., 260  
 Ahn, J.-Y., 318  
 Ahtikoski, A., 233  
 Ahuja, P.S., 55  
 Ahumada, R., 58  
 Aigner, R., 82  
 Aitken, S.N., 103  
 Akbarzadeh, M., 166  
 Akhter, M.F., 122  
 Akim, E.L., 135  
 Akinnifesi, F., 70  
 Al Sayegh, P., 243  
 Alenius, V., 205, 363, 368  
 Alexander, S.J., 142, 143  
 Alfaro, R.I., 84, 262  
 Alfenas, A., 254  
 Alig, R.J., 102, 112, 231  
 Allan, E., 45  
 Allen, D.J., 88  
 Allen, M., 133  
 Allen, R., 238  
 Allen, S.D., 346  
 Alloysius, D., 28  
 Almeida Jr., A.C., 3  
 Alpizar, F., 263  
 Alves, J.U., 291  
 Alves, M.V.G., 112  
 Alzate, S.B.A., 67  
 Amani, M., 7  
 Amaral, A., 22  
 Amatya, S.M., 106  
 Ambrosi, P., 36  
 Ambrosi, P., 87, 186  
 Amorini, E., 342  
 Ampun, J., 77  
 An, S.-H., 77  
 Andersen, E.R., 83  
 Andersen, H.E., 181  
 Anderson, D.H., 251, 268, 288, 357  
 Anderson, I.C., 243  
 Anderson, K.R., 77  
 Anderson, S., 250  
 Andersson, F., 234, 300  
 Ando, K., 124, 277, 331  
 Andrada, M.G., 356  
 Andrian, G., 293  
 Ang, L.H., 57  
 Angeles-Pérez, G., 294  
 Angelsen, A., 334  
 Angelstam, P., 273  
 Anim, A., 108, 124, 152  
 Annandale, M., 148  
 Anola-Pukkila, A., 1  
 Anthon, S., 293  
 Antonangelo, A., 374  
 Antonova, G.F., 369  
 Aoki, H., 65  
 Aoki, K., 337  
 Aoki, M., 282  
 Apan, A., 299, 357  
 Appanah, S., 264, 278  
 Apps, M.J., 228, 305  
 Aquino-Ong, S.C., 302  
 Arai, N., 395  
 Araman, P., 160  
 Arentz, F., 226  
 Arévalo, R., 5  
 Arikawa, J., 378  
 Aris, W., 123  
 Arp, P.A., 88  
 Arteni, A.A., 92  
 Artenie, V., 92  
 Aruga, K., 373  
 Asanuma, T., 59  
 Asbjornsen, H., 190  
 Ashaari, Z., 176  
 Ashmore, M.R., 283  
 Ashton, M.S., 96  
 Assael, F., 86  
 Assis, M.A., 331  
 Assyh, N., 170  
 Astrup, R., 256  
 Atmopawiro, V., 184  
 Attiwill, P.M., 256  
 Atul, 277  
 Atzman, N., 91  
 Auclair, A., 252, 257  
 Auger-Rozenberg, M.A., 252  
 Austin, J., 319  
 Avissar, R., 321, 370  
 Avni, Z., 250, 384  
 Awang Nor, A.G., 28  
 Awang, K., 66, 369  
 Axelsson, A.-L., 37  
 Azadfar, D., 22  
 Azman, A.R., 269  
 Azman, H., 243  
 Azpilicueta, M.M., 68  
 Azyyati, A.K., 269  
 B.H., Fei., 169  
 Babatunde, A., 278  
 Bachofen, H., 310  
 Backiel, A., 362  
 Badea, O., 282  
 Badola, R., 137, 223, 314  
 Baguma, T., 149  
 Bahari, S.A., 144  
 Bailey, A.D., 91  
 Baillères, H., 52, 121, 122, 175, 379  
 Bakam, I., 41  
 Baldwin Jr., V.C., 10  
 Baldwin, P., 40  
 Balete, D., 15  
 Ballerini A., A., 126, 127  
 Balooni, K., 213  
 Baltra, R., 374  
 Banfield, E., 77, 305  
 Bantayan, N.C., 14, 183, 198, 213, 219, 302  
 Banzhaff, W., 192  
 Barakoti, T.P., 31, 42  
 Barbati, A., 36  
 Barbour, R., 372  
 Barbour, J., 10  
 Barbu, M., 129  
 Bardon, R.E., 355  
 Bare, B.B., 6  
 Barnard, T., 219  
 Barnes, T.G., 258  
 Barret, T., 35  
 Barrett, F., 196  
 Barriguinha, A.F., 138  
 Barros, R., 30, 207  
 Barry, K., 334  
 Bartle, J., 114  
 Barton, J., 306

- Bascietto, M., 73  
 Bashford, D., 84  
 Basiliko, N., 245  
 Bastias, B.A., 243  
 Bastrup-Birk, A., 37, 88  
 Batish, D.R., 2, 145, 190  
 Batista da Luz, N., 196  
 Batkhuu, N.-O., 364  
 Battaglia, M., 180, 324  
 Battistel, G.A., 384  
 Battisti, A., 82  
 Bauhus, J., 167, 204, 295, 329  
 Baumann, K., 242  
 Bayala, J., 45  
 Bazhenov, A.N., 381  
 Beall, F.C., 165  
 Beardmore, T., 287  
 Beauregard, R., 133  
 Becher, G., 265  
 Beck, R., 157  
 Becker, G., 6, 12, 169, 180  
 Becker, M., 135  
 Beckley, T., 150  
 Beese, F., 329  
 Beets, P.N., 76, 107, 306  
 Bégin, J., 170  
 Begus, J., 157  
 Behera, B., 222  
 Bekessy, S.A., 5  
 Bélanger, L., 150  
 Belcher, B., 280  
 Belem, O.M., 45  
 Bell, L.C., 238  
 Bell, S., 301  
 Bellow, J.G., 187  
 Belyazid, S., 35  
 Bengston, D.N., 218  
 Benko, M., 46, 90  
 Bennell, M., 114  
 Bennett, A.F., 274  
 Benyon, R., 324  
 Berch, S.M., 245  
 Berg, S., 102, 192, 228, 373  
 Berger, F., 310, 313  
 Berghäll, S., 140  
 Bergstedt, A., 6  
 Bernhold, A., 80  
 Berthier, S., 313  
 Betancourt, Y., 145  
 Bezak, K., 34  
 Bhat, K.M., 105, 121  
 Bhattacharya, A., 55  
 Bhuiyan, M.K., 122  
 Bigsby, H.R., 10, 140, 192  
 Billand, A., 209  
 Binney, J., 262  
 Bird, N., 73  
 Birner, R., 150  
 Bisht, N.S., 294  
 Bisio, C., 53  
 Biswal, D., 215, 223  
 Biswal, M., 191, 215, 223  
 Bittencourt, E., 66  
 Björheden, R., 119  
 Björk, L., 278  
 Björkman, C., 80  
 Black, T., 131  
 Blanche, C.A., 379  
 Blank, G.B., 350  
 Blaschke, H., 246, 390  
 Blatner, K., 136  
 Bliss, J.C., 115  
 Blom, H.H., 39, 181  
 Blumberg, D., 86  
 Blumfield, T., 244  
 Boa, E., 356  
 Bodles, B.J.A., 56, 253  
 Boffa, J.M., 70  
 Boffi Lissin, L.D., 258  
 Bohrer, G., 370  
 Bonaagua, E.A., 33  
 Bondarenko, V.V., 268, 302  
 Bonnes, M., 291  
 Bonneville, J., 188  
 Bonora, L., 91  
 Booth, T., 319  
 Boquiren, R., 14  
 Borders, B.E., 231  
 Borgschulte, M., 161  
 Borralho, N., 67  
 Bostedt, G., 334  
 Boston, K., 130  
 Bosu, P.P., 80  
 Botkin, D.B., 34  
 Botosso, P.C., 73, 74, 75, 330  
 Bourque, C.-P.A., 88  
 Boyd, S., 239  
 Bozzano, M., 68  
 Brack, C.L., 285, 353  
 Bradley, G., 360  
 Brais, S., 324  
 Brancheriau, L., 379  
 Brand, D., 72, 86, 91  
 Brand, M.A., 66  
 Brang, P., 310, 313  
 Brawner, J., 61, 63  
 Braz, E.M., 180  
 Briggs, D., 6  
 Brigham, T., 357  
 Brito Zákia, M.J., 322  
 Brockhoff, E., 2  
 Brodie, G., 379  
 Brogt, T., 161  
 Brookhouse, M., 76  
 Brophy, J., 115  
 Brown, A.G., 342  
 Brown, J.J., 85, 390  
 Brown, M., 362  
 Brown, S., 72, 73  
 Brownlie, D., 340  
 Bruce, A., 340  
 Bruckner, A., 249  
 Bruijnzeel, L.A., 307  
 Buchanan, A., 165  
 Buchy, M., 226  
 Bücking, M., 169  
 Buckley, G.P., 24  
 Buckley, M., 135  
 Buddle, C.M., 324  
 Büker, P., 283  
 Buldgen, A., 187, 188  
 Bull, G., 286  
 Bull, L., 131, 162, 163  
 Bun Radar, 15  
 Buonamici A., 60  
 Buongiorno, J., 87  
 Burch, W.R. Jr., 263  
 Burger, J.A., 21  
 Burgess, T., 392  
 Burgman, M.A., 5  
 Burström, L., 118  
 Burton, J., 244  
 Burvill, C., 381  
 Bussotti, F., 282  
 Bustos, O., 373, 374  
 Butnor, J.R., 95  
 Butovets, G.N., 229  
 Butt, D., 379  
 Buttoud, G., 213  
 Bybljuk, N., 271  
 Byrd Jr., J.D., 261  
 Byrne, M., 247  
 Bytnerowicz, A., 87, 88, 282  
 Cabello, G., 10  
 Caes, B.R.M., 370  
 Cairney, J.W.G., 243  
 Caldentey, J., 46, 378  
 Calfapietra, C., 89  
 Callot, H., 175  
 Camacho, L.D., 219  
 Camacho, S.C., 281  
 Cámara Cabrales, L., 12  
 Câmara, C.D., 322  
 Cameron, S., 281  
 Campbell, A., 114  
 Campbell, B., 138, 210, 266  
 Campoe, O.C., 42  
 Campos, J.J., 151, 263  
 Campos, P., 297  
 Canadell, P., 73  
 Canaveira, P., 332  
 Cao, Y., 267  
 Caparrós, A., 297  
 Capistrano, D., 213  
 Capretti, P., 83  
 Caprile, R., 10, 378  
 Carabelli, E., 10

- Carandang, M.G., 198  
Carino, H.F., 379  
Carlyle, C., 180  
Carmona, J.C., 55  
Carnegie, A.J., 82, 84, 200, 394  
Carnus, J.-M., 200, 293  
Carpenter, K., 165  
Carr, R., 77  
Carroll, A.L., 84  
Carrus, G., 291  
Carswell, F., 238  
Carter, J., 324  
Carvalho, P.E.R., 75  
Case, B.S., 23  
Cashore, B., 264, 266, 273  
Casimirri, G., 347  
Castañeto, E.T., 65  
Castañeto, Y.T., 65  
Castillo, E., 219  
Catchpole, K., 172  
Catterall, C.P., 308, 326  
Cavers, S., 276  
Cerra, T., 110  
Ceulemans, R., 89  
Chacko, K.C., 13, 360  
Chairul, 101  
Chaix, G., 52, 175  
Chakma, S., 327  
Chamberlain, J., 142  
Chandran, A., 339  
Chang, H.-T., 176  
Chang, S.-T., 176, 389  
Chang, Z., 99  
Chapligina, I.A., 369  
Chappelka, A.H., 283  
Chastagner, G.A., 258  
Chastagner, M.W., 126  
Chatziphilippidis, G., 343  
Chauhan, N.S., 149  
Chauhan, P.S., 392  
Chauvat, M., 244  
Chavarriaga, D., 253  
Checcacci, E., 91  
Chee, Y.C., 54  
Chen, C.R., 239  
Chen, H.-C., 380  
Chen, J.-C., 167  
Chen, T.-Y., 380  
Chen, W.-J., 389  
Chen, X., 62  
Chen, X.-R., 381  
Chen, Y.-N., 389  
Cheng, R., 88, 97  
Cheng, S.-S., 176, 389  
Cherubini, P., 72, 76, 94, 98, 283, 288  
Chheang Dany, 15  
Chidel, M., 41  
Chikumbo, O., 10, 232  
Chin, C.C., 176  
Cho, C.-L., 9, 380  
Cho, S.-T., 8  
Choi, D.-H., 118, 372  
Choi, H.S., 53  
Choi, J.W., 118  
Choi, W.-Y., 63  
Choi, Y.E., 55  
Chong, S.-K., 27  
Choy, S.L., 315  
Christersson, L., 106  
Chua, M.-T., 389  
Chung, M.S., 63  
Chung, Y.-L., 167  
Chuter, A., 11  
Ciccarese, L., 73, 231  
Cieszewski, C.J., 231  
Clark, J.K., 288  
Clinton, P.W., 76, 107  
Clough, G., 345  
Clutter, M.L., 135  
Cobbinah, J.R., 54, 56, 57, 86  
Cockfield, G., 299, 357  
Coe, R., 349  
Coggan, A., 152  
Cohen, D.H., 135  
Coker, G., 107  
Colchester, M., 263  
Colfer, C.J.P., 235, 236, 263  
Collazo, J., 366  
Collet, C., 206, 368  
Collins, A., 260  
Conard, S.G., 228  
Conese, C., 91  
Connor, K.F., 160, 286  
Copley, T.R., 156, 171  
Cordero, E., 145  
Corell, E., 271  
Corkrey, R., 316  
Cornelius, J.P., 50, 70, 275, 348  
Cornu, G., 23  
Corona, P., 36, 194  
Corral-Rivas, J.J., 308  
Cortiçada, A., 22  
Costales, A.B., 211, 384  
Côté, L., 14  
Coulson, G., 349  
Courtois, R., 150  
Coutinho, T.A., 57, 58, 335  
Couto, M., 176  
Couture, S., 99  
Cowie, A.L., 119, 294  
Cown, D., 105  
Cox, R.M., 88  
Crane, D.E., 302  
Creanga, I.A., 36, 92  
Creighton, J.H., 136, 358  
Crespell, P., 162  
Croise, L., 81  
Croitoru, L., 17  
Crompton, H., 42  
Crow, T., 307  
Cruz, G., 10, 378  
Cruz, R.V.O., 198  
Cubbage, F.W., 18, 201, 272, 350  
Cui, T.Y., 272  
Cullen, R., 10  
Culvenor, D., 180  
Cummings, J., 3, 308  
Cunningham, A.B., 236  
Cunningham, S.A., 276  
D'Alessandro, C.M., 288  
D'Amours, F., 130  
D'Amours, S., 130  
d'Oliveira, M.V.N., 180  
da Costa Santos, R., 140  
da Silva Jr., E.C., 173  
da Silva, C., 318  
da Silva, J.F., 67  
Daenner, M., 386  
Dai, G., 111  
Dale, G., 239  
Dalibor, B., 62  
Damayanti, E.K., 222  
Damery, D.T., 232  
Daneshgar, P., 260  
Danjon, F., 313  
Darbah, J., 89  
Dasgupta, S., 194, 220, 322, 394  
Davenport, M.A., 251, 268, 357  
Davey, S.M., 10, 15, 217, 232, 257  
Davidson, E., 369  
Davies, S., 11  
Davis, C., 133  
Davis, M.R., 107  
Dawson, B.S.W., 109, 178  
Day, K., 24, 365  
De Angelis, P., 89  
de Assis, T.F., 61  
De Baar, M., 168  
de Bauer, M. de L., 282  
de Beer, Z.W., 176, 394  
de Carvalho, C., 369  
De Clercq, E.M., 184  
de Gier, A., 184  
de Groot, B., 77  
de Groot, P., 253  
de Groot, W.J., 77  
de la Roche, I., 153  
de la Torre, A., 275  
de los Santos-Posadas, H., 294  
de Mar, P., 196  
de Meyer, E.M., 176  
De Natale, F., 194  
de Oliveira, V.C., 180  
de Roman, M., 356  
de Siqueira, L., 67  
de Urquiza, M., 258



- de Vries, S., 267, 268  
 De Wulf, R.R., 184  
 De Zoysa, M., 187  
 Deal, R.L., 234  
 Deal, R.L., 39  
 Debnath, R.K., 54  
 Debusse, V.J., 325  
 Dedi, 122  
 Deflorio, G., 334, 335  
 Deleporte, P., 249  
 Deltuvas, R., 100  
 Demissew, S., 51  
 DeMontigny, L., 245  
 Demuner, B., 173  
 Denich, M., 51  
 Denslow, J.S., 259  
 Depommier, D., 386  
 Derome, J., 205  
 Détienne, P., 379  
 Devall, M.S., 74, 160, 239, 286  
 DeWalt, S.J., 259  
 DeYoe, D., 357  
 Dhakal, M., 111  
 Dhanda, R.S., 43  
 Dharmawan, I.W.S., 212, 242  
 Diaw, C., 41  
 Diaz-Balteiro, L., 163  
 Dien, D.L., 380  
 Dieter, M., 299  
 Dieters, M.J., 61, 63, 156, 171  
 do Carmo Calijuri, M., 322  
 do Loreto Monteiro, M., 342  
 Dobies, T., 275  
 Dobson, D., 365  
 Doetzer Rosot, M.A., 196  
 Dogra, A.S., 43  
 Dogra, K.S., 259  
 Doherty, J., 238  
 Doi, S., 390  
 d'Oliveira, M.V.N., 180  
 Dolom, P.C., 281  
 Domac, J., 119  
 Donahoo, J., 286  
 Donis, J., 301  
 Donmez, A., 126  
 Donoghue, D.N.M., 278  
 Dorren, L.K.A., 310, 313  
 Dounias, E., 236  
 Dower, R., 193  
 Doyle, J., 253  
 Drake, D.R., 92  
 Drapeau, P., 274  
 Drenth, A., 337  
 Dreyer, E., 81  
 Driscoll, D., 315  
 Drobyshev, I., 98  
 Drummond, F., 261  
 Du, S., 74, 101  
 Dubé, Y.C., 112  
 Dubravac, T., 46, 90  
 Duc Tuan, P., 40  
 Duery, S., 131  
 Duggin, J.A., 243  
 Duke, N.C., 289  
 Duncan, F., 11, 39  
 Dünisch, O., 172  
 Dunn, G., 198, 199  
 Durall, D.M., 244, 245  
 Duran, N.J.E., 37  
 Durst, P.B., 278  
 Durusoy, I., 220, 224, 328  
 Dutkowski, G., 49  
 Dutschke, M., 73  
 Dutt, V., 45  
 Dutta, I.C., 385  
 Dvorak, W.S., 56, 68  
 Dykstra, D.P., 180, 278  
 Dyson, P., 362  
 Eamus, D., 92  
 Eatwell, K.A., 171  
 Eccel, E., 99  
 Echt, C., 286  
 Eckelman, C.A., 153  
 Eckmüllner, O., 204  
 Eddington, M.M., 217  
 Edeburn, J., 350  
 Edenius, L., 199  
 Edmiston, M.F., 65  
 Efransjah, E., 28  
 Egger, K.N., 245  
 Eggers, T., 296  
 Eid Chajtur, A.A., 131  
 Ekbom, B., 326  
 Ekvall, H., 334  
 El-Kassaby, Y.A., 52  
 Eldoma, A., 369  
 Elfving, B., 74  
 Ellatifi, M., 327  
 Ellgaard, E., 239  
 Elliot, C., 308  
 Ellis, T., 115  
 Elsasser, P., 299  
 Emberson, L.D., 283  
 Emmer, I., 117  
 Emtage, N., 136  
 Endamana, D., 44  
 Engel, V.L., 3, 42, 240, 246, 296, 370  
 Englefield, P., 77  
 Englund, F., 102  
 Enroth, R.-R., 162, 383  
 Eom, T.-J., 177  
 Epron, D., 249  
 Epron, E., 206  
 Erikson, O., 229  
 Erskine, P., 308  
 Ersoz, E., 60  
 Esaki, K., 254  
 Essmann, H.-F., 293  
 Estigoy, D.A., 158  
 Estreguil, C., 199  
 Evans, D.L., 167  
 Evans, J.W., 153  
 Evans, R., 172  
 Exconde, L.M., 384  
 Falacy, J., 258  
 Falck, J., 28, 210  
 Fan, Z.-F., 393  
 Fankap, R., 188  
 Fantu, W., 6  
 Farabi, H., 394  
 Faridah, Q.Z., 371  
 Faridah-Hanum, I., 143  
 Farooq, S., 183  
 Feary, S., 250  
 Fedorenko, S., 229  
 Fedotov, G.N., 244  
 Fei, B.H., 176  
 Feng, F.-L., 195, 208  
 Feng, Y., 284  
 Fenner, P.T., 374  
 Ferguson, I., 11  
 Fernández-Núñez, A., 189  
 Fernando, E.S., 302  
 Ferraz, J., 318  
 Ferreira, A., 286, 350  
 Ferreira, S.F., 318  
 Ferretti, M., 88  
 Fiani, A., 390  
 Fiedler, J., 73  
 Figueiredo, R., 369  
 Filloy, J., 258  
 Finley, J.C., 160  
 Fischer, R., 37, 265  
 Fischer, Th., 242  
 Fitzgerald, C.J., 85  
 Fjeld, D.E., 130  
 Flannigan, M.D., 77, 228  
 Flavier, M.E., 279  
 Fleischer, P., 282  
 Fletcher, S.C., 28  
 Flinn, D., 216  
 Florence, E.J.M., 121  
 Floris, A., 194  
 Flowers, G., 239  
 Floyd, R.B., 276  
 Foahom, B., 391  
 Foissner, W., 249  
 Fonseca-Gessner, A.A., 322  
 Fontes, L., 81  
 Force, J.E., 263  
 Forshed, O., 210  
 Foster, G.S., 10  
 Foster, S., 49  
 Fourcaud, T., 313  
 Fowler, C.T., 146, 160, 340, 345  
 Fowler, G., 252

- Fox, J.C., 5  
Fraczek, W., 282  
Franc, A., 4, 206  
Francis, L.P., 168, 177, 303  
Franzoni, J.A., 120  
Fraser, R.H., 77  
Frayret, J.-M., 130, 133, 164  
Fredman, P., 269  
Freed, J., 143  
Freeman, M., 74  
Freer-Smith, P., 232, 290  
Freibauer, A., 73  
Frimpong-Mensah, K., 154  
Fröblom, J., 155  
Froment, A., 236  
Frost, P., 210  
Frühwald, A., 13, 279, 304  
Frusawa, H., 381  
Fryer, J., 359  
Fu, J., 143  
Fuchs, M.A., 259  
Fuentes, J.P., 46  
Führer, J., 283  
Fujii, S., 101  
Fujikake, I., 201, 204  
Fujiwara, A., 385  
Fukuda, K., 99, 247  
Fukuda, K.I., 60  
Fukushima, K., 204  
Fulton, J.P., 182  
Furuberg, A.M., 208, 361, 385  
Furukawa, K., 375  
Futai, K., 241, 253  
Gacitúa E., W., 126, 127  
Gaeti, N., 110  
Gafur, A., 245  
Gaines, J., 340  
Gallagher, S., 109  
Gallardo-Lancho, J.F., 343  
Gallegos R., A., 27, 145  
Gallegos, A., 145  
Gallo, L., 68, 70  
Galloway, G., 158, 232, 263, 264, 350  
Galvagni, D., 197  
Galvão, F., 74  
Gamage, H.K., 92, 96  
Gan, K.S., 32  
Gandaseca, S., 353  
Ganesamoorthi, 385  
Gangadharappa, N.R., 43, 385  
Ganio, L.M., 47  
Gao, S.-Y., 381  
Gapare, W.J., 156, 157  
Garay, V., 131  
García, C., 28, 386  
García, C.M.C., 33  
García, J.N., 383  
Gardiner, E.S., 160, 286, 363  
Garrity, D., 362  
Gasman, B., 253  
Gasmi-Boubaker, A., 187, 188  
Gasparini, P., 194  
Gathright, J., 291  
Gauli, K., 227  
Gautier, D., 267  
Gazo, R., 124, 140  
Geburek, T., 49, 103  
Geiger, D.R., 259  
Geils, B., 309  
Geldenhuis, C.J., 145, 151, 259  
Gera, M., 294  
Gera, P., 339  
Gérard, J., 177  
Gerrand, A., 321  
Gerwin, W., 238  
Gessler, A., 96  
Ghadiri, H., 244  
Ghani, A.R.A., 66  
Giardina, C., 89  
Gifford, R.M., 92, 294  
Gilfedder, M., 319  
Gilkes, N., 118  
Gillis, M., 305  
Gillison, A.N., 3  
Giménez, R.A., 245  
Ginsberg, H., 261  
Gion, J.M., 52, 175  
Giordanengo, T., 52, 175  
Gios, G., 18, 215, 298  
Gisip, J., 124  
Giudici, F., 175, 342  
Gjerde, I., 39, 181  
Gladkova, G.A., 229  
Glatzel, G., 309  
Glauner, R., 13  
Glen, M., 50, 254  
Glück, P., 264  
Gobakken, T., 305  
Godzik, B., 282  
Goh, D., 121  
Goio, I., 18, 215, 298  
Goldammer, J.G., 77  
Gollberg, G., 340  
Gollin, L.X., 237  
Golos, P., 114  
Gombya-Ssembajjwe, W.S., 182  
Gomes, J.A., 138  
Gomes, J.M., 291  
Gómez-Guerrero, A., 294  
Gomon, S., 141  
Gonçalves, A.C., 138, 195  
Gonzalez, E., 277  
González, R., 131  
González, R.S., 22  
Gonzalez-Martinez, S.C., 60  
González-Pachón, J., 163  
Gordon, A.M., 321  
Gordoncillo, P., 302  
Gorman, T.M., 153  
Goss, K., 322  
Goto, O., 166  
Gottschalk, K., 86, 255  
Goulding, C.J., 1, 306  
Gourlet-Fleury, S., 23, 211  
Goven, J., 340  
Grabitzki, S., 197  
Grace, J.K., 179  
Graham, D., 76  
Grant, G.E., 311, 312  
Grayston, S.J., 245  
Grebenc, T., 243, 246, 390  
Green, C., 340, 341  
Green, D.W., 153  
Gregg, D.J., 118  
Grelle, A., 79  
Griess, O., 344  
Griffiths, A., 233  
Griffiths, M.W., 84, 276  
Griffiths, S., 84  
Grillo, R., 246  
Grodzinska, K., 282  
Grodzki, W., 254  
Gronalt, M., 136  
Groom, L.H., 170  
Grossmann, C.M., 132  
Grove, S.J., 39, 47, 325  
Grove, T.S., 13, 360  
Grulke, M., 225  
Grulke, N.E., 90  
Gruselle, M.-C., 167  
Gryzenhout, M., 392  
Guehl, J.-M., 206  
Guénette, J.-S., 275  
Guerard, N., 81  
Guerrini, I.A., 296  
Guldin, J., 48  
Guldin, R.W., 218  
Gulzar, F., 183  
Gunarso, P., 212  
Gunawan, 128  
Günthardt-Goerg, M.S., 88  
Guo, J., 368  
Guo, L.B., 294  
Guo, X.-J., 393  
Gupta, A.K., 148  
Gupta, H.K., 18, 43, 147, 322, 394  
Guries, R.P., 372  
Gustavsson, L., 72, 297  
Gutowski, W.S., 110  
Guzmán Gutiérrez, R.A., 233  
Gytarsky, M.L., 305  
Gzaghne, A., 58  
Haack, R.A., 218  
Haartveit, E.Y., 162  
Habibi Bibalani, G., 238  
Hackl, E., 249

- Haddon, B., 343  
 Hadi, Y.S., 127, 128  
 Haggar, J.P., 153  
 Hagner, O., 167, 278, 285  
 Hailu, M., 345  
 Haines, R., 359  
 Hairsine, P.B., 115, 319  
 Häkkinen, R., 78, 143  
 Hall, M., 93  
 Hall, R.J., 23, 77  
 Hallikainen, V., 368  
 Halpern, C.B., 47  
 Hamann, A., 103  
 Hamberger, J., 195, 374  
 Hamel, P.B., 160, 286  
 Hamester, F., 241  
 Hammerbacher, A., 335  
 Hammett, A.L., 357  
 Hammond, D., 210  
 Hammond, J., 4  
 Hamzah, M.Z., 315  
 Han, H.-S., 133  
 Han, K.S., 118  
 Han, S.-U., 63  
 Hånell, B., 368  
 Hanley, T.A., 39  
 Hann, J., 109, 169  
 Hannerz, M., 386  
 Hänninen, R., 15, 132  
 Hannon, E.R., 85, 390  
 Hansen, C., 199  
 Hansen, E., 105, 133, 135, 162, 163  
 Hansen, K.B., 291  
 Hanson, P.J., 78  
 Hansson, P., 80  
 Haque, M.N., 122  
 Harada, K., 223  
 Harding, K.J., 156, 171, 172  
 Hardy, G., 392  
 Hares, M., 137  
 Haron, N., 303  
 Harou, P., 18  
 Harris, G.P., 318  
 Harris, S., 165  
 Harrison, K., 279  
 Harrison, S., 116, 136  
 Hartshorn, G.S., 210, 386  
 Harvey, B., 324  
 Hasegawa, M., 378  
 Hasenauer, H., 23  
 Hashidoko, Y., 248  
 Hassan, A., 369  
 Hassani, M., 7  
 Hattori, E., 59  
 Hattori, N., 124, 277  
 Hauhs, M., 257, 354, 386  
 Hauser, S., 41  
 Haviarova, E., 153  
 Hawkins, T., 160, 286  
 Hayashi, A., 395  
 Haynes, R.W., 11  
 Haywood, A., 40  
 Heaver, A., 251  
 Heilman, W.E., 257  
 Heinemann, H.-R., 151, 373  
 Heinonen, J., 78, 143  
 Heiskanen, J., 205, 368  
 Helms, J., 343  
 Hemm, M., 209  
 Hemmens, T.J., 168, 184  
 Hennessey, M.K., 252  
 Hennon, P.E., 39  
 Heräjärvi, H., 135  
 Herbohn, J., 116, 136  
 Herbohn, K., 298  
 Hernández, G., 276  
 Hernández, L., 211  
 Hernández, P., 46  
 Hernández, R., 5  
 Hernández-de la Rosa, P., 294  
 Herruzo, A.C., 163  
 Heuveland, J., 13  
 Hickey, G.M., 217, 233, 349  
 Hickey, J.E., 40, 47  
 Hidayati, N., 390  
 Hiers, K., 340  
 Hietala, A., 336  
 Hildebrand, E.E., 374  
 Hirai, K., 318  
 Hiroshima, T., 102  
 Hiziroglu, S., 109, 126, 129  
 Ho, S.-L., 391  
 Ho, W.M., 57  
 Hobbs, T., 114  
 Hoberg, G., 16, 147  
 Hock, B., 199  
 Höcke, C., 325  
 Hoeflich, V.A., 112, 120, 121, 338, 350  
 Hoehne, N., 73  
 Hoem, L., 162  
 Hoen, H.-F., 228  
 Hoen, H.F., 305  
 Hoffmann, C., 229  
 Hogan, L., 315  
 Högberg, M.N., 79  
 Högberg, P., 79, 230  
 Hogn, K., 214  
 Hogue, A.T., 252  
 Holder, B., 341  
 Hollstedt, C., 338, 346, 358  
 Holmgren, P., 195, 343  
 Holopainen, M., 168, 301, 304, 354, 377  
 Hong, J., 65  
 Hong, J.-S., 94  
 Honma, T., 94, 95, 98  
 Hoosbeck, M., 89  
 Hoppus, M., 285  
 Hori, Y., 136  
 Horisawa, S., 381, 390  
 Horn, A., 81  
 Horne, P., 16  
 Horsley, T., 370  
 Hossain, M.K., 50, 260  
 Hotta, M., 101  
 Hou, Q., 101  
 Hou, Q.C., 74, 101  
 House, A.P.N., 325, 326  
 Howell, C.I., 217  
 Hsu, C.-H., 380  
 Hsui, Y.-R., 176  
 Huang, B., 381  
 Huang, D., 111  
 Huang, J.-G., 393  
 Huang, Q.J., 59  
 Huang, S., 34  
 Huang, Y.-J., 251  
 Hubbard, B., 345  
 Hubbard, W., 340  
 Hughes, J., 54  
 Hughson, T., 40  
 Hujala, T., 354  
 Humphrey, J., 12  
 Hussain, S.A., 137, 223, 314  
 Hussin, Y.A., 184, 185  
 Huth, A., 203  
 Hüttl, R.F., 239, 242  
 Hutton, S.G., 124  
 Huttunen, S., 100  
 Hyams, M., 125  
 Hynynen, J., 233, 297  
 Hyppönen, M., 363, 364  
 Hytönen, J., 319, 320  
 Hyttinen, P., 116  
 Hyun, J.O., 52, 53  
 Hyvönen, J., 368  
 Ibanez, L., 99  
 Ibarra, M., 46  
 Ibrahim, S., 43, 385  
 Ichihara, T., 381  
 Ieyama, H., 165  
 Igeta, Y., 254  
 Iiyama, K., 99  
 Ikami, Y., 125  
 Ikeda, H., 337  
 Ilvesniemi, H., 328  
 Im, S., 311  
 Imanishi, T., 381  
 Imatomi, Y., 374  
 Indriksons, A., 395  
 Ingram, C.D., 112  
 Innes, J.L., 217, 312, 314, 338, 347  
 Inoue, A., 24  
 Inoue, M., 7, 213, 327  
 Inoue, Y., 120

- Ishibami, N., 203  
 Ishigami, S., 24  
 Ismail, H., 26, 28, 30, 31  
 Ito, S., 24, 212, 247, 274, 391, 392  
 Ito, S.-I., 390  
 Ito, T., 269  
 Ivković, M., 156, 157  
 Iwaoka, M., 181  
 Iwasaki, Y., 125  
 Jacobs, D.F., 153, 287  
 Jacqmain, H., 150  
 Jactel, H., 4  
 Jäger, S., 103  
 Jaimes C., E.J., 93, 96, 388  
 Jakes, P.J., 357  
 Jama, B.A., 216  
 Jamaludin, M.A., 127, 128, 144  
 Jamalung, L., 43  
 James, R., 394  
 Jamnadass, R., 70  
 Jamroenprucksasri, M., 352  
 Jandl, R., 79, 89  
 Janssens, I.A., 329  
 Janssens, M., 165  
 Jarnehammar, A., 102  
 Järvinen, E., 137, 162  
 Jehopio, P., 182  
 Jellesmark Thorsen, B., 293  
 Jensen, F.S., 269  
 Jeong, J.H., 52  
 Jerez, M., 19, 131  
 Jesson, L.K., 92  
 Jia, L., 62  
 Jiang, M.-S., 381  
 Jiang, X., 33  
 Jiang, Z.H., 169  
 Jien, S.-N., 32  
 Jin, H.O., 246  
 Jin, J.-Z., 77  
 Jin, S., 285  
 Jinkawa, M., 183, 375  
 Jöbstl, H.A., 298  
 Johann, E., 249, 288  
 Johansson, R., 102  
 Johansson, S., 386  
 Johns, T., 237  
 Johnsen, K., 95  
 Johnson, D.W., 78, 240, 329  
 Johnson, J.E., 358  
 Johnson, K.N., 273  
 Johnson, S., 370  
 Jones, B., 34  
 Jones, M.D., 244, 245  
 Jones, T., 49  
 Jonsson, M., 334  
 Joo, R.W., 27  
 Jordin, B., 340, 345  
 Jörgensen, J., 122  
 Jose, S., 260  
 Joshi, L., 263  
 Joshi, M., 18, 147  
 Jourdan, C., 249  
 Jung, J.H., 336  
 Jung, M.-S., 52, 53  
 Juniper, L., 125, 381  
 Jurc, D., 243, 246, 336, 390  
 Jurc, M., 81  
 Jurskis, V., 196  
 Juslin, H., 105, 140  
 Jusof, K., 383  
 K. Sayok, A., 28  
 Kaegi, W., 117  
 Kaennel Dobbertin, M., 342, 343  
 Kafaki, S.B., 166  
 Kageyama, P.Y., 65  
 Kahle, H.-P., 89, 99  
 Kai, S., 212  
 Kaimowitz, D., 29, 271  
 Kain, D., 61  
 Kalaycioglu, H., 126  
 Kalberer, M., 311  
 Kalinganire, A., 70  
 Kallio, M., 15, 202  
 Kallweit, K., 117  
 Kalwanyi Nanyunja, R., 149, 356  
 Kamata, N., 254  
 Kammesheidt, L., 351  
 Kamo, K., 43  
 Kanal, A., 367  
 Kanashiro, M., 25  
 Kang, B.-Y., 64  
 Kang, B.S., 63  
 Kang, H., 318  
 Kang, H.-S., 205, 364  
 Kang, H.-Y., 372  
 Kang, K.-S., 63, 371  
 Kang, K.S., 63  
 Kang, S.-K., 188  
 Kang, Y.J., 63  
 Kanninen, M., 13, 262, 264  
 Kanowski, P., 308, 338, 351  
 Kant, P., 395, 396  
 Kant, S., 191, 202, 347  
 Kanuma, K., 16, 193  
 Kanzaki, N., 337  
 Kaosa-ard, M., 112  
 Karas, J., 303, 358  
 Karjalainen, T., 228  
 Karlsson, A., 210  
 Karlsson, M., 368  
 Karlton, E., 279, 306, 329  
 Karmona, J., 16  
 Kärnä, J., 11, 135, 173, 174  
 Karnosky, D.F., 54, 57, 86, 89, 93, 283  
 Karoles, K., 367  
 Karsenty, A., 211, 212  
 Kastenholz, E., 161, 163, 377  
 Kato, A., 391  
 Kato, K., 254  
 Kato, T., 295, 331  
 Katsuhisa, H., 344  
 Katul, G.G., 95  
 Kauppi, P., 295  
 Kaur, S., 2, 145, 190  
 Kavanagh, R., 40, 318  
 Kawabe, T., 124  
 Kawachi, S., 247  
 Kay, N., 254  
 Kayouli, C., 187, 188  
 Kee Seng, G., 32  
 Keena, M., 252  
 Keenan, R., 15  
 Kehl, J., 315  
 Kekeunou, S., 391  
 Kelemwork, S., 154  
 Kellogg, L., 133  
 Kelty, M., 12  
 Kempf, A., 341, 343  
 Kengen, S., 263  
 Kennard, D., 340, 345  
 Kennedy, J.F., 168  
 Kenney, A., 344  
 Kent, D., 85  
 Kerdelhué, C., 81, 252  
 Kerr, G., 12  
 Kesten, E., 245  
 Kesteven, J., 76  
 Khadka, K., 226  
 Khali, A.H., 28  
 Khanna, P., 329  
 Khasa, D., 188  
 Kiguchi, M., 109  
 Kile, G., 216  
 Killerby, S., 134  
 Killmann, W., 344  
 Kim, C.-W., 64, 371  
 Kim, C.M., 185  
 Kim, C.S., 63  
 Kim, D.H., 77  
 Kim, D.Y., 246  
 Kim, E.-G., 220, 388  
 Kim, H., 32  
 Kim, I., 221  
 Kim, I.-S., 371  
 Kim, J.-H., 318  
 Kim, J.-S., 350  
 Kim, J.H., 188, 371  
 Kim, J.M., 27, 224, 350  
 Kim, K.-H., 68  
 Kim, K.-M., 185  
 Kim, K.H., 336  
 Kim, N.-S., 371  
 Kim, S.-Y., 68  
 Kim, S.H., 388  
 Kim, W.-J., 8  
 Kim, Y.S., 177, 178

- Kim, Y.W., 52  
 Kimberley, M., 76  
 Kimmins, J.P., 34, 41  
 Kimoto, M., 391  
 Kinal, J., 324  
 Kindt, R., 70  
 King, J., 85, 89, 325  
 Kirschbaum, M.U.F., 73, 320  
 Kishi, M., 236  
 Kitching, R.L., 326  
 Kittelson, N.T., 85, 390  
 Kleine, M., 264  
 Kleinn, C., 44, 204  
 Kleinschmit, D., 346  
 Klepzig, K., 394  
 Klimo, E., 12  
 Knauff, F.-J., 354, 386  
 Knowles, C., 133, 162  
 Kobayashi, M., 318  
 Koch, A., 315  
 Koch, N.E., 159  
 Koeckemann, B., 295  
 Koelewijn, H.P., 26  
 Koh, C.-L., 69  
 Köhl, M., 194  
 Kohli, R.K., 2, 145, 190, 259, 260  
 Kohsaka, R., 16  
 Koivula, M.J., 325  
 Kokou, K., 122  
 Kokutse, A.D., 122, 313  
 Kollert, W., 333  
 Komaki, T., 387  
 Komarova, T.A., 364  
 Konerira, N., 386  
 Kong, G.-S., 185  
 Konijnendijk, C.C., 293, 301, 303, 344  
 Konovalov, N.T., 381  
 Konovalova, N.T., 381  
 Koolen, A.J., 268, 302  
 Koretsune, S., 99  
 Korhonen, K., 246  
 Korhonen, S., 133, 163  
 Kosaka, T., 124  
 Koskela, J., 51, 68  
 Kosonkarn, P., 109  
 Kostilainen, A., 339  
 Kotagama, S.W., 190  
 Kougionis, C., 109  
 Kowero, G., 266  
 Kozak, J., 199  
 Kozak, R., 133  
 Kraigher, H., 243, 246, 390  
 Kräuchi, N., 94, 96, 98, 283  
 Krcmar, E., 348  
 Kremer, A., 49, 59  
 Krishnapillay, B., 27, 57  
 Kroese, H., 109  
 Krogh, E., 349  
 Krott, M., 150, 218  
 Krovak, F., 322  
 Krutovsky, K., 60  
 Krzyzanowski, J., 347  
 Ku, C.-W., 382, 383  
 Kubiske, M., 89  
 Kubo, E., 381  
 Kubo, M., 395  
 Kubota, J., 396  
 Kudinov, A.I., 205  
 Kulhavý, J., 12, 240  
 Kull, O., 89  
 Kumar, R., 194, 220  
 Kunes, I., 241  
 Kuniyoshi, Y.S., 74  
 Kuo, Y.-L., 94  
 Kupänskiendö, E., 100  
 Kupka, I., 4  
 Kurz, W.A., 77, 84, 305, 330  
 Kushalappa, C.G., 386  
 Kushida, T., 59, 94, 95, 98  
 Kusumaningrum, W., 127  
 Kuuluvainen, J., 327  
 Kuvan, Y., 315  
 Kwiatkowski, A., 109  
 Kwon, Y.-H., 372  
 La Porta, N., 4, 36, 53, 62, 69, 82, 83, 87, 99, 186, 246, 336, 384  
 Laaksonen-Craig, S., 264  
 Laasasenaho, J., 354  
 Labat, A., 73  
 Laengin, D.W., 354  
 Laflamme, G., 309  
 Laforteza, R., 291  
 Lagan, P., 333  
 Lagergren, F., 79  
 Lagunzad, C., 15  
 Lagunzad, D., 15  
 Laine, J., 320  
 Lakatos, F., 254  
 Lal, C., 45  
 Lal, S., 359  
 Lamb, D., 240, 308, 369  
 Lambert, M., 216  
 Lamontagne, M., 85  
 Lance, D.R., 252  
 Landry, R., 77  
 Landsberg, J.J., 81  
 Lane, P., 307  
 Lane, W., 165  
 Lange, G.-M., 112, 299  
 Langer, E.R., 340  
 Langor, D.W., 4, 326  
 Lankreijer, H., 79  
 Lanvin, J.D., 175  
 Lapitan, F.G., 33  
 Larsen, J.B., 159  
 Larsmon, M., 361, 385  
 Larson, B., 256  
 Larsson, S., 80, 326  
 Larsson, T.-B., 36, 37  
 Lässig, R., 229  
 Last, I., 61, 63  
 Latta, G., 35  
 Lau, J., 165  
 Law, B., 41, 318  
 Lawson, S., 82, 200, 255  
 Leahy, J.E., 251, 268, 357  
 Leal, S., 173  
 Leban, J.-M., 7, 172  
 Lechner, H., 169  
 Leckie, A., 76  
 Leckie, D., 286, 305  
 Lecomte, N., 347  
 Ledig, F.T., 69  
 Lee Abt, K., 112  
 Lee, C.-T., 51, 69  
 Lee, C.-Y., 318  
 Lee, D.-S., 8  
 Lee, D.J., 62  
 Lee, D.K., 57, 94, 98, 139, 205, 265, 267, 364, 372  
 Lee, D.K., Kang, H.-S., 32  
 Lee, H.-J., 372  
 Lee, J.H., 52, 53  
 Lee, J.S., 185  
 Lee, K.H., 27, 177, 224  
 Lee, M.-H., 336  
 Lee, M.-J., 55, 389, 391  
 Lee, M.-K., 372  
 Lee, M.B., 77  
 Lee, M.J., 246  
 Lee, S.-H., 154, 185, 311, 336  
 Lee, S.-L., 51, 69, 371  
 Lee, S.I., 77  
 Lee, S.K., 336  
 Lee, S.S., 143, 341  
 Lee, S.Y., 336  
 Lee, T., 24  
 Lee, W.-S., 316  
 Lee, W.Y., 52  
 Lee, Y., 221  
 Lee, Y.K., 94, 98  
 Lefaix-Durand, A., 133  
 Legg, C., 41  
 Lehto, E., 221  
 Lehto, S., 173  
 Lehtonen, A., 296  
 Lehtonen, E., 327  
 Leininger, T.D., 160, 286  
 Leino, O., 301, 304, 377  
 LeMay, V., 80, 205, 286  
 Lemckert, F., 318  
 Lempinen, R., 1  
 Lengkeek, A., 70  
 Leodoro da Silva, J.C.G., 140  
 Leon, B., 303

- Leong, C.-M., 32  
 LeVan, S., 154  
 Lévesque, D., 230  
 Levesque, Y., 153  
 Lewark, S., 161, 163, 252, 351, 354, 377, 387  
 Li, B., 65  
 Li, C.-Z., 327  
 Li, H.-F., 393  
 Li, M., 94  
 Li, S., 110  
 Li, Y., 29, 248, 393  
 Li, Z., 302  
 Li, Z.-Q., 393  
 Liang, W.-X., 393  
 Liao, Y.-K., 336  
 Lidasan, H., 302  
 Lidestav, G., 116, 327  
 Liebhold, A., 255  
 Lieutier, F., 81, 82  
 Lievois, J., 310  
 Lim, G., 269  
 Lim, H.J., 118  
 Lim, N.P.T., 7  
 Lim, S.C., 32  
 Lima, W. de P., 322, 323  
 Lin, F.-C., 32  
 Lin, H.C., 178, 382  
 Lin, S.H., 110  
 Lin, Y.-T., 32  
 Lindenmayer, D., 16, 274, 275  
 Linder, S., 93, 97, 173, 230  
 Lindgren, D., 63  
 Lindholm, E.-L., 102, 192  
 Lindqvist, H., 329  
 Lindroos, O., 116  
 Lindroth, A., 79  
 Lindstrom, G.M., 286  
 Ling, W.C., 177  
 Lisi, C.S., 73, 330  
 Liski, J., 296, 297  
 Litschauer, R., 103  
 Littell, J.S., 348  
 Littvay, T., 46  
 Litvay, T., 90  
 Liu, C.M., 171  
 Liu, J.-Y., 176  
 Liu, J.L., 221  
 Liu, S., 29, 97, 231  
 Liu, X., 33  
 Liu, Y.-Y., 55, 389, 391  
 Liu, Z.-M., 170  
 Lo, S.-L., 225, 251, 387  
 Lo, Y.-H., 34  
 Lobovikov, M., 262, 280  
 Lockhart, B.R., 160  
 Löf, M., 365, 368  
 Logan, K.A., 77  
 Lomský, B., 240  
 Lönnstedt, L., 387  
 Loo, J.A., 69, 287  
 Lopez, A.V.B., 144  
 López, C., 275  
 López-Díaz, M.L., 189  
 López-Sors Cano, C., 14  
 Lorenz, M., 265  
 Lorenzini, G., 284  
 Lott, R., 114  
 Louman, B., 263  
 Loureiro, A., 342  
 Louw, J.H., 181  
 Lowe, A., 276  
 Lowe, R.C., 231  
 Loyn, R.H., 41  
 Lu, K.-C., 38  
 Luangjame, J., 323  
 Lugo, A.E., 289, 363  
 Luján Alvarez, C., 266  
 Lukkarinen, A., 173, 174  
 Lundblad, M., 306  
 Lundin, L., 329  
 Lunnan, A., 164  
 Luoma-aho, T., 51  
 Luxmoore, R.J., 296  
 Lynham, T.J., 77  
 Lyrén, L., 388  
 Mabee, W.E., 118  
 Mac Donagh, P., 350  
 MacDonald, G., 261  
 Machado, C.C., 108, 209, 375  
 Machlis, G., 263  
 MacHunter, J., 41  
 Macintosh, D., 289  
 MacLean, D.A., 84, 86  
 MacMiller, E., 315  
 Macnab, B., 348  
 Maddumba, H.A., 144, 158, 211, 356, 384  
 Madsen, P., 365  
 Maelim, S., 372  
 Maestri, R., 8  
 Magnoux, E., 252  
 Maguire, D.A., 47  
 Mahat, M.N., 66  
 Mainwaring, D.B., 47  
 Majnonian, B., 238  
 Major, J.E., 64, 104  
 Major, M., 163  
 Makarova, O.V., 268, 302  
 Mäkelä, A., 25, 233  
 Mäkinen, A., 354, 377  
 Mäkipää, R., 296  
 Mäkiranta, P., 320  
 Mäkitalo, K., 205, 368  
 Makoto, I., 16  
 Mala, W.A., 41  
 Malecdan, M., 211  
 Malheiros de Oliveira, Y.M., 196  
 Maljanen, M., 320  
 Malone, M., 366  
 Man'ko, Y.I., 205  
 Manabe, T., 381  
 Manalo, A.C., 33  
 Manetti, M.C., 342  
 Mann, I.K., 64  
 Manning, W., 282  
 Manohar, M., 269  
 Manso Martin, M., 12  
 Mansur, A., 144  
 Mapanao, J.S., 158  
 Maplesden, F., 134  
 Maraseni, T.N., 299, 357  
 Marcar, N., 319  
 Marchelli, P., 68  
 Marchetti, M., 36, 37, 194  
 Marchi, E., 91, 107  
 Marcot, B.G., 21  
 Maresi, G., 87, 186  
 Margueret, V., 188  
 Maria, V.R.B., 73  
 Marinucci, L., 53  
 Marjokorpi, A., 5  
 Marland, G., 73  
 Marquisa, F., 230  
 Marshall, D., 48  
 Marshall, E., 134, 280  
 Marshall, H., 130  
 Marshall, P., 24  
 Marshall, P., 80, 286, 365  
 Martin, F.B., 211  
 Martineau-Delisle, C., 347  
 Martinelli, L., 369  
 Martinez, M., 163  
 Martins Pinto, A.C., 209  
 Martins Rufino, A.M., 269  
 Martins, A., 342  
 Martins, A.M., 240  
 Martins, E.G., 66  
 Martins, G., 140, 202  
 Maru%oák, R., 208  
 Marzullo, L., 197  
 Mason, B., 12  
 Mason, E., 258  
 Massijaya, M.Y., 127, 128, 170, 203, 331  
 Massoca, P.E. dos S., 246  
 Masters, R., 340  
 Masuda, M., 111, 222, 272  
 Masunaga, L., 274  
 Mat, S., 369  
 Matejka, K., 303  
 Matengu, K., 355  
 Matheson, A.C., 157  
 Mathey, A.-H., 348  
 Mathur, V.B., 21  
 Matsumoto, M., 305  
 Matsumura, J., 7, 378  
 Matsumura, Y., 125

- Matsune, K., 120  
 Matsushita, M., 247  
 Matteucci, G., 73  
 Mattsson, A., 231  
 Mátyás, C., 103  
 Mayer, A.C., 311  
 Mayer, P., 344  
 Mbang, T., 177  
 Mbiru, S.S., 159  
 McAdam, J., 189  
 McCarthy, H.R., 95  
 McCormack, B., 319  
 McDermott, C., 266  
 McDonald, J., 82, 255  
 McDonald, T.P., 182  
 McDowell, R.M., 252  
 McEwin, G., 289  
 McGeoch, M.A., 326  
 McGowen, M., 49  
 McGrath, J., 324  
 McIlwain, J.-J., 303  
 McKeand, S.E., 65  
 McKenzie, P., 278  
 McKinnon, G., 49  
 McNabb, E.G., 41  
 Månsson, J., 387  
 McPherson, G., 166  
 McRae, T.A., 156, 157  
 Mårell, A., 234, 300  
 Medeiros, J.G.S., 75  
 Medhurst, J., 97  
 Medraj, I., 54  
 Meguro, S., 247  
 Mehta, R., 287  
 Mekic, F., 62  
 Melkas, T., 377  
 Mello, E.J., 67  
 Melnikova, M., 4  
 Men/Āele, L., 112, 227  
 Mendel, Z., 86  
 Mendham, D.S., 13, 324, 360  
 Mendoza M., J.G., 93, 96, 388  
 Mendoza, G.A., 191  
 Mery, G., 262, 264, 265  
 Messi, J., 391  
 Metzler, J., 285  
 Michaelowa, A., 73  
 Mickler, R.A., 91  
 Mikhailov, Y., 229  
 Mikkola, K., 205  
 Mikusifski, G., 199  
 Milasowszky, N., 249  
 Miller, G., 228  
 Miller, R., 148  
 Mills, R., 341  
 Minematsu, H., 181  
 Miner, C., 157  
 Minerbi, S., 98  
 Minette, L.J., 108, 209, 290, 291, 375  
 Minkinen, K., 320  
 Misbahuzzaman, K., 288  
 Mischis, C.C., 245  
 Mitchell, D., 357  
 Mitchell, S.J., 41  
 Mitsuhiro, S., 381  
 Mittempergher, L., 62  
 Miyake, M., 186  
 Miyamoto, M., 113  
 Miyata, E.S., 373  
 Mizoue, N., 24, 207, 212  
 Mizunaga, H., 24, 101  
 Mochalov, S., 229  
 Mochan, S., 313  
 Mochida, H., 272  
 Modesto, 245  
 Mohali, S., 58  
 Mohamed, A., 9, 122, 351  
 Mohamed, A.M., 216  
 Mohammed, C., 50, 254, 334, 335  
 Mohan, G., 294  
 Mohd. Zaki, M.I., 341  
 Mohn, W.W., 245  
 Moiseev, P., 229  
 Moiseyev, A., 202  
 Moktar, J., 122  
 Mölder, M., 79  
 Molenaar, S., 110  
 Möller, R., 178  
 Monda, Y., 396  
 Mononen, J., 333  
 Monserud, R.A., 13, 34  
 Montagnini, F., 188, 267  
 Montenegro, F., 142  
 Monteuiis, O., 121  
 Moon, H.K., 52  
 Moore, J., 306  
 Moore, S.E., 350, 355  
 Moosavy, S.A., 382  
 Mora, E., 206  
 Morales, D., 44, 204  
 Moran, B., 319  
 Moreira, F.M.T., 108  
 Morgan, P., 340  
 Mori, E.S., 65, 372  
 Morita, M., 291  
 Mörling, T., 74  
 Mosquera-Losada, M.R., 189  
 Moss, P., 165  
 Mosseler, A., 64, 104  
 Moynihan, M.R., 55  
 Mozuna, M., 183  
 Mridha, M.A.U., 122  
 Muccinelli, I., 4, 53, 69  
 Mueck, S., 216  
 Mues, V., 265  
 Mugumya, X., 117  
 Muhammad, N., 51  
 Mühlisegl, R., 375  
 Muktar, E., 101  
 Mulatya, J., 216  
 Muller, A.C., 120  
 Mullin, T.J., 63, 65  
 Mund, M., 1  
 Munks, S.A., 39, 315, 316  
 Murakami, T., 207  
 Murali, K.S., 386  
 Murata, K., 125  
 Murata, M., 392  
 Murdiyarsu, D., 320  
 Murphy, G., 130  
 Murphy, J.F., 153  
 Murray, M.H., 380  
 Musselman, R., 282  
 Mutamba, M., 266  
 Muti Lin, J.C., 375  
 Muukkonen, P., 296  
 Muys, B., 117  
 Muzika, R.-M., 282  
 Nadeau, S., 347  
 Nadel, R., 247  
 Nagaike, T., 395  
 Nagata, H., 94  
 Nagesha, G., 43, 385  
 Nair, P.K.R., 187, 188, 189  
 Nair, V.D., 190  
 Nakabonge, G., 392  
 Nakajima, T., 296  
 Nakamura, A., 326  
 Nakamura, K., 120  
 Nakanishi, T.M., 373  
 Nakao, T., 212  
 Nakashima, A., 94, 95, 98, 302  
 Nakashima, T., 241, 392  
 Nali, C., 284  
 Naoko, M., 100, 261, 396  
 Nardoto, G., 369  
 Näsholm, T., 229  
 Nasi, R., 25, 191, 209, 386  
 Naskali, A., 333  
 Nath, T.K., 327  
 Naurzbaev, M.M., 75  
 Navarro, C., 276  
 Ndoye, O., 44, 349  
 Neale, D.B., 60  
 Nealis, V., 84  
 Nedorezov, L.V., 349  
 Negri, M., 110  
 Neilson, T., 289  
 Nelson, H., 147  
 Nelson, N., 89  
 Nemoto, J., 302  
 Nester, M., 172  
 Neuhoferova, P., 358  
 Neuvonen, M., 270  
 Neville, P., 37  
 Newman, D., 272  
 Newton, A., 134, 280

- Newton, P.F., 206  
Neyland, M.G., 47, 325, 365, 366  
Nezcek, R., 160  
Ng Kit-Siong, K., 69  
Ng, F., 369  
Ng, K.K.-S., 51, 371  
Ngobo, M., 41, 144, 261, 349  
Ngugi, M.R., 34  
Nichols, O., 238  
Nicholson, E., 5  
Nickerson, R.G., 268, 288  
Nicolescu, N.-V., 37, 366  
Niemela, J., 324  
Niemelä, P., 82  
Nieminen, J., 354  
Nieuwenhuis, M., 196, 344  
Nikinmaa, E., 25  
Nikles, D.G., 62, 66  
Nilsson, K., 291  
Nilsson, M., 196, 278  
Nirmala Sari, E.N., 193  
Nishimoto, T., 100  
Nishimura, S., 101, 211  
Niskanen, A., 164, 272  
Nitami, T., 376  
Nitschke, C.R., 233, 361  
Niu, J.Z., 323  
Njui, A.N., 216  
Nkabonga, G., 58  
Nkongmeneck, A.B., 349  
Nobel, A., 109  
Nobis, M., 343  
Nolan, G., 33  
Nolasco, A.M., 383  
Nolte, C., 41  
Noor Azlin, Y., 269, 304  
Nordin, K., 127, 128, 172  
Norjamäki, I., 377  
Norland, E.R., 159, 346, 358  
Norlia, B., 371  
Norton, J., 177  
Norwati, A., 371  
Norwati, M., 371  
Notaro, S., 18, 298  
Nötzli, M., 98  
Nouvellon, Y., 249  
Novak, K., 283  
Nowak, D.J., 302  
Nur Hajar, Z.S., 31  
Nur Supardi, M.N., 211  
Nurdin, W., 123  
Nurhajar, Z.S., 28  
Nurrochmat, D.R., 150  
Nurse, M., 227  
Nuruddin, A.A., 6, 77, 155  
Nuruddin, A.A., 155  
Nuryawan, A., 170  
Nutto, L., 8, 12  
Nuutinen, T., 1  
Nyam-Osor, B., 205  
Nybakk, E., 164  
Nyberg, B., 214  
Nyberg, J.B., 21  
Nygren, A., 263  
O'Brien, N., 352  
O'Connell, A.M., 360  
O'Hara, K.L., 311  
O'Neal, A., 261  
Ochiai, Y., 243  
Ochimaruru, T., 247  
Ochoa, H.G., 145  
Oda, K., 7, 378  
Odsey, M.S., 252, 378, 384  
Ofori, D.A., 56, 86  
Ogino, K., 101  
Ognouabi, N., 52, 175  
Oh, J.S., 27, 224  
Ohkawabata, O., 382  
Okai, R., 125, 154  
Økseter, P., 208  
Oktalina, S.N., 295  
Oktalina, S.N., 223  
Okuda, T., 211  
Okuma, M., 128  
Okuyama, T., 120  
Oliveira, Â.C., 195  
Oliveira, L.C., 180  
Oliver, C.D., 234  
Olivier, A., 188  
Olsson, H., 278  
Olsson, M.T., 350  
Olsson, P., 230  
Omasa, K., 87  
Ometto, J., 369  
Omidvar, A., 178  
Ong, P., 14  
Onofre, F.F., 3  
Opuni-Frimpong, E., 54, 57, 86  
Orazio, C., 200  
Orea, U., 145  
Orekhova, T.P., 205  
Oren, R., 95  
Orlikowska, E.H., 39  
Oryang, D.O., 252  
Osaki, M., 248  
Osawa, Y., 166  
Osbulan, P., 211  
Oslejs, J., 138  
Osterbauer, N., 258  
Ostry, M.E., 309  
Otaala, B., 355  
Othenin-Girard, A., 121  
Otsamo, A., 5  
Otsamo, R., 5  
Otsuki, K., 74, 100, 101  
Ou, C.-H., 38  
Ouedraogo, S.J., 45  
Owari, T., 140  
Oyarzún R., P., 127  
Ozanne, L.K., 135, 140, 192  
Ozarska, B., 109, 121, 125, 380, 381  
Öztürk, A., 224, 328  
Pabuayon, I.M., 33  
Packalén, K., 164  
Page, A., 262  
Paik, K.-H., 372  
Pain-Orcet, M., 386  
Paiva, M.R., 37  
Pak, M., 18, 224, 328  
Pakhomov, E.I., 244  
Paldanius, P., 133  
Palijon, A.M., 302  
Palik, B., 48  
Pallett, R.N., 57  
Palmér, C.-H., 386  
Palmroth, S., 95  
Palo, M., 221, 222  
Palosuo, T., 296  
Pampolina, N.M., 37  
Pandalai, R.C., 13, 360  
Panditharathna, K.A.K., 96  
Panesar, T.S., 245  
Pankova, E., 322  
Pannatier, E., 90  
Paoletti, E., 87, 284  
Papanastasis, V.P., 189  
Paradine, D., 305  
Pardini, A., 189  
Paredes, G., 201  
Parfitt, R.L., 107  
Pariani, S., 53  
Park, B.-S., 8  
Park, D.K., 265  
Park, H., 246  
Park, J.-H., 8  
Park, M.S., 346  
Park, P.S., 107  
Park, Y.-S., 316  
Park, Y.D., 265, 364  
Paron, M.E., 246  
Parrotta, J.A., 2, 4, 42, 246, 263, 368  
Parshov, S.M., 381  
Parsons, M., 33, 139  
Parviainen, J., 193  
Paschalis-Jakubowicz, P., 235, 300, 338  
Páscoa, F., 22  
Pasha, M.K., 260  
Pasicznik, N.M., 342  
Passerotti, S., 4, 53, 69  
Passos, C., 180  
Pastorino, M., 70  
Paul, K., 320  
Paul, T., 199  
Paulo, J., 20



- Paulo, J.A., 75  
Pavlic, D., 57  
Payn, T.W., 76, 107, 199  
Payton, I., 307  
Pearson, A., 41  
Peça, J.O., 138  
Pech, P., 352, 358  
Pecl, J., 117  
Pegg, G.S., 247, 303, 337  
Pek, Y.K., 7  
Pekkarinen, A., 168  
Pelkonen, P., 351, 355  
Peltoniemi, M., 296  
Pelz, D.R., 378  
Pena, N., 73  
Penman, D., 363  
Penman, J., 73  
Pepke, E., 135  
Peralta, E.O., 281  
Percy, K.E., 88, 89, 283  
Pereira, H., 173  
Pérez, D., 13  
Pérez-Martínez, P.-J., 89  
Peri, P.L., 10  
Persson, R., 271  
Perttunen, J., 25  
Peter, B., 266  
Peters, R.F., 156, 171  
Peters, V., 77  
Petersen Raymer, A.K., 305  
Peterson, C.E., 2  
Peterson, D.L., 348  
Petersson, H., 306  
Petheram, R.J., 346  
Petit, R., 49  
Petritan, A.-M., 37  
Petritan, I.-C., 37  
Petrokofsky, G., 342, 345  
Pettenella, D., 293  
Peyron, J.-L., 19, 99, 298, 299  
Pfautsch, S., 96  
Pfeffer, M., 249  
Phan Hoang, D., 149  
Phua, M.-H., 185, 186  
Pião, A.C.S., 331  
Piao, C., 248  
Piao, C.-G., 393  
Piboule, A., 206  
Picard, N., 23  
Pido, M., 14  
Pierskalla, C.D., 288  
Piispanen, R., 173  
Pilz, D., 142, 143  
Pinaki, S., 144  
Pineda C., N.M., 93, 96  
Pingoud, K., 72, 73, 102, 297  
Pinheiro, A.C., 138  
Piñon, A.A., 37  
Piovani, P., 69  
Pipatwattanakul, D., 352  
Pividori, M., 342  
Plamondon, A.P., 230  
Plomion, C., 60  
Plonzack, M., 131  
Plotkin, J., 69  
Podrazsky, V., 25, 26, 48, 182, 200, 241, 248, 297, 303, 316, 321, 322, 352, 358  
Pohjola, J., 102, 297, 333  
Pohl, G., 4  
Pohtila, E., 205  
Pokharel, B., 227  
Pokorny, B., 375  
Polglase, P., 319  
Pollard, D., 5, 308  
Polle, A., 245  
Pollini, C., 215, 298  
Pollisco, J.P., 37  
Pommerening, A., 344  
Popescu, F., 282  
Porro, R., 348  
Portales, J.M., 394  
Porter, K., 84, 86  
Possingham, H.P., 5  
Post III, W.M., 296  
Pothier, D., 14  
Potoánik, I., 271  
Potter, N., 115  
Potter, S., 171  
Potts, B., 49, 372  
Poulin, D., 133, 164  
Pouta, E., 270, 327  
Povoa de Mattos, P., 66, 74, 75, 155, 180, 196, 331  
Powell, M., 157  
Powers, R.F., 79  
Prabhu, R., 191  
Prasolova, N., 108  
Pregernig, M., 214  
Prescott, C.E., 245  
Prestemon, J.P., 87  
Pretzsch, H., 35, 81  
Prévost, M., 230  
Price, C., 202  
Primmer, E., 17  
Pritchard, J., 77  
Pröbstl, U., 270, 293  
Promis, A., 10, 46, 378  
Protasov, A., 86  
Prüller, R., 343, 344  
Pulkrab, K., 203  
Punam, 149, 328  
Puodžiūnas, M., 130  
Purfürst, T., 376  
Puri, R., 263  
Putro, W.T., 223  
Puzzolo, V., 199  
Quarles, S.L., 165  
Quesada, H.J., 140  
Quijano, J.G., 117  
Quine, C., 12  
Racchi, M.L., 60  
Race, D., 352  
Rachmi, A., 203  
Raddi, P., 82  
Radford, J.Q., 274  
Raffaelli, R., 18  
Raftoyannis, Y., 78, 241  
Rahim Nik, A., 293, 303  
Rahim, S., 154  
Raison, J., 319  
Raja Barizan, R.S., 26, 29  
Raja Yusoff, 304  
Rajora, O.P., 64, 104  
Rajvanshi, A., 21  
Ramamonjisoa, B., 222  
Ramamonjisoa, L., 70  
Rametsteiner, E., 73, 106, 163  
Ramírez-Angulo, H., 30, 206, 207  
Rämö, A.-K., 119, 134, 137  
Rämö, A.-K., 162  
Ramos da Silva, R., 321  
Ramos G., Y.T., 93, 388  
Rampley, G., 305  
Ramsden, M., 84, 168, 184, 247, 303  
Ramsey, C., 260  
Ramsfield, T.D., 255, 337  
Rana, V., 277  
Randrup, T.B., 344  
Ranganath, A.D., 43  
Ranius, T., 334  
Rankin, I., 362  
Rantala, T., 272  
Räntfors, M., 93  
Rashid, A.S., 28  
Rasmussen, K.R., 293  
Rastin, N., 241  
Ratnasingam, J., 125  
Rauch, P., 136  
Rauscher, M., 340, 345  
Rawat, J.K., 194, 220  
Rayner, J., 264  
Rayner, M.E., 42  
Razal, R.A., 281  
Read, S., 349  
Real, A., 346  
Reams, G.A., 74  
Rebugio, L.L., 139, 219, 224, 338  
Redsven, V., 1  
Reed, S., 346  
Regan, T., 16  
Regan, T.J., 5  
Reid, N., 3, 308, 309  
Reid, R., 115, 346  
Reilly, D.F., 66  
Reitz, R., 160  
Rekola, M., 272, 327, 352

- Remes, J., 25, 26, 48, 200, 248, 316  
Rennenberg, H., 295  
Resalati, H., 382  
Reuter, M., 13, 330  
Reynolds de Souza, D., 138  
Rezende, G.D.S.P., 61  
Rezende, G.D.S.P., 173  
Rhim, S.-J., 316  
Rho, D.-K., 185  
Ribeiro, N.A., 138, 286  
Ric, J., 253  
Ricard, R., 344  
Richards, A., 295  
Richards, G., 305, 306  
Richards, K., 119  
Richardson, J., 119  
Richardson, S., 238  
Richter, D., 350  
Ricse, A., 50  
Riekkinen, M., 173, 174  
Riera, P., 19  
Rieske-Kinney, L., 58  
Rigueiro-Rodríguez, A., 189  
Rigueiro-Rodríguez, E., 189  
Rihm, B., 90  
Riitters, K., 200  
Rimbawanto, A., 64  
Riopel, M., 14  
Riov, J., 91  
Ripatti, P., 137  
Risbrudt, C., 152  
Rishi, P., 227  
Ritson, P., 107, 330  
Roberds, J., 58  
Roberge, J.-M., 273  
Robertson, R.M., 66  
Robichaud, F., 133  
Robiglio, V., 41  
Robison, D.J., 58, 160, 366  
Rochadelli, R., 202  
Rochester, W., 17  
Roda, J.-M., 266  
Rodas, C., 58  
Roderjan, C.V., 74  
Roeder, A., 300  
Roetzer, T., 81  
Rohman, 223, 295  
Romani, M., 91  
Romero, C., 163  
Ronalds, G., 19  
Roque, R.M., 67  
Roques, A., 252  
Rosales, G., 19  
Rosen, H., 105, 378  
Roshetko, J., 70  
Rosin, A., 299  
Rossi, S., 41, 107  
Rothpfeffer, C., 279  
Roux, J., 58, 59, 83, 392  
Roy, S.K., 54, 144, 366  
Rozados Lorenzo, M.J., 14  
Rozas, V., 14  
Rozsa, A., 125  
Rua, D.R., 370  
Rudebjer, P.G., 352  
Rufino, A.M.M., 296  
Ruiz Selmo, F., 258  
Ruiz-Garvia, C., 330  
Russo, I., 303  
Ryan, P., 180  
Ryu, K.-O., 371  
Ryu, K.S., 350, 388  
Sá, M., 70  
Sabatti, M., 89  
Sabja, A.M., 55  
Saddler, J.N., 118  
Sader, S.A., 285  
Sadhardjo, Sm., 123  
Sadykov, A., 349  
Sadykova, D., 349  
Sætersdal, M., 39, 181  
Sagheb-Talebi, K., 160  
Saito, K., 385  
Sajeev, M.V., 43  
Sajeev, T.V., 86  
Sakagami, H., 378  
Sakai, N., 59  
Sakai, T., 353  
Sakals, M.E., 312, 314  
Sakamoto, K., 100, 261  
Sakuma, Y., 390  
Salbitano, F., 303  
Salehi Shanjani, P., 70  
Sales Medrado, M.J., 112  
Sales, C.G., 174  
Salin, F., 313  
Salinas Castillo, W.E., 186, 242  
Salis, S.M., 331  
Salo, K., 143  
Salvadori, C., 36, 87, 99, 186  
Salvatera, M.E., 158, 356  
Sam, N., 359  
Sample, V.A., 250  
Samsi, H., 9  
Samsudin, M., 26, 29, 30, 31  
Sanaev, V.G., 353  
Sandak, J., 110  
Sands, R., 258, 352  
Sanesi, G., 291  
Sanii, H., 238  
Sankaran, K.V., 13, 360  
Santana, D.L. de Q., 255  
Santiago, B.R., 276  
Santini, A., 62  
Santosa, K.D., 212  
Sanz, M.J., 284  
Saphir, N., 86  
Saracino, A., 288  
Saraíva Dias, S., 138  
Saralde Jr., T.C., 33  
Saramäki, J., 267  
Saranpää, P., 173  
Saroinsong, F.B., 261  
Sartori, M.S., 3  
Sarvaš, M., 100  
Sarwar Jahan, M., 8  
Sasaki, A., 64  
Sasaki, H., 99  
Sasaki, Y., 64  
Satake, T., 375  
Sathre, R., 297  
Saurer, M., 98, 283  
Sauvard, D., 81  
Savolainen, O., 60  
Saw, L.-G., 51, 69  
Sawada, Y., 277  
Sawarkar, V.B., 316  
Sawyer, A.J., 252  
Sayeed Hassan, A.K.M., 144  
Sayer, J.A., 4, 308  
Scarascia-Mugnozza, G., 73, 89  
Schaaf, W., 242  
Schack-Kirchner, H., 374  
Schanz, H., 132, 215  
Schaub, M., 90, 94, 96, 282, 283, 284  
Scheer, L., 286  
Schiff, N.M., 160, 286  
Schindlbacher, A., 79  
Schinnerl, S., 355  
Schipperijn, J., 303  
Schlamadinger, B., 73, 117, 119, 305, 306  
Schmerbeck, J., 222  
Schmidt, H., 378  
Schmidt, S., 295, 369  
Schmiegelow, F.K.A., 325  
Schmithüsen, F., 112  
Schmitt, J., 225  
Schmitt, M., 76, 90  
Schmitt, U., 178, 179  
Schneider, B.U., 242  
Schneider, R., 14, 170  
Schoenholtz, S., 79  
Schoettle, A.W., 256  
Scholes, M., 247  
Schönenberger, W., 310, 312, 313  
Schopfer, S., 203  
Schrader, H., 197  
Schram, P., 344  
Schraml, U., 136  
Schreuder, G.F., 181  
Schroeder, M., 326  
Schroeder, R., 143  
Schuck, A., 38  
Schuck, S., 119  
Schüler, G., 149, 312, 323  
Schuler, J., 366

- Schulz, R., 80  
 Schulze, E.-D., 1  
 Schützendübel, A., 245  
 Schwaiger, H., 117  
 Schwarze, F.W.M.R., 335  
 Schwitzer, M., 109  
 Scrinzi, G., 197  
 Scrinzi, G., 194  
 Sean, H.S., 120  
 Sebastiani, F., 60  
 Sebbenn, A.M., 372  
 Sedjo, R.A., 19, 72, 102  
 Seen, D.L., 386  
 Segura-Bonilla, O., 163  
 Selig, M.F., 287  
 Senbeta, F., 51, 67  
 Sennerby Forsse, L., 293  
 Seo, J.-W., 388  
 Seok, H.D., 44, 388  
 Serrão, A., 348  
 Sessions, J., 373  
 Sessitsch, A., 249  
 Setyawati, T., 349  
 Setzer, F., 301  
 Severeid, L.R., 287  
 Sevrin, E., 343  
 Seydack, A., 25  
 Seymour, R.S., 48  
 Shackleton, S., 138  
 Shaginov, A., 110, 169  
 Shalaev, V.S., 244, 268, 302  
 Shamoun, S.F., 309, 337  
 Shamsudin, I., 26, 28, 29, 30  
 Shand, A., 84  
 Shanley, P., 237  
 Shannon, M.A., 214, 273  
 Sharifi, A., 187  
 Sharma, M., 55, 171  
 Sharma, N., 185  
 Sharma, P.K., 149  
 Sharma, R.K., 55  
 Sharry, S., 53  
 Sheil, D., 236, 349  
 Shek, L.P., 54  
 Shelton, D., 152  
 Shen, Y., 62  
 Shi, Z., 88, 97  
 Shiah, T.-C., 178, 382  
 Shiau, R.-J., 380  
 Shiba, M., 193, 313  
 Shiga, K., 222  
 Shilling, D.G., 261  
 Shim, K.-B., 8  
 Shim, S.-R., 8  
 Shim, T.-H., 64  
 Shimamura, M., 361  
 Shimase, T., 141  
 Shimizu, H., 284  
 Shin, H.N., 52  
 Shinohara, K., 49  
 Shivamurthy, M., 43  
 Shiver, B., 231  
 Shon, C.H., 44, 220, 388  
 Shook, S., 163  
 Shore, T., 86  
 Shupe, T.F., 170  
 Shvidenko, A., 228  
 Si, N.W., 176  
 Sibirina, L.A., 364  
 Sidders, D., 321  
 Siddique, I., 369  
 Sidle, R.C., 312, 313  
 Sidorova, O.V., 75  
 Siegwolf, R., 98  
 Sievänen, R., 25, 297  
 Sievänen, T., 270  
 Siipilehto, J., 297  
 Siitonen, M., 1  
 Sills, E., 18, 350  
 Silva, K.R., 375  
 Silva-Pando, F.J., 14, 190  
 Simard, S.W., 245  
 Simcock, R.C., 107  
 Simioni, F.J., 121  
 Simon, H., 295  
 Simon, J., 316  
 Simons, A.J., 70  
 Simpson, D., 287  
 Simpson, J., 108  
 Sims, N.C., 186  
 Simula, M., 264  
 Singh, A.M., 215, 235  
 Singh, A.P., 109, 177, 178  
 Singh, H.P., 2, 145, 190  
 Singh, M., 146, 225, 235  
 Singh, S., 45  
 Singh, S.S., 392  
 Singh, U., 20  
 Singhakumara, B.M.P., 96  
 Sinha, P., 366  
 Siraj, S.S., 371  
 Siregar, C.A., 212, 242, 331  
 Siregar, I.Z., 71, 123  
 Siregar, U.J., 71, 123, 331  
 Siringoringo, H.H., 242  
 Siry, J.P., 135  
 Siry, J.P., 201, 272  
 Sisak, L., 19  
 Sist, P., 25  
 Sitepu, I.R., 248  
 Sjaastad, E., 334  
 Sjöberg, K., 395  
 Skaugset, A., 361  
 Skelly, J.M., 283  
 Skorupski, M., 248  
 Skoupy, A., 117, 316  
 Skov-Petersen, H., 269  
 Skovsgaard, J.P., 35  
 Slaney, M., 97  
 Slippers, B., 57, 58  
 Smaill, S., 107  
 Smith, C.T., 119  
 Smith, F., 54  
 Smith, G., 9, 315  
 Smith, G.K.M., 346  
 Smith, J., 143  
 Smith, M., 308  
 Smith, M.T., 253  
 Smith, N., 205  
 Smith, P., 73  
 Smith, R., 141, 281  
 Snedden, C., 174  
 Snook, L.K., 277  
 Soares Koehler, H., 112  
 Soares, P., 332  
 Soares, P., 22  
 Sober, A., 89  
 Sober, J., 89  
 Solberg, B., 202, 273, 305  
 Somers, M., 196  
 Somogyi, Z., 73  
 Son, Y.H., 246  
 Son, Y.M., 27  
 Sonesson, K., 98, 368  
 Song, J.-M., 64  
 Song, J.I., 107  
 Sonwa, D.J., 44, 349  
 Sood, A., 55  
 Soriano, F.P., 33  
 Sotelo-Montes, C., 50  
 Sousa, V.B., 173  
 Souvannavong, O., 157  
 Souza, A.L., 209  
 Souza, A.P., 108, 209, 290, 291, 375  
 Spanos, I., 78, 241  
 Spence, H., 219  
 Spence, J.R., 325, 326  
 Spicer, M., 110  
 Spiecker, H., 76, 89, 99, 101, 311  
 Spilsbury, M., 264  
 Spolc, D.J., 168  
 Springfors, A., 327  
 Sraku-Lartey, M., 342  
 Šrámek, V., 240  
 Sreetheran, M., 304  
 Srinivasa Reddy, M.V., 43  
 Srivastava, D.S., 245  
 Staal Wästerlund, D., 117, 118, 358  
 Ståhl, G., 197, 199, 305, 306, 329  
 Ståhl, P.H., 71  
 Stähli, M., 76  
 Stancioiu, P.-T., 366  
 Stanger, T., 370  
 Stanton, B., 139  
 Stanton, M., 40  
 Stanturf, J.A., 160

- Starr, M., 328, 332  
Stary, N., 98  
Stasova, V.V., 381  
Stauffer, Ch., 254  
Steane, D., 49  
Stein, T.V., 288  
Stendahl, J., 329  
Stendahl, M., 133  
Stener, S.O., 208  
Stennes, B., 266  
Stephens, P., 306  
Sterba, H., 204, 207  
Stevenson, M., 230  
Stewart, G.H., 256  
Stewart, H.A., 124  
Still, G., 214  
Stine, M., 170  
Stinghen, A.B.M., 155  
Stinson, G., 305  
Stirn, L.Z., 20  
Stock, J., 131  
Stocks, B.J., 77  
Stöd, R., 174  
Stoecker, M., 169, 376  
Stoian, D., 151, 232, 263  
Stoian, S., 232  
Stokes, A., 122, 313  
Stone, C., 186, 200  
Stoneman, G.L., 14, 42  
Storer, A., 54, 57, 86  
Storrie, G., 308  
Strasser, R.J., 282  
Streil, M., 146  
Strimbu, B.M., 349  
Strimbu, V.G., 349  
Strom, B., 58  
Strzelifski, P., 248  
Stubbs, C.S., 261  
Stull, R., 41  
Styranivsky, O., 271  
Styranivsky, Y., 271  
Su, W.-C., 382, 383  
Su, X., 243  
Su, X.-H., Huang, 59  
Sudheendrakumar, V.V., 86  
Sudin, M., 9  
Sugi, P., 123  
Sugito, Sadhardjo, Sm., 122  
Suhaimi Bakar, E., 128  
Sukandi, T., 44, 270  
Sunarti, S., 64  
Sunarya, S., 71  
Sunuprpto, H., 185  
Supangat, A., 315  
Supryo, H., 295  
Suratman, M.N., 286  
Surovy, P., 286  
Suzuki, H., 307, 361, 382  
Suzuki, K., 337, 393  
Suzuki, S., 128  
Svennerstam, H., 229  
Sverdrup, H., 35  
Svoboda, M., 26, 48, 200, 316  
Swift, E., 170  
Swift, S.A., 325  
Szabó, I., 393  
Szaro, R.C., 2  
Tabacchi, G., 194  
Tahara, S., 248  
Tahir, P.Md., 154, 176  
Tahvanainen, L., 119, 351, 355  
Tahvanainen, T., 355  
Takagi, T., 60  
Takahashi, H., 261  
Takahashi, K., 395  
Takahashi, Y., 337  
Takashima, A., 207  
Talvitie, M., 168, 301, 304  
Tamayo, J.P., 279  
Tambunan, B., 128  
Tamminen, P., 328  
Tamura, Y., 277  
Tan, C.Y., 125  
Tan, Y.E., 32  
Tanaka, C., 125  
Tanaka, N., 269  
Tanaka, Y., 183  
Tanase, M., 282  
Tang, L.-C., 38  
Tang, X.-P., 381  
Taniguchi, T., 253  
Tanoue, M., 7  
Tarumi, A., 138  
Tausz, M., 90  
Taylor, A.R., 307  
Taylor, D.W., 148, 325  
Taylor, G., 290  
Taylor, J., 124  
Taylor, S.E., 182  
Tchatat, M., 44, 349  
Tchoundjeu, Z., 70  
Teissier du Cros, E., 49 369  
Temesgen, H., 35  
Temu, A., 264  
Tennigkeit, T., 117, 197  
Teplyakov, V., 218, 230  
Tesi, E., 91  
Teskey, R., 97  
Tessadri, B., 110  
Tewari, V.P., 30  
Thackway, R., 198, 199  
Thakur, A., 287  
Thakur, P.S., 45  
Thakur, R., 54  
Tharp, M.L., 296  
Thevathasan, N.V., 321  
Thévenon, M.-F., 175, 177  
Thi, B.K., 32  
Thibaut, A., 177  
Thibaut, B., 177  
Thien, L.B., 239  
Thimonier, A., 76, 90  
Thoemen, H., 129  
Thomsen, I.M., 83  
Thongo M'bou, A., 249  
Thöni, L., 90  
Thoroé, C., 99, 299  
Thulasidas, P.K., 121  
Thuresson, T., 195  
Thwaites, R.N., 182  
Tian, G.-Z., 248, 393  
Tiburan Jr., C.L., 198  
Tiessen, H., 330  
Tikkanen, I., 273  
Todaro, L., 288  
Todd, J.B., 77  
Togari-Ohta, A., 361  
Toivonen, R., 119, 132, 134, 137, 162  
Tokola, T., 354  
Toledo, S.L., 145  
Tolpekin, V., 187  
Tomazello Filho, M., 67, 73, 75, 330  
Tomé, J., 22  
Tomé, M., 20, 22, 75, 81, 106, 195, 200, 332  
Tomich, T., 349  
Tommerup, I., 50, 254  
Tomppo, E., 198  
Tong, T., 171  
Tonye, J., 41  
Toon, P.G., 171  
Top, N., 212  
Toppinen, A., 132, 264  
Torgovnikov, G., 110, 169  
Torng, C.-S., 387  
Torr, K., 109  
Torres, M.J.A., 37  
Torres-Lezama, A., 30, 206, 207  
Torres-Rojo, J.M., 2  
Tosi, V., 194  
Touza Vázquez, M.C., 8  
Townsend, M., 268  
Treviño Garza, E.J., 186  
Trifkovic, S., 166, 198  
Trines, E., 73  
Triviño, C., 55  
Trockenbrodt, M., 13  
Trosper, R., 142, 147  
Trotter, C., 306  
Tsai, K.-H., 389  
Tsai, M.-H., 375  
Tsai, S.-T., 38  
Tsai, T.-Y., 380  
Tsogtbaatar, J., 364  
Tsuyuki, S., 185, 186

- Tučeková, A., 100  
 Tullus, A., 367  
 Tullus, H., 367  
 Tumaneng-Diete, T., 262  
 Tumwebaze, S.B., 45  
 Tunytsya, Y., 219  
 Tuominen, S., 168  
 Turgeon, J., 253  
 Türker, M.F., 18, 113, 220, 224, 328  
 Turland, J., 40  
 Turnblom, E., 6  
 Turnbull, J.W., 342  
 Turnbull, M., 97  
 Turner, J., 216  
 Turner, J.A., 87  
 Turnhout, E., 215  
 Turok, J., 68  
 Tuttle, A., 362  
 Ty, S., 212  
 Tyrväinen, L., 293  
 Tyynelä, T., 5  
 Tzschupke, W., 300  
 Uddin, M.B., 260  
 Ugarte-Guerra, L.J., 50  
 Ulbrichova, I., 26, 241, 297  
 Uliana, L.R., 383  
 Umeda, S., 307, 382  
 Unseld, R., 89, 99  
 Upadhyay, A., 43  
 Vacas de Carvalho, M.A., 138  
 Vaganov, E.A., 75  
 Vaillancourt, R., 49, 372  
 Valdez-Lazalde, R., 294  
 Valentinotti, R., 36, 87, 186  
 Valgimigli, M.C., 53  
 Valkonen, S., 363, 364  
 Valsta, L., 72, 102, 233, 333, 377  
 Van Brusselen, 38  
 van den Heuvel, M., 134  
 van der Kamp, B.J., 337  
 van der Zouwen, M.W., 215  
 van Dijk, A.I.J.M., 307, 319  
 Van Horne, C., 164  
 van Straaten, O., 117  
 Vanclay, J., 352  
 Vanhanen, H., 266, 267  
 Vantomme, P., 281, 293  
 Vares, A., 367  
 Vargas Tristán, V., 242  
 Vargas-Hernandez, J.J., 69  
 Varma, R.V., 86  
 Varmola, M., 267  
 Vasilescu, M.-M., 366  
 Vedeld, P., 334, 349  
 Velázquez-Martínez, A., 294  
 Vendramin, G.G., 60, 70  
 Vennesland, B., 164  
 Verbij, E., 113  
 Verkasalo, E., 135, 155, 173, 174, 383  
 Verma, M., 20  
 Vermeulen, W.J., 145  
 Verryn, S.D., 61, 171, 174  
 Vertinsky, I., 348  
 Verwijst, T., 108, 120  
 Via, B.K., 170  
 Vieira, I., 369  
 Viewegh, J., 182, 352, 358  
 Vignerón, P., 52, 175  
 Vilanova, E., 30, 207  
 Villa-Castillo, B., 308  
 Villalobos, R., 151  
 Villancio, V., 352  
 Villanueva, M.M.B., 281  
 Villard, M.-A., 275  
 Villarreal, B., 53  
 Vincent, B., 252  
 Vinden, P., 109, 110, 169  
 Vinokurova, N., 289  
 Visschedijk, P.A.M., 270  
 Visser, A.-K., 209  
 Vlosky, R.P., 131, 135, 139, 152  
 Vogler, D.R., 255  
 Vogt, P., 199  
 Volin, J.C., 262  
 Volin, V.C., 262  
 Volker, P., 372  
 Vollenweider, P., 88  
 Volney, W.J.A., 326  
 von Gadow, K., 1  
 von Teuffel, K.F., 161  
 von Weissenberg, K., 83  
 Vorobyova, M., 229  
 Vrbek, B., 46, 90  
 Vuillermoz, M., 339  
 Vuletić, D., 46, 90  
 Vyskot, I., 303  
 Wadsworth, F.H., 277  
 Wagner, M.R., 80  
 Wahab, R., 9, 122, 128  
 Waiswa, D., 182  
 Waitzbauer, W., 249  
 Waldner, P., 76, 90  
 Walker, B., 316  
 Wall, A., 319  
 Wall, T., 155  
 Wallin, G., 93, 97  
 Wallman, P., 35  
 Walters, B.B., 290, 317  
 Walton, J.T., 302  
 Wan Ab Kadir, W.R., 376  
 Wan Mohd Shukri, W.A., 28, 31  
 Wan, H., 170  
 Wang, C., 302  
 Wang, G., 168  
 Wang, G.-L., 208  
 Wang, H., 65  
 Wang, H.H., 110  
 Wang, J.R., 307, 368  
 Wang, S., 101, 266  
 Wang, S.-Y., 32  
 Wang, S.Q., 74  
 Wang, T., 103  
 Wang, X.M., 170  
 Wang, Y., 165, 382, 383  
 Wang, Y.-N., 65  
 Wapstra, M., 316  
 Ward, E.J., 95  
 Ward, M., 73  
 Ward, S., 192  
 Ward, S.E., 276, 277  
 Wardell-Johnson, G., 308  
 Waschkowski, J., 241  
 Wästerlund, I., 130, 377  
 Waterworth, R., 76  
 Watson, D.M., 309  
 Watt, M.S., 107  
 Weber, J.C., 50  
 Wehrli, A., 310, 312, 313  
 Weih, M., 108  
 Weise, D.R., 166  
 Weise, S., 41, 44, 144, 261, 349, 391  
 Wen, X.-J., 393  
 Wen, Z., 31  
 Werth, D., 321  
 Wessels, B., 174  
 Westermayer, T., 377  
 Westman, C.J., 319  
 Whan, J., 247  
 Wheeler, N., 52  
 Wheeler, N.C., 60  
 White, D., 324  
 White, R.H., 166  
 White, T., 305  
 Whitten, S.M., 152  
 Why Kong, H., 120  
 Wibom, M., 358  
 Wickneswari, R., 51, 54  
 Widsten, P., 110  
 Widyatmoko, A.Y.P.B.C., 64  
 Wierzbicka, A., 275  
 Wieser, G., 90  
 Wightman, K.E., 153, 276  
 Wijaya, A., 187  
 Wijeven, S.M.J., 26, 275  
 Wijesekara, V.P.R., 190  
 Wijewardana, D., 216  
 Wilford, D.J., 312, 314  
 Wilhelmson, E., 118  
 Willcocks, C., 362  
 Williams, A., 34  
 Williams, R.S., 110  
 Wilson, A.D., 160, 217  
 Wilson, B., 266  
 Wilson, D., 286

- Wilson, M.L., 237  
Winandy, J.E., 129  
Winarni, I., 71  
Wingfield, B.D., 58, 59, 335  
Wingfield, M.J., 57, 58, 59, 83, 176, 218, 335, 337, 392, 394  
Winter, A., 84  
Witzell, J., 80  
Wolcott, M.P., 126  
Woldemariam, T., 51, 67  
Woldeyohanes, F., 155  
Wollenmann-Brandenberger, R., 332  
Wolters, V., 244  
Won, M.S., 77  
Wong, A.H.H., 177, 178, 179  
Wong, E.D., 154  
Wonneberger, E., 252  
Woo, S.-Y., 94, 98, 318, 364  
Woodward, S., 38, 56, 253, 356  
Worbes, M., 330  
Work, T.T., 324  
Worsey, M., 125, 381  
Wotton, B.M., 77  
Wright, W., 41  
Wu, C.-L., 176  
Wu, H.X., 156, 157  
Wu, L.-J., 375  
Wu, S., 280, 395, 396  
Wu, S.-H., 38  
Wu, S.-T., 167  
Wu, S.-Y., 9, 380  
Wu, Z.-X., 65  
Wulan, R., 71  
Wullschleger, S.D., 78  
Wunder, S., 113, 212  
Wyatt, S., 148  
Wylie, F.R., 276  
Wyman, M.S., 147  
Xiao, W.-F., 88, 248  
Xu, D., 360  
Xu, Z.H., 54, 108, 239, 243, 244  
Xue, J.M., 76, 107  
Xue, Z., 101  
Yada, Y., 391  
Yadessa, A., 67  
Yahagi, S., 124  
Yamada, T., 337, 373, 392  
Yamada, Y., 291, 292  
Yamagata, Y., 59, 73  
Yamaguchi, H., 183, 375  
Yamaguchi, K., 390  
Yamaguchi, S., 307, 382  
Yamamoto, F., 74, 101, 288  
Yamamoto, H., 120, 166, 198  
Yamamoto, M., 94, 95, 98  
Yamamoto, N., 389  
Yamamoto, S., 59  
Yaman, T.H.A.R., 383  
Yamanaka, N., 74, 101  
Yamasaki, M., 241  
Yamato, M., 373, 393  
Yameogo, J., 45  
Yanchuk, A.D., 103  
Yang, C.-M., 167  
Yang, J.L., 9  
Yang, T.-S., 32  
Yanusa, I., 92  
Yarie, J., 231  
Yatabe, T., 64  
Ye, K., 129  
Yeates, G.W., 249  
Yeh, M.-C., 225  
Yeh, S.-U., 380  
Yeh, Y.-J., 55  
Yeo, H.-M., 8  
Yi, J.-S., 55, 64, 371  
Yin, Y., 33  
Yokoo, K., 7  
Yokota, Y., 223  
Yoneda, T., 101  
Yoo, B.I., 388  
Yoshida, M., 120  
Yoshida, S., 207  
Yoshikawa, K., 100, 261, 288, 396  
Yoshimoto, A., 209  
Yoshimura, T., 271, 353  
You, X.L., 55  
Youn, H.-J., 318  
Youn, Y.-C., 221, 223  
Yu, X.X., 323  
Yue, C., 378  
Yukutake K., 204  
Yulianti, E., 122  
Yusof, M.S.M., 77  
Zadnick Stirn, L., 20  
Zagt, R., 210  
Zahedi, E., 178  
Zaitunah, A., 184  
Zajac, S., 114  
Zakaria, M.N., 172  
Zalitis, P., 395  
Zamri, Z., 54  
Zamudio, F., 157  
Zasada, M., 231  
Zauza, E., 254  
Zawila-Niedzwiecki, T., 166, 284  
Zechmeister-Boltenstern, S., 79, 249  
Zeila, A.D., 216  
Zhabyko, E.V., 205  
Zhang, B.-Y., 59  
Zhang, Q.-H., 254  
Zhang, S., 221  
Zhang, S.L., 239  
Zhang, S.Y., 157, 170, 171  
Zhang, X.-H., 59  
Zhang, X.-Q., 320  
Zhao, R.J., 169  
Zhou, X., 13  
Zhou, X.D., 394  
Zhou, Y., 33  
Zhu, S., 87  
Zhu, X.B., 88  
Zhukov, D.V., 244  
Ziesak, M., 183  
Zimback, L., 65, 372  
Zimmermann, N., 96  
Zingg, A., 23, 207, 310, 342  
Zolfeghari, I., 317  
Zomer, R., 117  
Zoteeva, E., 229  
Zoyo, D., 364  
Zuercher, E., 175  
Zweig, R., 289  
Zyusko, A., 229

