The Congress logo symbolizes the Earth composed of trees, forests, mountains, and waters in harmony, representing the Congress title "Forests for the Future: Sustaining Society and the Environment." In Oriental philosophy, the universe consists of heaven being made of yin and yang; and earth is composed of the five elements (metal, wood, water, fire and earth) in a state of flux and constant interaction. The logo illustrates the philosophy of conservation and sustainable management of the world's forests following natural law.

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The International Forestry Review

Forests for the Future: Sustaining Society and the Environment

XXIII IUFRO World Congress, 23–28 August 2010, Seoul, Republic of Korea

Abstracts

EDITORS

JOHN A. PARROTTA and MARY A. CARR

Preface

On behalf of the Congress Scientific Committee for the XXIII World Congress of the International Union of Forest Research Organizations (IUFRO), it is my pleasure to present this collection of abstracts of plenary, sub-plenary, technical, and poster presentations that constitute the Congress scientific program. These 2,165 abstracts represent the latest research of forest scientists and students from nearly 100 countries, as well as the significant contributions of the approximately 200 session organizers, the Congress Organizing Committee at the Korea Forest Research Institute in Seoul, and colleagues from IUFRO Headquarters in Vienna since the Congress Scientific Committee began its work in 2006.

The Congress title, *Forests for the Future: Sustaining Society and the Environment*, reflects both the long-standing ethos of our profession and the aims of IUFRO. In its 2006-2010 Strategy, IUFRO committed itself to strengthen forest research for the benefit of forests and people in part by addressing the changing needs and priorities of forest science and IUFRO's members. The strategy also aims to expand IUFRO's strategic partnerships and cooperation by promoting interdisciplinary scientific cooperation; increasing involvement of students (our future) in IUFRO's activities; expanding partnerships with international organizations, governments and stakeholders; and strengthening communication and linkages with the broader scientific community, policy-makers, and society at large.

The themes around which the Congress scientific program is structured, cover the full range of IUFRO's traditional and emerging scientific priorities, and highlight issues of paramount importance for the future of forests and the broad spectrum of environmental, social, cultural, and economic benefits that forests provide to people in both rural and urban societies worldwide. Three of these themes—*Forests and Climate Change*, *Biodiversity Conservation and Sustainable Use of Forest Resources*, and *Frontiers in Forest and Tree Health*—underscore the contributions that forest science has and will continue to make towards enhancing understanding of, and developing strategies to help address, the deepening global environmental challenges that we face in this increasingly unsustainable era. The Congress themes on *Forest Environmental Services*, *Forest Products and Production Processes for a Greener Future*, and *Emerging Technologies in the Forest Sector* cover a range of socioeconomic, policy, and technological issues and topics related to the evaluation and sustainable utilization of forest ecosystems and forest products. Under the theme *Asia's Forests for the Future*, the Congress will showcase advancements in forest science across all disciplines with a focus on issues of particular relevance for Asia, including the host country for the Congress, the Republic of Korea. Finally, the Congress themes, *Forests, Communities and Cultures*, and *Forests, Human Health and Environmental Security*, highlight IUFRO's commitment to strengthen the role of forest research and interdisciplinary collaboration to better understand the social, cultural, economic, and political dimensions of the complex relationships that exist between people and forests worldwide.

Regardless of your particular areas of interest and scientific expertise, we hope that this volume of abstracts—organized by Congress program structure with its menu of 5 plenary, 15 sub-plenary, and 150 technical and poster sessions—will encourage, perhaps inspire, you to explore and expand your interests in a broad array of contemporary topics in forest science.

Dr. John A. Parrotta
U.S. Forest Service, Research & Development
Chair, Congress Scientific Committee

PLENARY SESSIONS

The disastrous trajectory of the rain forests: research imperatives. Ashton, P.S. (*Harvard University, USA; pashton@oeb.harvard.edu*).

The continuing loss of tropical evergreen lowland forests worldwide annually contributes nearly 20% of elevated atmospheric carbon. That could be remedied by reforestation of agriculturally marginal lands, provided that the carbon is semi-permanently thereby sequestered in wood products. It is the extraordinary biodiversity of these forest ecosystems which is unique and cannot be recreated. Sadly, the richest forests are valued for other uses, and are therefore the most threatened. Does this matter? Rain forest biodiversity is usually upheld as a source of novel pharmaceuticals but, far more important but rarely reasoned, is their vital importance for future crop protection, especially of tree plantations. Current research is revealing that tropical forest tree species diversity is maintained by a balance of species' population numbers sustained by the dispersal distances of host-specific pests and pathogens, thereby providing space for other tree species, differing ecologically solely in being susceptible to different pests and pathogens, to co-exist in stable mixture. There are two solutions: Conservation of the gene sequences which imbue wild crop relatives with resistance, that they may be available for genetic engineers; or a revolution in tree crop design, based on what is being learned by research in surviving rain forests. It is not too late to conserve, and the costs are not prohibitive. Who are the beneficiaries, and who should pay? Solutions will require vision, goodwill and solidarity among policymakers that is as yet not in evidence.

Integrating scales and sectors to foster sustainable livelihoods, landscapes and forests. Campos, J.J., Alpizar, F., Beer, John, de Camino, R., Faustino, J., Finegan, B., Galloway, G., Gutierrez, I., Ibrahim, M., Somarriba, E., and Stoian, D. (*CATIE, Costa Rica; jcampos@catie.ac.cr*).

Forestry research must more effectively address the complex challenges and uncertainties we face today. Under this scenario social and ecological resilience should be an aim for development agendas, and good science is essential for enhancement of the community capitals on which that resilience depends. Integrated action at the stand, farm, landscape, national and international scales is needed. Interdisciplinary research and policymaking based on multi-scale system approaches, development of multiple value chains and internalization of spatially determined externalities in the landscapes has much to offer to both sound rural development and environmental conservation. Integrated models combine different production systems (agriculture and forestry) and the provision of ecosystem services; the integration of disciplines; knowledge and learning generated by research, education and horizontal cooperation with multiple partners, and innovations from genes, technologies, landscapes and policies. Experiences include improving the well-being of poor rural families through perennial crops (such as coffee and cacao) in agroforestry systems, providing ecosystem services by managing woody perennials in degraded pasturelands, maintaining and restoring large-scale hydrological and ecological processes through effective local governance and co-management structures, helping rural people benefit from their environmental and social responsibility in forestry and agricultural value chains, effective payment for ecosystem services, constructing biodiversity-friendly landscapes through locally led biological corridors and leveraging collective action via multiple-use forestry, local leadership and forest landscape management. These approaches bring new questions requiring innovative professional education and continued research.

Forest is short; desert is long. Ko Un (*Dankook University, Korea; koun_poet@yahoo.co.kr*).

"Art is long; life is short," still resonates today. The pun, "Art is short; life is frustratingly long," is not yet persuasive. Instead, we often talk about "Forest is short; desert is long," which may be interpreted as the forest is getting much smaller while the desert is getting far wider on the continents. That is a result of reflection on the essence of the historic phrase by relating to forest destruction in the past thousands of years. Too often, intentionally or not, we have neglected the fact that the splendor of civilization, enhanced human welfare and linear progress are the other side of anthropogenic crimes that destroyed the forest. Under the circumstances, let me look back on the past and present of the forest on the planet. The forest is a means of overcoming the fears of survival caused by God and maintaining human being's life today. Now I would like to look ahead of our future that covers the spirit, reality and fate of the forests in the far future facing us.

The potential role of communities in sustaining forest resources. Ostrom, E. (*Indiana University and ASU, USA; ostrom@indiana.edu*).

A team of researchers associated with the International Forestry Resources and Institutions (IFRI) research program have been conducting research since the early 1990's on forest and social conditions in a large number of communities in: Bolivia, Colombia, Guatemala, Indiana, Kenya, Mexico, Nepal, Tanzania, Thailand, Uganda, and the United States. Our sample of over 200 sites includes government-owned, privately-owned, community forests, and co-managed forests. Second and third visits have been made to many of these forests. No specific ownership arrangement is consistently related to better conditions. Rather, we have found that when local users do have some rights to long-term harvesting of at least some products from a forest, they are more likely to invest in monitoring the activities going on in a forest. And, most important – locally monitoring makes a very substantial difference in the likelihood that a forest is regenerating (or at least not degrading). Thus, future policies should not focus on formal ownership as "the" most important factor affect forest sustainability but rather how to insure the participation of local users in developing plans for the forest and gaining their involvement.

Forests, climate change, and communities: making progress up the learning curve. Seymour, F. J. (*Center for International Forestry Research, Indonesia; f.seymour@cgiar.org*).

Reducing deforestation and forest degradation and enhancing carbon stocks (REDD+) is a critical component of the emerging global climate protection regime. Forests also have a key role to play in ecosystem-based climate adaptation strategies. Recognition of these essential contributions of forests to human security in the context of climate change are attracting welcome

political attention and finance to forest management efforts. But ensuring that those efforts benefit rural communities – and especially poor households, women, and indigenous peoples – remains a challenge. REDD+ and adaptation initiatives are being superimposed on existing forest governance institutions that are often systematically biased against the interests of rural resource users and forest stewards. Research on forest tenure, community forestry, integrated conservation and development, and forest law enforcement all suggest lessons for REDD+ and forest-related adaptation interventions. Forest researchers attempting to assess how new climate-driven policies and practices are likely to affect communities are faced with a highly varied and rapidly changing landscape. Preliminary findings are beginning to emerge, and highlight the institutional deficits likely to constrain success. Unless such initiatives are able shape – rather than be shaped by – the political economy of forests at global, national, and local levels, the opportunity to improve the lot of forest communities will be lost.

SUB-PLENARY SESSIONS

SP-2 Can forestry and forest sector activities contribute to mitigating climate change?

Organizer: Werner Kurz *Natural Resources Canada, Canada, Werner.Kurz@nrcan.gc.ca*

Assessment of Mexico´s readiness for REDD. De Jong, B., Olguin, M. *(El Colegio de la Frontera Sur, Mexico; bjong@ecosur.mx; molguin@ecosur.mx),* Paz, F. *(El Colegio de Postgraduados, Mexico; pellat@colpos.mx)*, Rojas, F., Maldonado, V. *(El Colegio de la Frontera Sur, Mexico; fabiosxto1981@yahoo.com.mx; vmm_14@yahoo.com).*

Reducing emissions from deforestation and forest degradation (REDD) has been an important theme in the global climate change debate, as it is being considered as a cost-effective mitigation measure. Mexican forests and woody vegetation types (scrublands) cover about 87 M ha (as of 2007). Both deforestation and forest degradation are important issues in Mexico. Average biomass densities in most forest types are relatively low, due to degradation processes such as uncontrolled logging, extensive grazing, and fuelwood extraction. Mexico has been very active in developing forestry-based policies and programs since 2000, and is very keen to participate in future mechanisms that finance REDD-based activities, as stated in the National Strategy on Climate Change. In this presentation we assess Mexico's readiness to implement REDD, particularly in terms of quantifying the potential of emission reductions and the level of uncertainty in the most important data sources. We present data on biomass densities in the various forest types, historical trends of land-use and land-cover change between 1993 and 2007, and estimated emissions derived from deforestation and forest degradation. A preliminary analysis on the impact of forest management and conservation demonstrate the potential of REDD plus in Mexico.

Bio-mitigation of carbon through the reforestation of abandoned farmland. Harper, R.J., Sochacki, S.J. *(Murdoch University, Australia; r.harper@murdoch.edu.au; Stanleysochacki@oceanbroadband.net),* Smettem, K.R.J. *(University of Western Australia, Australia; smettem@sese.uwa.edu.au),* Kojima, T. *(Seikei University, Japan; st.seike.ac.jp).*

A major issue with using agricultural land for carbon mitigation, via either carbon sequestration or bioenergy production, is that it can displace food production. An alternative approach is to use abandoned land. Australia has 17 million ha of such land that is already saline, or could become so. The mitigation potential of reforestation was investigated on a representative low-rainfall (350 mm/year), salinized site. A range of factors markedly affected mitigation. These include hydrological conditions such as salinity and slope position, and a range of silvicultural factors such as species selection, planting density, and time to harvest. High density (2,000 trees/ha) *Eucalyptus occidentalis* produced approximately 20 t/ha average yield of dry biomass (equivalent to 68 t CO2-e/ha), within 4 years of planting and more than 37 t/ha (86 t CO2-e/ha) over 8 years, with values ranging as high as 47 t/ha. This was on land that had been effectively abandoned to agriculture. Continued mitigation is expected as the stands mature, assuming that growth is not affected by the accumulation of salt or by climate change. Further mitigation can be achieved by using saltbush (*Atriplex nummularia*). Utilization of such salinized land could represent a major contribution to carbon mitigation.

A global analysis of temperate old-growth forests: commonality in carbon storage and co-varying ecosystem functions. Keeton, W.S. (*University of Vermont, USA; william.keeton@uvm.edu),* Burrascano, S. (*University of Rome La Sapienza, Italy; sabinaburrascano@gmail.com),* Pucko, C. (*University of Vermont, USA; cpucko@uvm.edu),* Chen, J. (*University of Toledo, USA; Jiquan.Chen@utoledo.edu)*, Chernyavskyy, M. (*Ukrainian National Forestry University, Ukraine; tschern@mail.lviv.ua)*, Commarmot, B. *(Swiss Federal Research Institute WSL, Switzerland; brigitte.commarmot@wsl.ch),* Franklin, J.F. *(University of Washington, Seattle, USA; jff@u.washington.edu)*, Gratzer, G. *(BOKU – University of Natural Resources and Applied Life Sciences, Austria; georg.gratzer@boku.ac.at)*, Spies, T. *(U.S. Department of Agriculture, Forest Service, USA; tspies@fs.fed.us),* Swanson, M.E. *(Washington State University, USA; markswanson@wsu.edu).*

We tested the hypothesis that important ecological functions are provided universally by old-growth temperate forests, such as a high carbon storage and co-varying habitat complexity. We pooled site-specific (n = 449) forest inventory datasets representative of seven ecoregions: (1) U.S. Pacific Northwest, (2) U.S. Northeast, (3) Carpathian Mountains, (4) European Alps, (5) Apennine Mountains, (6) Tierra Del Fuego, and (7) northeastern China. We used non metric multi-dimensional scaling (NMDS) to analyze similarity/dissimilarity in stand structure among and within ecoregions and by age class. NMDS results suggested a wide range of structural variability within and among old-growth temperate forest systems, but with consistent separation of 'mature' and 'old-growth' ages classes. Above-ground biomass was the top-ranked variable in post-hoc analyses explaining variability among and within the systems evaluated. Coarse woody debris volumes and other indicators of structural complexity co-varied with biomass and explained clustering of mature and old-growth sites. The results suggest that management for and conservation of high biomass, late-successional forests provide both carbon storage benefits and structurally complex habitats. Climate change mitigation efforts targeting conservation of temperate forests need to account for variability in stand development processes attributed to differences in disturbance regimes, species composition, site productivity, and management history.

Can forestry and forest sector activities contribute to mitigating climate change? A science synthesis in support of policy. Kurz, W.A. *(Canadian Forest Service, Canada; Werner.Kurz@nrcan.gc.ca).*

In a carbon-constrained future, forestry and forest sector activities can contribute to climate change mitigation portfolios through direct and indirect impacts on the greenhouse gas balance. Mitigation objectives are achieved when, relative to a baseline, atmospheric greenhouse gas concentrations are reduced. Analyses must take into consideration the impacts of forest management on ecosystem carbon stocks and greenhouse gas emissions, the storage of carbon in wood products, the use of biomass for energy production, and the substitution benefits arising from wood use instead of more energy-intensive materials. The conclusions of the

analyses are sensitive to the assumptions about time horizon of the analysis, ecosystem conditions and dynamics, discount factors applied to future carbon benefits, and displacement factors in calculations of substitution benefits. Contributions to a global climate mitigation portfolio at competitive economic costs and with many ecological, social ,and environmental benefits can be achieved through large-scale afforestation, avoidance of deforestation and degradation, sustainable forest management, forest conservation, and the responsible use of wood products. Criteria to identify the type, scale, and location of activities with the greatest climate mitigation benefits are under development. These should include the impacts of changing climate on the forest sector and address interactions with adaptation strategies.

The global carbon footprint of the forest products industry. Miner, R.A. (*NCASI, USA; rminer@ncasi.org*).

NCASI recently completed a study, commissioned by the United Nations Food and Agriculture Organization (FAO), with support from the International Council of Forest and Paper Associations, of the impacts of the global forest products industry on atmospheric greenhouse gases. Based on data from developed countries, which together account for over one-half of industrial roundwood production, the study found that sustainable forest management practices are capable of maintaining carbon stocks in production forests. The data available at the global scale, however, were inadequate to determine global trends in carbon stocks in forests that produce wood for the industry. The amounts of carbon stored in forest products for extended periods are large enough to offset almost one-half of the industry's value chain emissions. The most significant emission sources in the value chain are attributable to fossil fuels used in manufacturing and methane emissions from forest products in landfills. Reductions in societal greenhouse gas emissions are associated with the use of wood-based building materials, the burning of used products as fuel at the end-of-life, and the development of additional supplies of sustainably produced forest biomass for use in applications that displace fossil fuels and greenhouse-gas intensive products.

Greenhouse gas dynamics of different forest management and wood use scenarios in Switzerland. Thürig, E. *(Swiss Federal Research Institute WSL, Switzerland; esther.thuerig@wsl.ch)*, Werner, F. *(Dr. Werner Environment and Development, Switzerland; frank@frankwerner.ch)*, Taverna, R., Hofer, P. *(GEO Partner AG, Switzerland; taverna@geopartner.ch; hofer@geopartner.ch)*, Kaufmann, E. *(Swiss Federal Research Institute WSL, Switzerland; edgar.kaufmann@wsl.ch)*

Adequate management of forests and an increased use of wood products help in mitigating climate change. However, response time to management actions in forestry are usually long and may build a conflict between carbon sink in forests and the use of wood as substitute material and energy. Therefore, an integral long-term strategic approach is required to formulate the most effective forest and wood management strategies for mitigating the increase of atmospheric greenhouse gases (GHG). We present an integral model-based approach to evaluate the GHG impacts of various forest management and wood use scenarios on a national basis, including trade-offs among the different strategies and country-specific import/export flows of wood products. On the basis of our models, the following recommendations are proposed to advance the contributions of the forestry and timber sector for mitigating climate change: (1) a maximum possible, sustainable increment should be aimed for in the forest; (2) this increment should be continuously harvested; (3) the harvested wood should be processed in accordance with the principle of cascade use, i.e., first be used as a material as long as possible; and (4) waste wood that is not suitable for further use should be used to generate energy.

SP-3 Conservation and sustainable use of forest genetic resources

Organizers: Yongqi Zheng *Chinese Academy of Forestry (China,) zhengyq@caf.ac.cn*; Heok-Choh Sim *APAFRI-Forest Research Institute Malaysia, Malaysia*, *sim@apafri.org*; Kyu-Suk Kang *Korea Forest Research Institute, Republic of Korea, kangks@forest.go.kr*

Identification of critical problems in forest genetic resources conservation and sustainable use: a global assessment. Bennadji, Z. (*INIA, Uruguay; zbennadji@tb.inia.org.uy*), Souvannavong, O. (*FAO, Italy; Oudara.Souvannavong@fao.org*).

The present works aims to identify, at global level, the main critical problems existing in forest genetic resources (FGR) conservation and sustainable use. Based on the FAO forest knowledge repository and its FGR Internet database, REFORGEN, a comparative study among and between regions (Africa, Asia, Europe, North America, and South America) was conducted. Data were collated from 70 national reports, 5 regional syntheses, the REFORGEN database, and the results of 5 sub-regional workshops. The time scale considered was 2000–2009. A comparative matrix of advances and needs was established, allowing a gap analysis and the identification of critical existing problems. An external focused bibliographical review was used as a triangulation tool for data analysis back up and interpretation of findings. Main problems identified at the global level were: (i) need for standardization of forest species priority setting and genetic diversity indicators, (ii) lack of strong mechanisms for science and technology findings exchanges at all level, and (iii) weakness of the interface between policy and science. The results will be use as a baseline for the elaboration of the first FAO report on the state of the world's FGR, and as input to establish action plans for different country and regional contexts.

Sustainable utilization and conservation of forest genetic resources through tree breeding and seed orchard management in Korea. Kang, K.S. (*Korea Forest Research Institute, Republic of Korea; kangks@forest.go.kr*), Hyun, J.O. (*Seoul National University, Republic of Korea; junghyun@snu.ac.kr*), Baik, E.S. (*Korea Forest Research Institute, Republic of Korea; 5491bkes@forest.go.kr*).

Research on forest genetic resource is essential concerning the impact of climate change. Selection of well-adapted and adaptive provenances is necessary so that vital and stable forests can be cultivated for the future. A general concept for conservation and utilization of forest genetic resources has existed in Korea since 1956 when the tree breeding program was initiated. Both *in-situ*

and *ex-situ* conservation programs are run by the Korea Forest Research Institute National Arboretum and Forest Seed and Variety Centre. In Korean tree breeding programs and seed orchards are the vital link between research and reforestation through delivery of consistent, abundant yields of genetically improved seed. Provenance research trials and progeny tests have been conducted for major timber species since the mid-1960s, with most being kept as *ex situ* conservation populations. We have produced about 172 tons of genetically improved seeds from seed orchards (733.6 ha, 59 species). We also designated a total of 288.9 ha seed production areas for those species whose seeds are not fully supplied from seed orchards. There are 3,091 ha of seed stands. The latest approaches and techniques in forest genetics research and management of forest genetic resources in Korea will be presented and discussed.

Seed orchards in a warm future. Lindgren, D. (*Swedish University of Agricultural Sciences, Sweden; Dag.Lindgren@genfys.slu.se*), Westin, J. (*Forestry Research Institute of Sweden, Sweden; Johan.Westin@skogforsk.se*), Prescher, F. (*Svenska Skogsplantor AB, Sweden; Finnvid.Prescher@skogsplantor.se*).

The world and Sweden are getting warmer. That justifies immediate actions in production and use of genetic materials. Seed orchards supply a robust, predictable, reliable, and controllable seed source. Modifications for climate prognosis immediate before seed harvest are possible by rouging, selective harvest, supplementary pollination, flower stimulation, and artificial crosses. Natural regeneration or local seeds cannot be regarded as well-adapted alternatives any more. The addition to forest production means a better utilization of the forest resource and a sustainable world supported by renewable resources. The recruitment population is drawn from and tested over a range of environments. This means that seed orchard clones are plastic and adapted over a range of environments, and thus a safer material for unpredictable future conditions. The temperature rise in Sweden relevant to seed sources can be set to one degree during 1991–2040, starting in 1990. Other factors are also likely to change (maritime, precipitation, pests, and pathogens), but quantitative predictions are too uncertain for recommendation of seed source within species. It is recommended that seed sources be deployed at a higher elevation rather than transferred north, to avoid affecting light climate. We need to establish new seed orchards for our forecasted one-degree-warmer climate.

Understanding, tracking, and documenting genetic resources of forest trees to improve management practices. Loo, J.A. (*Biodiversity International, Italy; j.loo@cgiar.org*).

Genetic resources of forest trees (FGR) are eroded as populations are lost. The variability in disappearing populations may be important for adaptation to drought, heat, insects, diseases, and other environmental challenges, but the value of such populations is generally not known and the urgency of stemming such losses is not recognised. Genetic information about tree species is increasingly assumed to mean molecular data; distribution of neutral marker alleles or, for a few species, variability in expressed DNA sequences. Such knowledge is available primarily for commercial species in regions having low species diversity. The challenge of addressing FGR in regions where 500 or more tree species have ecological, economic, or social value is daunting, and commonly genetic aspects are ignored in management plans and practices for lack of specific genetic information. Yet for many species, relevant information is known that could be used to improve genetic management. I address three questions: (1) what do forest managers need to know to make informed decisions about conservation and sustainable use of FGR? (2) How can available information be used and interpreted to predict status and threats to FGR? (3) How can such information be made available and useful for forest and park managers?

Forest conservation banks and their management like a genetic resource. Mendizábal-Hernández, L.C., Alba-Landa, J., Márquez Ramírez, J., Cruz-Jiménez, H., Ramírez-García, E. (*Universidad Veracruzana, México; lmendizabal@uv.mx*; *jalba@uv.mx; jumarquez@uv.mx; hcruz@uv.mx; elramirez@uv.mx*).

The effects of climate change on forest populations will lead to the reduction of genetic diversity of communities and species; this loss greatly diminishes the chances that forest populations will adapt to this new environment. Analysis of genetic testing of *Cedrela odorata* (400 m), *Liquidambar styraciflua* (1,400 m) and *Pinus teocote* (2,600 m), managed as conservation banks, was determined from evaluations of height and diameter at breast height (dbh) growth, the best provenances, families, and individuals trees adapted to altitudes of establishment. With these results we can: (1) reintroduce the species in areas where populations have been depleted natural and even disappeared, that under a well-defined strategy to achieve Hardy-Weinberg equilibrium with an array $(ab)^2$; and (2) identify best sources for commercial use, under a strategy based on increased allele frequencies of the desirable features for productive use. We conclude that the establishment of conservation banks is essential to protect the greatest genetic diversity of species as possible in order to be used as breeding parental sources in building restoration strategies of populations and/or commercial use.

Managing diversity of forest genetic resources for adaptation to uncertain environmental changes. Zheng, Y. (*Chinese Academy of Forestry, China; zhengyq@caf.ac.cn*).

Uncertain environmental changes including climate change impose significant negative impacts on forest genetic resources through loss of genetic diversity, which leads to decline of adaptability of forests. Management of genetic diversity is critical to enhancing adaptability of forest genetic resources to changing environment conditions. However, the environmental changes are frequently temporal and variable in direction, making adaptability assessment complicated. They may occur in different elements (or directions), and adaptability needs to be assessed in all these elements and its measurement focused on resilience of the stands. This approach to measuring resilience is suited for assessing adaptability to temporal environmental changes. A theoretical model was developed to demonstrate the relation between genetic diversity and resilience of a forest population. The model describes how an increase of genetic diversity would improve adaptabilities (both plasticity and resilience) of a forest population in different environment elements, for instance temperature and rainfall. For permanent environmental change, the population plasticity would be the maximal adaptabilities in all elements of the genotypes in the population, whereas for temporal changes, the population resilience for a certain element would be the gap between the lowest and the highest genotypes in the population.

SP-4 Forest biodiversity—the key to healthy and resilient forests

Organizers: Tim Christophersen *Secretariat, Convention on Biological Diversity, Canada, tim.christophersen@cbd.int;* Ian Thompson *Natural Resources Canada, Canada, ian.thompson@nrcan.gc.ca*; Robert Nasi, *CIFOR, Indonesia, r.nasi@cgiar.org.*

The effect invasive of *Acacia* spp. to native species on resilience boundary in Pleihari Tanah Laut natural conservation area, South Kalimantan. Bahtimi, Y., Wahyuni Firdaus (*International Forestry Students Association, Indonesia; anonymous_tymy@yahoo.co.id; wahyuni.fierdaus@gmail.com*).

Pleihari Tanah Laut is a natural conservation area, whose ecosystems include lowland forest, wetland forest, and mangrove forest. Decree of Ministry of Forestry No: 695/Kpts-II/1991 on October 11, 1991, decided on 27.500 ha as forest for production. Forest production, in which the forest was planted with monotypic (*Acacia* spp.) in large scale, has negative impacts on the forest conservation area around it. *Acacia* spp. in the forest production area are affecting the native species in the conservation area, not only depressing native species but also changing the ecosystem by disturbance from exotic species and threats to wildlife in the conservation area. The main effects of this damage are loss of the native plant, *Melaleuca leucadenron*, and declines in the Borneo endemic wildlife species, *Muntiacus atherodes,* and the native species *Cervus unicolor* and *Muntiacus munjak*. If this damage passes the boundary of resilience, the effects also will extend to climate change and ecosystem quality. However, there are linkages between ecosystem resistance to disturbance, the importance of biodiversity to ecosystem resilience, and the influence of a healthy ecosystem and forest biodiversity to mitigation of damage and climate change.

Arbuscular mycorrhizal diversity and pioneer plant species growth responses. Nakajima, M. (*Graduate University for Advanced Studies, Japan; nakajima@nibb.ac.jp*), Wu, B., Hogetsu, T. (*University of Tokyo, Japan; bingyun@fr.a.u-tokyo.ac.jp; ho@fr.a.u-tokyo.ac.jp*).

Arbuscular mycorrhizal symbiosis is known to be important for plant nutrient acquisition. Thus it is also assumed that arbuscular mycorrhizal fungi (AMF) have important roles for early processes of forest formation. But, empirical studies revealing their effects are few. We investigated the interaction of AMF with three pioneer plant species, which take root at different times of primary succession. We isolated AMF spores from field soils at the volcanic desert of Mt. Fuji, and inoculated them to the plant seedlings either singly or in a mixture. After 3 months cultivation, we examined plant growth responses and community structure of infected AMF. There were more than 10 AM species in the field soil, but the responses to AMF are apparently different among the three plants. Most initial pioneer *Polygonum cuspidatum* was not infected at all, while the secondary pioneer *Cirsium purpuratum* was infected with a restricted AMF species with some beneficial effect on growth. *Clematis stans,* which is the latter pioneer, was infected with multiple AMF species and its growth was greatly promoted. This suggests that in pioneer plants at a primary successional area, a gradual colonization occurs with increasingly diverse AMF species, which correlates positively with nutrient acquisition and growth.

Defaunation, resilience, and tropical forests. Nasi, R. (*CIFOR, Indonesia; r.nasi@cgiar.org*), Van Vliet, N. (*France; vanvlietnathalie@yahoo.com*).

Defaunation (the loss of wildlife) is occurring in many tropical forest ecosystems, leaving what is called “empty forests.” This has far-reaching and important though overlooked consequences in terms of forest resilience. Focusing on tropical forests and based on synthesis work and reviews made in partnership with the Convention on Biological Diversity, we examine the impacts of defaunation on ecological and livelihood terms for resilience considering hunting for food or wildlife products as one of the main causes of defaunation. Hunting concerns not only animal species but also hunters, traders, and consumers who behave and interact in variable political, socio-economic, cultural, and ecological environments within a social-ecological system. The implications of this interpretation for sustainability include changing the focus (i) from seeking maximum sustainable yields to resilience analysis and (ii) from conservation or repressive measures only to active management of the resource in the broader landscape. Finally, we present the recommendations prepared by the CBD Liaison Group on Bushmeat during its first meeting in October 2009 about maintaining the resilience and functioning of hunted tropical forests.

The relationship between biodiversity and forest ecosystem resilience and relationship to climate change. Thompson, I.D. (*Canadian Forest Service, Canada; ian.thompson@nrcan.gc.ca*); Mackey, B. (*Australian National University, Australia; brendan.mackey@anu.edu.au*); Mosseler, A. (*Canadian Forest Service, Canada; amossel@nrcan.gc.ca*), McNulty, S. (*U.S. Department of Agriculture, Forest Service, USA; steve_mcnulty@ncsu.edu*).

A resilient forest ecosystem can maintain its ‘identity’ in terms of taxonomic composition, structure, ecological functions, and process rates over time. The capacity of forests to resist change depends on biodiversity at multiple scales. Resilience is an emergent property of forest ecosystems and an ‘insurance policy’ against environmental change. Increasing forest biodiversity using especially endemic plant species in planted and semi-natural forests will have a positive effect on resilience and often on productivity (including carbon storage); >80% of the studies reviewed supported this concept. Larger, less fragmented primary forests are generally more resilient, stable, resistant, and adaptive than modified natural forests or plantations. Gamma diversity is an important component of resilience. If threshold conditions are exceeded, forests can change states, or even move to a non-forest state. Degraded forests, especially those dominated by invasive alien species, may be stable and resilient in a different state and be difficult to recover to the original forest ecosystem. Paradoxically, some forest ecosystems with naturally low species diversity also have a high resilience (e.g., boreal pine forests). These forests are adapted to severe disturbances, and the dominant species have high tolerance to a wide range of environmental conditions.

SP-6 New frontiers of forest economics

Organizers: Shashi Kant *University of Toronto, Canada, shashi.kant@utoronto.ca*; Martin Hostettler *Cycad, Switzerland, martin.hostettler@cycad.ch*; Hans Heinimann *ETH, Switzerland, hans.heinimann@env.ethz.ch.*

The experimental method and forest economy. Fischbacher, U. (*University of Konstanz, Germany; urs.fischbacher@uni-konstanz.de).*

What is the potential role of experiments in forest economics research? Forests are public goods and provide positive externalities such as the stabilization of soil, binding of carbon dioxide, biodiversity, or landscape quality. How people contribute to public goods has to be investigated empirically, and experiments are particularly well-suited for this question. It is possible to implement different institutions and investigate their impacts on cooperation. Furthermore, experiments are also well-suited to study peoples' preferences. It has been discovered that non-selfish preferences are important for an understanding of how people contribute to public goods. For instance, people are conditionally cooperative; therefore, higher contributions can result when people are optimistic about the other's contribution. Furthermore, willingness to incur costs in order to enforce norms can establish stable and high levels of contribution. To understand the structure of non-selfish preferences, many experiments have been conducted. It has been shown that people are heterogeneous in their non-selfish motives, and that important motives are inequity aversion, efficiency seeking, and reciprocity, that is, the willingness to reward kind and to punish unkind behavior. We will present experiments that demonstrate how institutions interact with these non-selfish preferences.

Forest economics in the 21st century. Kant ,S. (*University of Toronto, Canada; shashi.kant@utoronto.ca*).

The existing paradigm of forest economics is focused on the economics of timber, and is based on neo-classical economics driven by the assumption of a rational economic agent. In this century, forest ecosystem services (such as biodiversity, climate regulation, and watershed services) are becoming as important as timber for sustainable development. Hence, forest economics has to move from timber economics to economics of forest ecosystems and ecosystem services. Many streams of economics have challenged the basic foundations of neo-classical economics. For example, behavioral economics has moved economics from assumptions-based analysis to actual human-behavior-based analysis. Similarly, inclusion of multiple ecosystem services in the forest production function introduces higher-level non-linearities, and it requires economic analysis based on multiple equilibria rather than a single equilibrium. In addition, ecological economics, institutional economics, public choice theory, post-Keynesian economics, and social choice theory provide better frameworks for the economic analysis of multiple values of forests. The paper discusses various emerging values of forests and their economic characteristics; diversity and dynamics of social, economic, and cultural contexts of forest management; and relevance of various streams of economics to address economic challenges faced by foresters in this century.

Public choice, forest economics, and sustainable forest management. Laband, D. (*Auburn University, USA; labandn@auburn.edu*).

Although Adam Smith's recognition of humans' propensity to 'truck, barter, and exchange' was made in the context of private markets, this same propensity also applies to political markets. With the increasing recognition of, and appreciation for, the fact that forests generate multiple values, some of which are public goods, comes a strong implication that our understanding of sustainable forest management generally and forest economics specifically will be enhanced by explicitly incorporating principles of decision-making in a collective market context—public choice analysis. The self-interested behavior of politicians (elected), bureaucrats (unelected), and voluntary associations of individuals (NGOs) combined with the agency problems inherent to representative government has strong implications for the decision-making environment of private timberland owners. Unlike individuals who plant traditional row crops that are harvested after one growing season, timber growers make decisions that span (perhaps several) dozens of years. As public aspects of forests increase in value, collective decisions increasingly will influence forest management generally and private decision-making by landowners. But long-term decisions made even under conditions of scientific certainty necessarily are made in a context of political uncertainty. This political uncertainty must be integrated into models of sustainable forest management.

Reflections on new frontiers of forest economics. Löfgren, K.G. (*Umeå University, Sweden; Karl-Gustaf.Lofgren@econ.umu.se*).

Forest economics is a subfield of economics that used to contain both theoretically and empirically the most mature pieces of the economic sciences. The main contributors were the German forest economists and silviculturalists active during most of the 19th century. The development during the 20th century was meagre and is typically clustered to the end of the century. This paper will contain an analysis of the obstacles that may have slowed down the development of the discipline. It will, however, focus on the current and future challenges to forest economics and existing subfields of economics that may be relevant for its future development. One of the most important challenges is how forestry, and in particular forest economics. can contribute to the $C0^2$ issue. The main problem there on a global scale seems to be the lack of cooperation, and to this issue mainstream economics can be potentially helpful by making use of the recent developments in game theory. However, perhaps more important for the forest economics is the cost-benefit analysis of forest sequestration. Here the accounting framework needs a brush up, both through economic theory and natural sciences.

Change in forest conditions and sustainable forest management. Ostrom, E. (*Indiana University, USA; ostrom@indiana.edu*), Nagendra, H. (*ATREE, India; nagendra@indiana.edu*).

Much current research on forest economic takes into consideration a variety of measures of current forest conditions, including quantitative assessments of variables such as extent, density, diversity, and biomass; but also more qualitative and integrated estimates of forest condition provided by foresters and users. Very few studies of forest economics examine the change in forest

conditions over time so as to assess the consequences of institutional arrangements, economic pressures, or local organization—yet such assessments are also critically needed. The International Forestry Resources and Institutions research program, spread across 11 countries, takes a variety of measures of forest condition at repeated intervals of time. Using a dataset of 59 forests from 5 countries—Nepal, India, Kenya, Uganda, and the USA—we compare multiple indicators of forest change. Our findings indicate that human-impacted forests demonstrate considerable variation in different aspects, and that developing a single index of forest change that indicates whether a forest is deteriorating or improving over time is a very challenging task. Especially in light of current discussions on climate change and forest governance, these issues need to be highlighted and discussed as a foundation for future research and analysis.

SP-7 Agroforestry: the way forward

Organizers: P.K. Nair, *University of Florida, USA, pknair@ufl.edu*; Tony Simons *World Agroforestry Centre-ICRAF, Kenya, t.simons@cgiar.org*

Carbon sequestration potential of agroforestry in the African Sahel. Luedeling, E., Neufeldt, H. (*World Agroforestry Centre, Kenya; eluedeling@ucdavis.edu; h.neufeldt@cgiar.org*).

Recent conversion of large areas of Sahelian cropland to agroforestry has shown that adding trees to existing agricultural acreage can be a strategy for sequestering atmospheric carbon. We aim to quantify the extent of suitable areas for such conversions and the amount of carbon that could be stored. The analysis builds on a global dataset on the extent and geographical patterns of agroforestry developed at the World Agroforestry Centre. This dataset integrates information on cropland and land cover to estimate tree cover on cropland. Using multivariate statistics on these data, as well as auxiliary datasets and available knowledge of cropping systems across the Sahel, distinct agroforestry types are characterized. The maximum entropy approach is used to characterize the ecological niches of each of these types, based on regional data on temperature, precipitation, and soil. The potential spatial extent of each agroforestry type is derived from its climatic and environmental requirements. Since climatic conditions in this region can no longer be assumed to be static, projections are presented for a range of climate change scenarios. Using current and potential agroforestry areas and available information about biomass carbon in agroforestry systems, the climate change mitigation potential of Sahelian agroforestry systems is estimated.

Agroforestry: the way forward. Nair, R. (*University of Florida, USA; pknair@ufl.edu*).

During the past 3 decades, agroforestry has developed from a loosely defined concept to a science-based land-use discipline. Today there is global consensus that integration of trees into farms, ranches, and in other production landscapes, helps to promote social, economic, cultural, ecological, and environmental benefits. Development of the discipline to this level involved coordinated efforts by multidisciplinary teams of experts working in cohort with countless numbers of farmers the world over. While these accomplishments are creditable, the best results are perhaps yet to come. The way forward to energize the next wave of agroforestry will necessitate new approaches, making the best use of modern science and technology. However, for a complex human activity such as agroforestry, no scientific mantra alone can provide infallible and complete answers. The continuous replenishment and updating of the stockpile of our technical knowledge through deployment of cutting-edge science has to go hand in hand with effective transfer of such knowledge to practitioners. Thus, vigorous research efforts in concert with continuous feedback from on-field experience hold the key to success in this endeavor.

A global prognosis for tropical timber supply from farm land. Sinclair, F. (*World Agroforestry Centre, Kenya; f.sinclair@cgiar.org*), Robiglio, V. (*International Institute of Tropical Agriculture, Cameroon; v.robiglio@cgiar.org*), Ibrahim, M.; Somarriba, E. (*CATIE, Costa Rica; mibrahim@catie.ac.cr; esomarri@catie.ac.cr*); Singh, P. (*World Agroforestry Centre, India; v.p.singh@cgiar.org*); Chikamai, B. (*Kenya Forest Research Institute, Kenya; director@kefri.org*).

Recent estimates of the global extent of agroforestry suggest that nearly half of the world's agricultural land has more than 10% tree cover. While only some of these trees have timber value, they represent a vast but largely unquantified timber resource. In many tropical areas, where appropriate land and tree tenure have prevailed, decreasing access to often common property or state forests has led to more trees being retained on farms; therefore, the trend is for an increasing timber resources on farms, while in many places, forest timber resources decline. Farm timber, however, differs as a resource from that in forests, principally because trees are more dispersed and, in the smallholder sector, owned by a plethora of people, most of whom have little expertise in managing trees for timber or marketing the product. Here, we present a global analysis of the potential supply of tropical timber from farmland, based on case studies from Africa, Asia, and Latin America. Trends in timber supply from farmland and key issues surrounding farmers' abilities to manage and market this emerging timber resource are presented.

SP-8 Keep Asia Green: rehabilitating and restoring forest ecosystems in Asia

Organizers: Don Koo Lee *Seoul National University, Republic of Korea, leedk@snu.ac.kr;* Michael Kleine *IUFRO, Austria, kleine@iufro.org.*

Rehabilitating forests and extending tree cover in South Asia. Kant, P. (*Institute of Green Economy, India;, promode.kant@gmail.com*), Acharya, K. (*Department of Forest Research and Survey, Nepal; kpacharya1@hotmail.com*), Hossain, M. (*Institute of Forestry and Environmental Sciences, Chittagong University, Bangladesh; mkhossain2008@yahoo.com*).

South Asia covers a vast stretch of about 368 million hectares of land from the highest peaks of the Himalaya Mountains in the north to sea coasts in the south, from the deserts in the west to the rainforests in the east. Because of the diversity of landscapes

and climates, the region represents a wide range of ecosystems with extraordinary floral and faunal diversity. In the past, the sub-continent experienced large-scale deforestation and forest degradation caused, amongst others, by population pressure, poverty, insecure land tenure and market failures, leaving more than 50% of all forests today in need of some form of rehabilitation. This paper describes the current status and successes and failures of forest rehabilitation in South Asia over the past five decades across its varied ecological, economic, legal, social and political landscapes. Based on this analysis, recommendations are presented aimed at enhancing the extent and quality of forest cover and extending tree cover through stakeholder participation as well as innovative approaches such as landscape management planning, adjustments to land tenure systems, payment for environmental services and private sector investments. The potential of the recommended approach towards climate change mitigation has been specifically analyzed.

Rehabilitating degraded forest landscapes in Central Asia. Orozumbekov, A. (*Kyrgyz National Agrarian University, Kyrgyzstan; aorozumbekov_standrews@yahoo.com*), Meshkov, V. (*Zhassyl el Kasachstan, v_meshkov@list.ru*), Botman, E. (*Republican Scientific Production Centre for Decorative Gardening and Forestry, Uzbekistan; bek_darhan@list.ru*).

The rehabilitation of forest landscapes in Central Asia described in this paper covers the republics of Kazakhstan, Kyrgyzstan and Uzbekistan. The region's landscapes are very diverse, ranging from vast lowland plains with deserts and steppe ecosystems to high mountain territories covered alpine vegetation and glaciers. The mountains of Central Asia are recognized as one of the 32 global biodiversity hot spots. The area is located at the crossroads of early civilizations with economic and cultural connections between Europe and Asia. The landscape has been shaped by nomadic lifestyles for centuries whereby forests have been degraded through timber exploitation, uncontrolled livestock grazing and fire. Today, national forest cover ranges between 4–8%. Following independence from the Soviet Union, these countries have started to build their own forest sectors following a forest policy characterized of decentralization, increasing community involvement, enhancement of environmental services, expansion of conservation areas and forest rehabilitation. The paper describes major rehabilitation efforts including measures to combat desertification through afforestation, establishment of timber plantations mainly with conifers, regenerating high value natural forests particularly in the mountains such as walnut fruit forests and juniper forests as well as increasing tree cover in flood plains intensively used for agricultural production.

Rehabilitation of degraded forest lands in Southeast Asia. Rebugio, L. (*University of the Philippines, Philippines; lucrebugio@gmail.com*)

Southeast Asia occupies a large area of valuable tropical rainforest generally considered as one of the most complex and bio-diverse terrestrial ecosystems in the world. If sustainably managed, these resources will continuously provide socio-economic and environmental benefits to the region. However, over the past one hundred years, the landscape in Southeast Asia has changed significantly. The colonial period through the start of the 20th century up to the present has seen rapid diminution and degradation of forest resources due to various multifaceted factors such as rapid population increase, poverty and rapid industrialization. These had rendered large forest landscapes in the region environmentally, economically and aesthetically vulnerable. This paper presents a synthesis of the various initiatives of 10 countries of Southeast Asia to restore and rehabilitate its degraded tropical forest ecosystems. It focuses on the various forest restoration and rehabilitation strategies employed by each country, and on the various issues and concerns for successful implementation. Lessons learned from the experiences of each country have been drawn and serves as a basis for recommending future actions towards a more successful forest restoration, rehabilitation and sustainable management of Southeast Asian tropical forest ecosystems.

Forest landscape restoration and rehabilitation in West Asia. Sagheb-Talebi, K. (*Research Institute of Forests and Rangelands, Iran; saghebtalebi@rifr-ac.ir*), Colak, A. (*Istanbul University, Turkey; alpere@istanbul.edu.tr*).

West Asia is the meeting place of three phyto-geographical regions (Euro-Siberian, Mediterranean and Irano-Turanian), representing an area of high biological diversity including diverse forest ecosystems and endemism. As an ancient cultural landscape shaped by humans for several millennia, natural forests have been significantly altered resulting in severe degradation of soils and vegetation. In West Asia, in Iran and Turkey, home to the region's largest forest areas, many different forest rehabilitation and restoration activities have been implemented. These began with afforestation of bare areas, mainly with monocultures of native and exotic conifers including fast growing species for timber production. Later, the interest shifted to polycultures of native trees including broadleaved species with attempts to emulate natural recovery processes. Almost 3 million hectares of afforestation indicate the importance of land rehabilitation in the region. Forest restoration and rehabilitation of the remaining degraded areas over the coming decades will focus on strong participation of all forest stakeholders including local government, rural communities, and research and education sectors. In contemporary forest landscape restoration in both Turkey and Iran, there is a tendency to combine adaptive management, participatory techniques and new and established technologies to create a flexible and creative conceptual framework for future implementation.

Russian Far East forests use and rehabilitation: a new dogma or an old problem? Teplyakov, V. K. (*Seoul National University, Republic of Korea; teplyakovv@gmail.com*).

For decades forests of the Russian Far East and Siberia, comprising more than 70 percent of total forestlands in Russia, were a source of timber for domestic use and export to the Asia-Pacific region. Harvesting is by clear-cutting as most forests in Russia are still mature coniferous stands. Forest fires, pest outbreak, and logging have significantly reduced the quantity and quality of these forests. Forest restoration techniques in the region are determined by vegetation conditions, soil quality, harvesting operations, seed years and planned assistance to natural regeneration, availability of planting stock, i.e. from seed tree orchards and tree nurseries, as well as trained staff of foresters and workers. The new Russian Forest Code (2006) introduced innovative regulations in forest use and reforestation, empowering regional and local governments and forest lease holders to take a more active role in the forest sector. Timber markets have been affected by a set of external and internal changes that have dramatically affected timber harvesting and, consequently, funds available for forestry activities. The paper examines major challenges occurring in the forest sector due to administrative and legal reforms including adaptation of forest administration and management practices in forest rehabilitation to a new operational environment.

Afforestation and ecological restoration in the northeast Asian region. Zhang, Z. (*Beijing Forestry University, China; zhqzhang@bjfu.edu.cn).*

Afforestation and ecological restoration play very significant yet differentiated roles under the diversified socio-economic and natural conditions in China, DPR Korea, Republic of Korea, Japan, and Mongolia. These countries have experienced dramatic forest land use changes driven by different socio-economic and political developments ranging from deforestation and forest degradation to reforestation and ecological restoration. Over the past 50 years extensive forest-related land rehabilitation was undertaken in the region to meet the multiple demands for timber, biomaterials and bio-energy production, rural development, poverty alleviation, combating adverse impacts of sand storms and soil erosion, water conservation, climate change mitigation and other environmental services. In industrialized countries namely Japan and the Republic of Korea as well as some parts of China the main focus of forest rehabilitation is on ecological restoration for improvement of biological diversity and structural stability of successfully re-established forests. In other parts of Northeast Asia with developing economies such as China, Mongolia and DPR Korea priority in rehabilitation is given to afforestation of bare land and overall increase of tree cover for poverty alleviation and enhancement of environmental services crucial for the livelihood of poor rural communities. The paper describes the major approaches of forest rehabilitation in Northeast Asia.

SP-9 Enhancement of service life of wood in an environmentally conscious global society

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Roles of wood durability and wood protection in climate change mitigation. Deroubaix, G., Cornillier, C., Vial, E. (*FCBA, France; gerard.deroubaix@fcba.fr; claire.cornillier@fcba.fr; estelle.vial@fcba.fr*).

In the search for possible strategies to mitigate climate change, forests and forest products have important advantages that have already been acknowledged by the IPCC. Sustainable management makes forests a major carbon sink. Wood products have the potential to be a carbon sink with dynamics closely linked to the economy of the forestry-wood sector; examples of quantification at national level are given. Moreover, the low level of carbon production during wood product production has a potential for reducing CO_2 emissions by substitution for competing materials. However, this should nevertheless not exempt the wood industry from working on the reduction of fossil carbon emissions, just as other industries are strongly reducing their own emissions. After describing these assets of wood products, both on the macro-economical level and the single product level, this paper analyses the importance of wood durability to their carbon footprint and the related potential benefit of wood protection. An attempt is made to quantify this reinforcement to assess its importance and the conditions for the acknowledgement of this positive environmental role of wood protection.

Solubility and bioavailability of micronized copper based wood preservatives. Gao, W. (*Beijing Forestry University, China; gaowei21230@163.com*), Kamdem, D.P. (*Michigan State University, USA; kamdem@msu.edu*), Cao, J. (*Beijing Forestry University, China; caoj@bjfu.edu.cn*)

The effects of nanosize copper oxide and basic copper carbonate on physical and mechanical properties of flakeboards prepared with mixed wood species were investigated. Flexural properties, internal bond strength, water absorption and thickness swelling were determined according to ASTM Standard D-1037, and the curing process of phenol formaldehyde (PF) resin containing nanosize copper oxide and basic copper carbonate was investigated by using dynamic differential scanning calorimetry (DSC). Nanosize copper oxide showed an optimistic effect on the internal bond strength (IB), modulus of rapture (MOR), and modulus of elasticity (MOE) and dimensional stability (thickness swelling at edge (TS) and water absorption (WA)) of flakeboard. While basic copper carbonate increased thickness swelling and water absorption to some extent, but the difference was not statistically significant. The DSC results indicated that the activation energy and the reaction enthalpy of PF resin decreased significantly with addition of 0.68% basic copper carbonate, which resulted in the relatively lower bond strength. However, comparable activation energy and reaction enthalpy, obtained from nanosize copper oxide treated samples, contributed to the higher degree of conversion of PF resin and better bond strength.

Increased sustainability for wood construction by recycling. Heräjärvi, H., Pirhonen, I., Räty, T., Saukkola, P. (*Finnish Forest Research Institute, Finland; henrik.herajarvi@metla.fi; ilkka.pirhonen@metla.fi; tarmo.raty@metla.fi; pekka.saukkola@metla.fi*).

Wood is the only renewable and certified, industrially available construction material that has also unique opportunities as a carbon-storing, energy-independent, and generally approved resource. However, if burning for energy is not counted, there are only few viable and competitive solutions for re-use or recycling of various wood products. The biggest challenge related to recycling of wood products is incompatibility of different building elements and components with each other. As a result of lacking harmonised building standards, much usable wood products are burned or disposed in landfills. The objective of this study was to assess the current state of recycling in Finland; available raw material resources; restrictions set by laws, directives and standards; and the possibilities to launch new business in the field of wood product re-use and recycling. The results showed that recycled wood product volumes could relatively easily be increased by either normative or voluntary means. In fact, it is obvious that both these means will be put into practice within the next decade, which will lead to an increased rate of recycling. This, in turn, will cause positive changes to the actual environmental performance as well as the "green market competitiveness" of wood products.

Fungal biodegradation of CCA-treated wood waste. Kim, G.H., Choi, Y.S., Kim, J.J. (*Korea University, Republic of Korea; lovewood@korea.ac.kr; okssisi@korea.ac.kr; jae-jinkim@korea.ac.kr*).

Disposal of CCA-treated wood waste is a growing problem worldwide due to public concerns about the release of toxic CCA components. Fungal biodegradation could be used as a pretreatment to alleviate environmental concerns related to current disposal methods. It could be used to decrease the volume of waste wood in landfill disposal, and to reduce the amount of arsine in emitted gases and of CCA components in fly ash in burning disposal. We have screened hundreds of decay fungi, including fungi isolated from CCA-treated wood in service, in search of the CCA-tolerant fungal isolates. The decay capacity of the tolerant isolates was determined and the amount of CCA components removed during the decay process was also investigated. *Crustoderma* spp. and *Fomitopsis palustris* were selected for their capacity to degrade CCA treated wood and to remove CCA components simultaneously. *Crustoderma* spp. effectively decayed treated wood causing mass loss of up to 60.4%. Biodegradation with *F. palustris* showed extensive leaching of chromium and arsenic (up to 77%), but only moderate leaching of copper (32% or less). In this presentation, we will discuss the potential of fungal biodegradation of CCA-treated wood wastes based on our relevant research results.

Wood protection and utilization of naturally durable species in the moist tropics for sustainable tropical forestry and climate change mitigation. Wong, A.H.H. (*Universiti Malaysia Sarawak, Malaysia; ahhwong@frst.unimas.my*), Singh, A.P. (*Scion/New Zealand Forest Research Institute, New Zealand; adya.singh@scionresearch.com*), Bae, H.J., Kim, Y.S. *(Chonnam National University, Republic of Korea; baehj@chonnam.ac.kr; kimys@chonnam.ac.kr).*

Implementation of efficient wood protection strategies in moist tropical environments is long overdue as a contributory link to halting overexploitation of tropical forest timber resources that otherwise help store carbon in the ecosystem and mitigate against global climate change. Perceivably higher rates of biodegradation of unprotected (or poorly treated) wood materials under moist tropical conditions constitutes wastage of woody resources, facilitating rapid carbon emissions to the atmosphere when wood protection is not correctly applied or without adequate utilization of naturally durable species for wood products, particularly under high biological hazard conditions within a moist tropical clime. Consumer and specifier understanding of treated (durable) wood requirements remains a major issue to such efficient uses of tropical timbers. Comparisons of the carbon footprints of naturally durable wood species, treated woods, and alternative construction materials is necessary to convince national policy makers in the tropics of the essential role of wood protection and forest products industries to implement green construction technology, sustainable tropical forestry, and increased tropical forest plantations for a rejuvenated forest products industry that focuses on service life enhancement needs (durability quality) of timber products, with the ultimate aim of contributing to global initiatives in combating global warming for mankind's future.

Climate change and wood protection, increasing demand of long-life wood products and decreasing production of treated wood. Yamamoto, K., Kato H (*Forestry and Forest Products Research Institute, Japan; koichi@ffpri.affrc.go.jp*; *hikato@ffpri.affrc.go.jp*).

As awareness of climate change has grown strongly, several new topics related to the wood protection sector has appeared in Japan. The Basic Act for Housing (2006) and the Long-life Housing Promotion Act (2009) were enforced to form a safe and high quality housing stock and to form a long-service-life housing respectively. The *Green Guide to Specification* (2009) for building materials and components made by the Building Research Establishment, UK, also attracts an interest from the wood protection sector. The major reason for the interest is supposed to be that treated wood products used in exterior walls, window frames, and decking were evaluated as relatively superior materials by the several environmental criteria: climate change, fossil fuel depletion, and so on. Despite the favorable environmental background, the amount of treated wood was steadily decreasing to 202,057 m^3 in 2008 from the maximum of 445,689 m^3 in 1996, according to Japan Wood Preservers Industry Association statistics. The discussion in this presentation reflects how the wood protection sector combats climate change through the establishment of effective wood protection system and its promotion to society.

SP-11 Forest biomass utilization for bio-energy: technology, economics, and environment

Organizers: Woodam Chung *University of Montana, USA, woodam.chung@umontana.edu*; J. Greg Jones, *U.S. Forest Service, USA, jgjones@fs.fed.us*

Outcomes of a multi-scale, integrated research program to assess the feasibility of using pyrolysis to produce biochar and liquid fuels from forest biomass in Oregon, USA. Anderson, N., Chung, W. (*University of Montana, USA; nmanderson@fs.fed.us; woodam.chung@umontana.edu*), Jones, G. (*U.S. Forest Service, USA; jgjones@fs.fed.us*), Venn, T., Sorenson, C., Loeffler, D., Butler, E. (*University of Montana, USA; tyron.venn@cfc.umt.edu; colin.sorenson@grizmail.umt.edu; drloeffler@fs.fed.us; ebbutler@fs.fed.us*).

The use of pyrolysis to convert biomass into value-added products such as biochar and bio-oil holds great potential to facilitate fuels reduction projects, revitalize forest-dependent rural economies, and reduce net carbon emissions through fossil fuel offsets and carbon storage in biochar soil amendments. However, great uncertainty surrounds the use of pyrolysis technologies in the forest sector. Many of the knowledge gaps are related to understanding the economic and environmental performance of alternative technologies and operations, predicting feedstock flows and costs, and deploying equipment that can be effectively integrated into existing industrial infrastructure. Using a broad range of methods, this research provides: (1) financial analysis of mobile versus centralized pyrolysis operations; (2) spatially explicit models of biomass stocks, flows, and transportation costs under alternative land management scenarios; (3) assessment of energy and carbon balances associated with pyrolysis operations; and (4) productivity and financial analysis of in-woods pyrolysis based on data collected during field trials of a mobile pyrolysis

reactor in Umpqua National Forest, USA. Though pyrolysis is in the early stages of development for forestry applications, results indicate that it has the potential to be profitable and carbon negative under certain land management scenarios, operational configurations, and market conditions.

Discussion on economy and energy balances of forest biomass utilization for bio-energy at Sano city, Tochigi prefecture, in Japan. Aruga, K., Yamaguchi, R., Nakahata, C., Murakami, A., Ito, K., Saito, M. (*Utsunomiya University, Japan; aruga@cc.utsunomiya-u.ac.jp*).

In this study, current situations of forest biomass utilizations for bio-energy in Japan were summarized first. Then, as an example, economy and energy balances were discussed on Sano city, Tochigi prefecture in Japan, where a cement factory established a 25 MW power generation plant. The plant consumed 100,000 ton/year woody biomass, of which 6,000 ton/year was logging residues. The costs of logging residues were about 9,000 yen/ton from clear cutting, 11,000 yen/ton from thinning operations, and 18,000 yen/ton from pre-commercial thinning operations (1 USD = 90 yen). These costs were much more expensive than the expected price of the factory. Therefore, the logging company and we are conducting research and development in order to reduce costs of logging residue harvesting. Finally, the energy balance and carbon dioxide (CO_2) emissions were analyzed using the method of a life cycle inventory. The result indicated that the forest biomass utilization examined in this study could be feasible as an energy production system because the ratio of energy output to input was high and CO_2 emission was significantly reduced by replacing fossil fuel.

The comparative study of wood fuels (chips, pellets) using life cycle assessment (LCA). Choi, Y.S., Kim, J.S., Cha, D.S. (*Kangwon National University, Republic of Korea; zigoo0402@hanmail.net; jskim@kangwon.ac.kr; dscha@kangwon.ac.kr*).

This study purports to elicit the optimal production processes of wood chips and wood pellets from 5 different processes(2 chips, 3 pellets), from gathering raw materials onsite to final production, and to compare the outlook of the profits generated for producers and the degree of its efficiency for consumers. Results showed that the processing cost of wood chips was lower than of wood pellets. As it turned out, the lowest processing cost for wood chips was for those processed immediately onsite and sold to consumers. The lowest processing cost of wood pellets was for those produced at factories after being transported from the sites. The profit of wood chips was slightly higher than for the wood pellets. The price of wood pellets, which was to produce an equal amount of heating value as wood chips, was 1.27% higher than the wood chips. Although the price of the wood pellets is 1.5 times higher than the wood chips, wood pellets are just as competitive as wood chips because they can be used in a tank smaller than the one used for wood chips, and wood pellets produce less ash, so they have the advantage of reducing labor cost.

Collection and transportation of forest biomass for energy in the western United States. Han, H.S. (*Humboldt State University, USA; hh30@humboldt.edu*).

Commercial timber harvest or pre-commercial thinning operations often generate limbs, tops, and non-commercial sizes of trees, referred to as "slash," which can be ground into hog fuel that is delivered to energy plants for heat or power production. However, costs associated with collection and transportation of these materials are often higher than market values of hog fuel. Also, access to slash piles is limited because of poor road conditions (e.g., steep grades, rough road surface, and sharp curves). This presentation addresses innovative equipment options and their logistical arrangements to cost-effectively remove slash from landing areas that are not traditionally accessible with regular highway chip vans. Pre-hauling slash using small trucks such as roll-off containers and dump trucks to a central grinding location effectively improved access to slash piles in remote areas and operational efficiency in slash grinding (> 80% of machine utilization). The overall costs (stump-to-chip van) ranged between $26.47 and $51.26/bone-dry metric ton with various equipment options and operational arrangements. Small trucks are a low-cost option for compiling (pre-hauling) of slash, but the pre-hauling distance to a central grinding site should be kept short (<5 km) because traveling speeds on forest roads are often low (<30 km/hour).

Energy from conventional forestry in Sweden: concerns and research approaches for environmental effects and forest production. Lundkvist, H. (*Swedish University of Agricultural Sciences, Sweden; helene.lundkvist@ekol.slu.se*), Eriksson, H. (*Swedish Forest Agency, Sweden; hillevi.eriksson@skogsstyrelsen.se*), Olsson, B. (*Swedish University of Agricultural Sciences, Sweden; bengt.olsson@ekol.slu.se*).

Bioenergy has been an increasing part of the Swedish energy supply since the oil crisis in the mid 1970s. Presently approximately 25%, i.e. more than 120 TWh annually, of the energy used in Sweden is bioenergy, most of it generated from felling residues from conventional forestry. At an early stage concerns were raised regarding the effects of the increased intensity in harvesting on soil quality in terms of nutrients, carbon content, and water-holding capacity. With time concerns for soil base cation status and soil and ground water acidification were added, as well as for the effects on biodiversity above and below ground. To this list of concerns in the past decade has been added the complex issue of carbon balances and the role of bioenergy, forests, and forest soils. The present paper gives an overview of how documented or foreseen consequences of harvesting for bioenergy have been scientifically and practically approached in order to limit and mitigate negative environmental or production effects with the aim to optimize the environmental and economical value of bioenergy from conventional forestry.

Soil impacts from intensive biomass utilization. Page-Dumroese, D.S. (*U.S. Forest Service, USA; ddumroese@fs.fed.us),* Jurgensen, M. (*Michigan Technological University, USA; mfjurgen@mtu.edu)*, Coleman, M. *(University of Idaho, USA; mcoleman@uidaho.edu).*

Fuel reduction treatments that make use of thinning and underburning can potentially impact the soil resource by removing the forest floor, displacing topsoil layers, and/or causing mineral soil compaction. The extent of those impacts on soil porosity, organic matter (OM), carbon (C), or nitrogen (N) levels within a harvest unit or across a watershed will subsequently determine if net primary productivity and soil and site hydrology are affected. Understanding the changes in soil biological, chemical, and physical properties that affect soil sensitivity to disturbance are important for maintaining ecosystem function, and for the

successful implementation of best management practices that minimize the potential for long-term and cumulative effects. In addition, management of woody residues to both reduce fire hazard and maintain soil productivity will benefit ecosystem function. Development of best management practices should use available information from long-term studies to maximize the positive benefits and minimize negative effects of planned utilization activities.

Bio-oil production from fast pyrolysis of larch wood sawdust in a spout-fluidized reactor. Ren, X., Chang, J., Gou. J., Si, H., Gao, X., Wang, W., Ye, M. (*Beijing Forestry University, China; rxueyong@bjfu.edu.cn*; *cjianmin@bjfu.edu.cn*; *jinsheng@bjfu.edu.cn*; *sihui@bjfu.edu.cn*; *mazuka@163.com*; *ninhao.liang@163.com*; *jessie329958@163.com*).

Fast pyrolysis is one of the most effective ways to utilize forest biomass, which can directly convert low-grade biomass into profitable bio-fuel or high value-added chemical products. In this work, fast pyrolysis of larch wood sawdust was investigated under various reaction conditions (reaction temperature, particle size, flow rate of fluidizing medium, the moisture content of raw material, and static bed height of bed material) in a fluidized-bed reactor. GC-MS and GC were used to analyze bio-oil qualitatively and quantitatively. Analysis showed larch wood bio-oil is a mixture of many kinds of organism, including carboxylic acids, ethers, phenols, aldehydes , hydrocarbons and other. Single factor experimental results showed that the appropriate ranges of impact factor for high yields of bio-oil in the spout-fluidized reactor with a feed rate of 5 kg/h were temperature 500–600° C , particle size 0.2–1.2 mm, the moisture content of raw material 5wt%–15wt%, and static bed height of bed material 80–130 mm. Optimal parameters for fast pyrolysis of larch wood sawdust for increased yields of bio-oil were 550° C, gas flow 8 m3/h, and static bed height 120 mm. Under these reaction conditions, yields of larch wood bio-oil was 71.56 wt %.

Harvesting firewood from an aged oak coppice with a CTL hardwood harvester. Suchomel, C., Engler B. (*University of Freiburg, Germany; christian.suchomel@fobawi.uni-freiburg.de; benjamin.engler@fobawi.uni-freiburg.de*).

Coppiced forests are ecologically valuable and aesthetically unique in several parts of Germany. In their manifold structures these forests provide important living areas for various species of insects, birds, and plants. The biodiversity and richness in structure is due to the traditional utilisation and cultivation of these areas for decades. Today this traditional coppice-forest management is for technological and economical reasons out of use. Thousands of hectares were not used in the past 60–80 years because of cheap oil prices. In the context of energy from biomass ,there is a big interest in these traditional forest structures again. But practical, especially full mechanised, harvesting methods are not identified even today. Full mechanised harvesting systems can reduce costs in the forest, but in coppiced forests present several specific harvesting problems. The hardwood trees from coppice have bad forms, small diameters, and the stems grow as multiple stems from the tree stump. In a field study a HSM 405 H1 6WD harvester with a CTL hardwood processor head harvested the aged coppice to firewood assortments. Logging was done by a HSM 208 F forwarder. Intensive time studies have been done. Results will be presented at the conference.

SP-12 Forest health in a changing environment

Organizers: Elena Paoletti *National Research Council Plant Protection Institute ,Italy, e.paoletti@ipp.cnr.it;* Mike Wingfield *University of Pretoria-FABI, South Africa, mike.wingfield@fabi.up.ac.za.*

Responses of forest pests to climate change. Battisti, A. *(Padova University, Italy; andrea.battisti@unipd.it).*

Forest pests are affected in a number of ways by climate change. Effects can be seen at both individual and population levels. Generally foresters are considering population responses, such as outbreaks or variations of abundance, that are often associated with weather patterns, although the underlying mechanisms remain often unknown. Climate change may affect the drivers of pest abundance (e.g., drought, storm damage, fire frequency), resulting in a different occurrence and frequency of attacks. Individual responses are clearly a component of population responses, although they can be more easily analyzed by a mechanistic approach, by measuring the response of the individuals to the climatic driver. This is a common way by which it is possible to assess the upper edge of the geographic range, and consequently define the potential range expansion caused by climate change. The individual responses are generally of two types: (i) direct (e.g., faster development at higher temperature), and (ii) indirect (e.g., change of the quality of the host plant or in the higher trophic levels). The combination of individual and population responses to climate change may help in understanding the general effects of climate change and in making predictions.

Climate changes increase damage potential of many European forest pathogens. La Porta, N. *(FEM-IASMA, Italy; nicola.laporta@iasma.it).*

Large-scale of frequency and intensity of forest stresses are predicted in response to the altered rainfalls, temperature regimes, and climatic extremes associated with global climate change. Tree pathogens may have severe ecological impacts on forest health and are an important climate-forest feedback through their alteration of carbon, water, and energy fluxes of the forest ecosystems. Although it is more difficult to predict the effects of climate change on host-pathogen relationships than on the individual organisms, the impact on those pathogens, whose reproduction or dispersal is markedly influenced by temperature, is relatively predictable. Warmer winters may improve the activity of some weak pathogens that are effective only when the hosts are inactive. Warmer summers may support thermophilic fungi, which are currently rare or non-native in central or northern Europe. Pathogens that have been important in southern Europe are going to spread northward and also upward to mountains. Present trends in the health status of several tree species are leading to changes in species composition; silver fir, alders, elms, oaks, chestnut, and other hosts are declining over large parts of their European ranges. Results serve as an important baseline for evaluating how potential global climate warming will impact forest tree diseases.

Invasions of forest insects: agents of global change. Liebhold, A.M. *(U.S. Forest Service, USA; aliebhold@fs.fed.us).*

Globalization has greatly enhanced the movement of wood, live plants, and other pathways that facilitate the arrival of non-native forest insects in continents distant from their native ranges. As a result, there has been a steady increase in the number of new

pest establishments; spatial and temporal patterns of these invasions tend to mirror patterns seen in trade networks. Increasing numbers of alien insects can be expected to be one of the dominant influences altering the world's forest ecosystems over the next century. When considering the likely impacts of these invaders, it is necessary to consider their effects on forests as dynamic systems and evaluate the role that invaders play in altering long-term forest succession processes. Most alien insect species cause negligible effects, but a few induce changes to forest ecosystems, unlike any pre-existing disturbance agents, and these impacts may destabilize natural cycles of forest dynamics, altering ecosystem properties and ecosystem services. Insect invasions are particularly significant to the long-term sustainability of plantations of non-native tree species. The exceptional productivity of such plantations are partially attributed to a lack of forest pests, but such escape from enemies will ultimately fail as pests invade and "catch-up" with their host trees.

Further development of forest monitoring in Europe. Lorenz, M. (*Institute for World Forestry, Germany; martin.lorenz@vti.bund.de*).

Forest monitoring in Europe has been conducted for 25 years according to harmonised methods and standards by the International Cooperative 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). A future focus of ICP Forest will be the critical loads approach in Europe as well as in the United States of America and Canada who are also participating in the programme. Whilst ICP Forests will continue to provide scientific information on air pollution effects on forests to CLRTAP, most member states of the European Union (EU) are further developing forest monitoring towards meeting the information needs of the European Commission (EC) in the fields of climate change, carbon sequestration, and biodiversity. This is achieved by means of a project named Further Development and Implementation of an EU-level Forest Monitoring System (FutMon) which is co-financed under the EC LIFE Regulation. FutMon and ICP Forest are complementary to each other, pursue harmonised approaches, and avoid duplications. Results expected from the further development of forest monitoring include relationships among climatic factors, air pollution, forest health, forest growth, carbon sequestration, and biodiversity.

Site conditions, fire, and root disease: are *Leptographium* spp. and *Heterobasidion* spp. consequences of "exotic" ecosystems? Otrosina, W., Spaine, P., Sung, S., Kliejunas, J. (*U.S. Forest Service, USA; wotrosina@fs.fed.us; pspaine@fs.fed.us; ssung@fs.fed.us; jkliejunas@fs.fed.us).*

Forest tree species have evolved under climatic, geological, and biological forces over eons of time. Recent management activities and various land uses have dramatically altered edaphic and environmental conditions from those under which forest tree species and ecosystems have evolved. For example, fire suppression in fire-dependent *Sequoiadendron giganteum* stands has resulted in increased mortality due to *Heterobasidion* spp. One hypothesis is that fire suppression results in increased encroachment of true firs, readily infected by *Heterobasidion occidentale*, thereby transferring the disease via root contacts with *S. giganteum*. In addition, the existence of a hybrid between the *H. occidentale* and *H. americanum* may be evidence for anthropogenic influences on evolutionary pathways in this pathogen. In other ecosystems, such as *Pinus palustris* (longleaf pine) in the southeastern United States, increased mortality following prescribed fire is being observed. Various *Leptographium* species and *Heterobasidion* have been associated with this mortality following relatively cool fires. How these fungi interact with fire and various edaphic factors is not known, however, these examples illustrate the concept of "exotic ecosystems" corresponding to root disease effects on some present day forest ecosystems**.**

Air pollution impacts on forest ecosystems in a changing climate. Paoletti, E. *(IPP-CNR, Italy; e.paoletti@ipp.cnr.it).*

Air pollution is the main driver of climate change. Current knowledge suggests that climate change may become more harmful to pollution-affected forests, although the magnitude of these feedbacks is still to be determined. At present, the air pollutants of most concern to forests are ground-level (or tropospheric) ozone and nitrogen deposition. Humans have already doubled the flow of reactive nitrogen on the continents, and projections suggest that this may increase by roughly a further two-thirds by 2050. Nitrogen also plays a role in creation of ground-level ozone. Ozone concentrations have increased by 2 to 4.5 times, depending on the site, since the pre-industrial age and are expected to double again by the end of 2100. Both ozone and nitrogen affect biodiversity and increase forest susceptibility to drought, pest attacks, windstorms, and fire. The impacts on forest ecosystems, however, have traditionally treated air pollution and climate change separately, although they are, in fact, cause-and-effect. This paper reviews current knowledge on integrated climate change and air pollution impacts on global forests.

SP-13 Promoting urban forest services in partnership between scientists and communities

Organizer: Cecil Konijnendijk *University of Copenhagen, Denmark, cck@life.ku.dk.*

Green compact cities: challenges of urbanization and urban-rural linkages. Nilsson, K. (*University of Copenhagen, Denmark; kjni@life.ku.dk*).

Changing land use relationships within emerging rural-urban regions, and their manifestation in phenomena such as urban sprawl and development of large transport corridors have long-lasting consequences for the regions' sustainability. The drivers of land use changes and how they interact with regional, national and European policies need to be better understood to minimise negative consequences of urbanisation and to enhance the adaptive capacity of rural-urban regions. Rural-urban regions can become centres of sustainable development, but this requires strategies that are developed by means of participatory planning and decision making. These challenges form the basis for the PLUREL project. PLUREL is a large integrated research project funded within the 6th Research Framework Programme of the European Union. 31 partners from 14 European countries and China

participate in the project, which is coordinated by the Danish Centre for Forest, Landscape and Planning at the University of Copenhagen. In seven case study regions; Montpellier (FR), Leipzig (DE), Warsaw (PL), Koper (SI), Haaglanden (NL), Manchester (UK) and Hangzhou (CN), local stakeholders are involved in analysis of the regional context as well as development of scenarios and strategies.

Promoting urban forest services in partnership between scientists and communities in the United States. Nowak, D.J., Rodbell, P. (*U.S. Forest Service, USA; dnowak@fs.fed.us; prodbell@fs.fed.us*), Maco, S. (*Davey Tree Expert Company, USA; smaco@davey.com*).

Trees and forests in urban areas provide critical ecosystem services that enhance environmental and human health. To understand and better optimize these services, resource managers need to be able to measure the urban tree population structure (e.g., number of trees, species composition, tree sizes) and assess how current or future structural designs will affect the magnitude and distribution of these services. Management efforts to increase the extent of urban forests have been hampered by insufficient local data related to resource structure and its associated ecosystem services and values, and lack of community engagement and funding. To help managers and citizens assess their local urban tree population and the ecosystem services they provide, the USDA Forest Service has partnered with private industry, professional associations, non-profit groups, and universities to develop a freely accessible, public domain urban forest assessment suite of tools called i-Tree (www.itreetools.org). The i-Tree partnership continues to develop, refine, disseminate and support the software with more than 5,300 copies of this program being distributed in 47 countries in the last few years. This presentation will discuss the success of the i-Tree collaborative partnership, the tools, and the urban forest management and funding impacts it is having across the globe.

Urban community forestry in Japan and the facilitating role of participatory science. Yokohari, M., Bolthouse, J. (*University of Tokyo, Japan; myoko@k.u-tokyo.ac.jp; jay@nenv.k.u-tokyo.ac.jp*).

In Japan, a new urban forest paradigm—characterized by volunteer management of urban and peri-urban *satoyama* woodlands—has emerged in recent decades. The term *satoyama* signifies woodlands [*yama*] historically managed by nearby agricultural villages [*sato*] to produce an essential supply of green fertilizer and woodfuel. From the 1960s onwards, these woodlands were abandoned as a result of a 'fuel revolution' and subsequently either developed or simply abandoned, becoming overgown with bamboo grasses and targets for illegal waste disposal. In contrast to urban forests in Europe and North America, where large tracts of forests were transferred from private to public ownership, the vast majority of urban fringe woodlands in Japan remain privately owned. Accordingly, urban forestry practice in Japan is predicated on securing flexible agreements between landowners, citizen volunteers, and local government officials. Based on a review of urban forest policy, interviews with key actors and a case study of current practice on Tokyo's urban fringe, this paper discusses the role that scientists can play in facilitating the management and utilization of peri-urban *satoyama* woodlands. We focus in particular on the role of scientists in establishing and strengthening community forestry networks that link disperse and fragmented volunteer groups.

SP-14 An honest conversation about decentralization and forest livelihoods in a globalized world

Organizer: S. Denise Allen; Joleen Timko; Juan Chen, *University of British Columbia, Canada, sdallen@interchange.ubc.ca.*

The impact of global economic development on cultures embedded in forested landscapes: lessons from the Office of the Wet'suwet'en First Nation in Canada. Allen, S.D. (*University of British Columbia, Canada; sdallen@interchange.ubc.ca*).

From the political economy perspective, the pursuit of sustainability can be characterized as a question of how to create a level playing field in a multidimensional space. More culturally sensitive sustainable forest management (SFM) is needed to support decentralization of resource stewardship and landscape connections for Aboriginal communities, which at times seem to function in a separate economy. This case study investigates the complex interaction between globalism and localism through community research with the Office of the Wet'suwet'en First Nation (OWFN) on their traditional territory in north-central British Columbia, Canada. Interviews with OWFN Hereditary Chiefs and resource managers were used to identify social and cultural impacts of industrial forest management on the Territory and systemic barriers to Aboriginal participation in an industry driven by global commodity chains. The evolving nature and sustainability of cultural institutions stemming from a history of traditional governance, local management authority, access to resources, and language are also identified to reveal how they are used to negotiate overlapping resource management regimes and facilitate territorial stewardship. These lessons are then used to investigate methods for improving the successful and local relevance of development opportunities for Aboriginal communities politically and economically marginalized from their traditional livelihoods.

Local farmers' perspectives on eliminating obstacles to the implementation and promotion of sustainable forest management and forest certification in China. Chen, J., Innes, J.L. (*University of British Columbia, Canada; candice10933@yahoo.ca; john.innes@ubc.ca*).

Although sustainable forest management (SFM) and forest certification have increased worldwide, their development in China is still at a preliminary stage and their uptake depends largely on the acceptance of local farmers with newly-acquired small forest holdings. Interviews were conducted during May and August 2009 with local farmers to explore their general knowledge of and their willingness to engage in SFM and certification. Local farmers were selected from two forest-dependent areas, Tonggu and Yong'an. The results indicate that the awareness of SFM and certification amongst local farmers was extremely low. Their expressed willingness to engage in SFM and certification was also low due to the lack of understanding and uncertain financial benefits. Short-term economic income was the dominant priority and principal motivation for the majority of participants.

However, China's forest tenure reforms have brought a greater sense of security to forest ownership rights, providing some motivation to local farmers to operate and manage their forests responsibly and sustainably. The results also indicate that better promotion of SFM and certification amongst local farmers could be achieved through more comprehensive education and wider advertising campaigns. The support of local governments is critical, as is financial assistance to help defray the increased costs.

Are forest-dependent communities securing legitimate management authority over their forests? case studies from Brazil and Mexico. Hajjar, R. (*University of British Columbia, Canada; reem.hajjar@gmail.com*).

It is often said that where there is ownership or similarly perceived attachment to a resource, there is greater responsibility for its continued health. This has been used as a strong argument for the devolution of ownership of forest resources to local communities as a way to conserve forests more effectively while also improving rural and forest-dependent livelihoods. As this trend increases in many countries, it is important to critically examine whether decentralization of forest management authority is actually happening: are communities in fact securing legitimate decision-making power over the forests on which they depend? I explore this question by examining the legitimacy of communities' decision-making authority in case studies of community forestry in Brazil and Mexico. Among the issues addressed are: the legitimacy of development approaches that aim to devolve more power to local forest-dwelling people but impose models of community forestry rather than work with existing and long-standing local practices; the balance of power in community-company partnerships; and the role of local participation in decision-making in either ensuring or hindering sustainable forest management.

Community forestry experiences of indigenous communities in India and Canada. Singh, M. (*University of British Columbia, Canada; monikaxing@gmail.com*).

Aboriginal communities in India and Canada are involved with community forestry that allows them to manage forests along with the government. However, the management paradigm often is dictated by the Forest Department, which quite often is in conflict with the traditional livelihood practices of aboriginal people. Both countries have experimented with approaches that help to decentralize certain functions, but nevertheless retained centralized approaches. Two case study examples of community forestry are taken for closer examination—Community Forestry Agreement in British Columbia, Canada and Joint Forest Management in Gujarat, India. In both cases, the final authority of management lies with the government, though with different minimum processes laid out for involving aboriginal people. This seems to be more specific in the case of Canada as compared to India. Policies relating to people's rights and access to forest lands that have undergone changes fairly recently in both countries are discussed and analyzed. I examine the extent to which community forestry initiatives have addressed local participation by tribal people and First Nation communities in forest management in India and Canada respectively.

An assessment of the community forest model in Cameroon. Timko, J.A., Alemagi, D. (*University of British Columbia, Canada; joleen.timko@ubc.ca; dalemagi@yahoo.co.uk*).

This presentation reviews the community forest model prevailing in Cameroon in West Africa. A series of assessment criteria emanating from community forest attributes were identified and employed as a basis for assessing the performance of the model. These criteria specifically included: legislation governing community forests; procedures for performing community forests; administrative and oversight of community forests; and several other measures for maintaining and improving community forest operations (such as certification, legalized logging, and reforestation). Data collection included a review and analysis of data from secondary sources including relevant governmental reports, non-governmental organization and aid agency reports, community forest legislation, and peer-reviewed literature where relevant. This synthesis was supplemented by data from primary sources gathered using unstructured interviews. Results of this study revealed that, while the model in Cameroon could be improved, indeed legal, administrative, and procedural frameworks for community forest management have been clearly established, and a monitoring and enforcement system to ensure legislative compliance has been instituted. To conclude, the paper prescribes a series of recommendations for improving the efficiency and quality of the community forest model.

SP-15 IUFRO award winners—the next generation

Organizers: Su See Lee *Forest Research Institute Malaysia, Malaysia, leess@frim.gov.my;* Michaël Rivoire *International Forestry Students' Association, France, michael.rivoire@gmail.com.*

IUFRO Outstanding Doctoral Research Award (ODRA) presentations

Silvopastoral models in western Iberian open woodlands. Gea-Izquierdo, G. (*Dendro Sciences-Swiss Federal Research Institute WSL, Switzerland; guigeiz@gmail.com*).

Quercus ilex L. open woodlands of western Iberia were the subject of this Ph.D. study. Like other species in the area, *Q. ilex* is becoming more sensitive to climate and is impacted by summer drought. The first chronology of more than 100 years for the species was constructed. Then dynamic age-diameter growth models were fitted and the effect of competition on diameter increment studied using Gamma regression. Since age estimation for the species is difficult, age dependent and age independent formulations were compared. Root competition limits growth in the closest stands and affects the climate-growth response. Since timber is generally not the main product in agroforestry systems, the state of the art of fruit production was revised and the spatio-temporal effect of the tree stratum in the grass understory ecology analyzed. The tree-grass interaction was variable in time and space. Nutrient increase below the canopy resulted in enhanced production, however, grass nutrient concentration was not increased with the exception of K and to a lower extent Ca. Modifications in understory nutrient composition were mostly related to variability driven by climate and phenology. These models will assist in the management of the *Q. ilex* open woodlands ecosystem.

Seed orchards: genetic considerations on function, management and seed procurement. Prescher, F. (*Svenska Skogsplantor AB, Sweden; finnvid.prescher@skogsplantor.se*).

Models were developed and seed orchard data evaluated to improve seed orchard management of *Pinus sylvestris* and *Picea abies.* Since the variation in female clone fertility was found to be rather low and difficult to forecast, less emphasis should be put on selecting clones with high fertility when establishing a new seed orchard. The active life time of a seed orchard was found to be 30 years for *Pinus sylvestris*, and 40 years for *Picea abies.* An advanced generation seed orchard should contain 20–25 tested clones, with ramets deployed linearly with respect to their breeding values, for an effective number of 15–18 clones. The linear deployment algorithm was applied to genetic thinning of two seed orchards, combining requirements for high gain and gene diversity. The harvest of cones can often be started typically at age 8 for *Pinus sylvestris*, but if contaminating pollen change the adaptability of the harvested seed, harvest may be postponed or the use of the seeds modified. The cone harvest is a major cost which has consequences for management, e.g. orchards should be pruned in order to reduce tree height and thus harvest costs.

Pareto-optimality between road construction costs, forest harvesting costs and negative ecological impacts. Stückelberger, J.A. (*EcoEng Ltd., Switzerland; andreas. schindlbacher@bfw.gv.at*), Heinimann, H.R. (*ETH Zurich, Switzerland*; *hans.heinimann@env.ethz.ch*), Chung, W. (*University of Montana, USA*; *woodam.chung@umontana.edu*).

Economic objectives are generally opposed to ecological objectives. There are solutions which can improve one objective only at the expense of the other. Such solutions are called Pareto-optimal. This study presents a forest road network design model which is able to find the set of Pareto-optimal solutions between forest harvesting costs and negative ecological impacts caused by road construction and timber harvesting. The model considers four objectives: (1) minimizing road construction and maintenance costs, (2) increasing attractiveness for cable yarding, (3) reducing negative impact on marshland, and (4) minimizing disturbances for endangered birds (i.e. *Tetrao urogallus*). The road network problem was mapped on a mathematical graph and solved as a Steiner-Tree-Problem. This problem is NP-hard (non-deterministic polynomial-time hard), and the solution space is too large to be optimally solved by complete enumeration. However, an algorithm was developed which can provide a near-optimal solution very quickly. The model has been applied in several mountainous areas in Europe. These tests led to three major findings: (1) the model representation is crucial for accurate and practical solutions, (2) there are very few Pareto-optimal solutions, and (3) small changes in the preferences of the stakeholders may greatly influence the solution.

Dynamic modeling of branches and knot formation in loblolly pine (*Pinus taeda* L.) trees. Trincado, G. (*Universidad Austral de Chile, Chile; gtrincad@uach.cl*).

A stochastic framework was developed to simulate the process of initiation, diameter growth, death and self-pruning of branches in loblolly pine (*Pinus taeda* L.) trees. Destructive sampling of whorl sections was carried out from 34 trees growing under different initial spacing. Data from dissected branches were used to develop a model for representing knot shape. For simulating branch dynamics, three different components were modeled and hierarchically connected: whorls, branches and knots. For each new growing season, whorls and branches are assigned stochastically along and around the stem. Thereafter, branch diameter growth is predicted as a function of relative location within the live crown and stem growth. At the end of the projection period information on (i) vertical trend of branch diameter and location along and around the stem, (ii) volume of knots, and (iii) spatial location, size and type (live and dead) of knots can be obtained. Moreover, the developed framework allows the inclusion of additional wood properties in the simulation. This integrated modeling system significantly advances methods for quantitative modeling of crown and branch dynamics, which are essential information for the optimization of forest management and industrial conversion processes.

Effects of temperature, time and frequency on the dynamic viscoelastic properties of wood. Jiang, J. (*Research Institute of Wood Industry, Chinese Academy of Forestry, China; jialiwood@caf.ac.cn*).

Information on dynamic viscoelasticity of wood is important for various manufacturing processes. Effects of temperature, time, and frequency of dynamic viscoelasticity of Chinese fir (*Cunninghamia lanceolata* [Lamb.] Hook) were examined. Critical strain was generally reduced with increasing temperature between –120° and 220° C, with exceptions at –80°, –20°, 40°, 120°, and 220° C, attributed to occurrence of relaxation processes that cause narrowing of the linear viscoelastic region. Wood specimens with parallel grains have higher storage modulus and lower loss at peak temperatures than those with perpendicular grains. The dynamic mechanical temperature spectrum indicated presence of four relaxation processes. Loss of relaxation processes at peak temperatures shifted to a lower temperature range with increase in moisture content. Heating time mainly resulted in thermal softening and degradation, and reduction in wood stiffness. Stiffness and damping of rapid-heated wood were generally lower and higher than those of iso-heated wood, respectively, suggesting that the unstable state was created by rapid heating, which increased mobility of molecular chains. Storage modulus data had a good fit with the William-Landel-Ferry model, indicating validity of the model to characterize dynamic stiffness behavior of dry wood between 25° and 150° C using the time-temperature superposition principle.

Economic analyses of Ontario's stumpage pricing system. Yang, F. (*Ontario Ministry of Natural Resources, Canada*; *Fiona. Yang@ontario.ca*).

This thesis contains three essays that investigate subsidy and dumping issues in the long-standing and contentious softwood lumber trade dispute between Canada and the United States. Ontario is one of the four provinces in Canada that are subject to this trade dispute. The first and second essays investigate the subsidy issue by analyzing the market performance and rent capture capacity of Ontario's stumpage system, using Johansen's multivariate co-integration approach, the Granger-causality test, and an Enhanced Parity Bounds Model (EPBM). The results indicate that Ontario's stumpage system has the ability to capture full economic rent in the long run, and thus indicate that there is no subsidy being given to Ontario's softwood lumber producers. The third paper uses the EPBM to examine the issue of whether Ontario's lumber industry dumped softwood lumber into a major

U.S. market from April 1996 to September 2006. This is a critical issue for Ontario's stumpage system because dumping could lead to lower stumpage prices under the current system. This analysis indicates that the industry gained considerably more profit from the U.S market than from the home market, and thus did not dump lumber into the U.S. market during this period.

Taxonomy and phylogeny of *Cryphonectria* and allied genera. Gryzenhout, M., Wingfield, B.D., Wingfield, M.J. (*University of Pretoria-FABI, South Africa*; *Marieka.gryzenhout@fabi.up.ac.za; Brenda.wingfield@fabi.up.ac.za; Mike.wingfield@fabi.up.ac.za*).

This Ph.D. study undertook a detailed taxonomic revision of the fungal genus *Cryphonectria* which includes some of the most devastating pathogens of forest trees in the world. Among these is *Cryphonectria parasitica*, the fungus that causes chestnut blight and that has almost decimated the native American Chestnut population in North America. Another important pathogen is the *Eucalyptus* canker pathogen *Cryphonectria cubensis*, which has shaped *Eucalyptus* plantation forestry world-wide. All of the chapters making up this Ph.D. dissertation which entail critical taxonomic and nomenclatural re-evaluations and morphological comparisons have been published in highly respected international journals. These results showed that *Cryphonectria* consists of numerous genera and species supported by morphological characteristics and multiple gene phylogenetic analyses, leading to the description of the Cryphonectriaceae fam. nov. The study culminated in the publication of a monograph entitled "Taxonomy, phylogeny, and ecology of bark-infecting and tree killing fungi in the Cryphonectriaceae," which includes all relevant and current information on the taxonomy of this important family, as well as identification keys and illustrated descriptions. This monograph should empower quarantine authorities and those working with these fungi in forest protection, forest biosecurity, mycology and forest pathology.

Assessing potential climate change effects on greenhouse gas emissions from forest soil: observations from the manipulation site at Achenkirch, Austria. Schindlbacher, A., Zechmeister-Boltenstern, S., Kitzler, B., Jandl, R. (*Federal Research and Training Centre for Forests, Natural Hazards and Landscape–BFW, Austria; andreas.schindlbacher@bfw.gv.at; sophie.zechmeister@bfw.gv.at; barbara.kitzler@bfw.gv.at; robert.jandl@bfw.gv.at*).

Soil respiration is a major flux in the global carbon cycle and its potential global warming effects have received much attention. A long-term soil warming/drought experiment was conducted in a mountain forest in Tyrol, Austria. The topsoil was warmed by 4 °C higher than the actual soil temperature during the growing seasons since 2005 in untreated plots and in plots where tree roots were excluded (trenched plots). Soil warming increased soil respiration by ~40% in 2005 and 2006, in both untreated and trenched plots. The consistent response indicated that the autotrophic and heterotrophic components of soil respiration responded equally to the temperature increase. The treatment effect on CO_2 emissions started to level off after three years. Warming increased N_2O but decreased CH_4 emissions. Besides rising soil temperatures, a decrease in summer precipitation is also predicted for the northern Austrian Alps. In a combined treatment where an artificial one-month summer drought during July 2008 and 2009 was superimposed on soil warming, drought partly (2009) or completely (2008) offset the warming effect on soil respiration. Soil respiration measured during the dormant season showed that CO_2 efflux through the snow-cover in winter contributes ~15% to the annual CO_2 emissions from the soil.

IUFRO International Student Award (ISA) presentations

Applying ant colony optimization (ACO) metaheuristic to solve forest transportation planning problems with side constraints. Contreras, M.A. (*University of Montana, USA; marco.contrerassalgado@grizmail.umt.edu*).

Traditionally, forest transportation planning problem (FTPP) goals were set to find combinations of road development and harvest equipment placement to minimize total harvesting and transportation costs. However, modern transportation problems also need to consider multiple uses of roads and their social and ecological impacts. These requirements introduce side constraints, increasing the complexity of the FTPP problem. A new problem solving technique was developed using the Ant Colony Optimization (ACO) metaheuristic. To test the performance of this metaheuristic, a 100-edge hypothetical FTPP was created and sediment yields representing the environmental impact of forest road networks was considered as side constraints. The results show that transportation costs increase with restriction of allowable sediment yield. This algorithm was compared with a mixed-integer programming (MIP) solver to solve a comparable mathematical programming formulation. Four cases were analyzed including cost minimization, cost minimization with two increasing levels of sediment constraint, and sediment minimization. For both the cost and sediment minimization problems, the difference between the ACO solution and the optimal MIP is within 1%. The current MIP solver, however, was not able to find a feasible solution for either of the other two cost minimization problems with increasing levels of sediment constraint.

Characteristics, management and economics of homestead forests in Bangladesh. Alam, M. (*Ehime University, Japan; malam.ku@gmail.com*).

The farmers of Bangladesh grow a variety of plants under intensive and efficient agroforestry systems. Unfortunately, there is a lack of research and extension work to improve overall productivity. This study was conducted in the drought-prone northwestern region to assist in the formulation of national policies and management plans. The rural people were found to be highly dependent on these agroforests to meet their demands for products such as timber, fuel, fruit and medicines. Calculated overall values of four non-parametric diversity indices were 1.82 (H', Shannon-Wienner diversity index), 0.45 (*J'*, Pileou's evenness index), 3.41 (λ^{-1}, inverse Simpson's index), and 2.08 (d^{-1}, inverse Berger-Parker index). The farmers showed a strong preference for planting fruit species especially mango (*Mangifera indica*). Financial analysis showed that the market price of all homestead products (i.e., timber, fruit, fuel and bamboo) produced annually was US$ 1269.46. Itemized annual production per homestead for timber, fruit, fuel and bamboo were US$ 36.25, US$ 74.45, US$ 1108.63 and US$ 50.13, respectively. Such smallholder agroforestry can play vital roles in greening this drought-prone region and in ensuring alternative livelihoods. National policies should thus focus on promoting farmers' indigenous knowledge of environmentally friendly agroforestry in the region.

DNA profiling databases of Chengal (N*eobalanocarpus heimii*) for forensic forestry investigations. Tnah, L.H. (*Forest Research Institute Malaysia, Malaysia; leehong@frim.gov.my*).

Illegal logging poses a significant threat to the sustainability of tropical forest ecosystems. The DNA profiles of 30 natural populations of *Neobalanocarpus heimii* (Dipterocarpaceae) were developed using 12 short tandem repeats (STRs) as a tool to identify the source of illegally logged timber. Cluster analysis divided the 30 populations into three genetic clusters corresponding to three sub-regions within Peninsular Malaysia. The DNA databases were characterised at the levels of population, sub-region and Peninsular Malaysia. Independence tests within and among loci were violated in all the databases due to significant levels of population differentiation and inbreeding. Thus, the effects of population substructure and inbreeding should be incorporated into the calculation of random match probability by using the sub-population-cum-inbreeding model. Conservativeness tests showed that the sub-region and Peninsular Malaysia databases were conservative, and that these databases could provide legal evidence for court proceedings. The comprehensive DNA profiling databases developed for *N. heimii* are the first reported for a tropical tree species and the methodology developed can serve as a model for the study of other important timber species in Malaysia.

TECHNICAL SESSIONS

Theme A: Forests and Climate Change

A-01 Climate change in the boreal forest zone: impacts and interactions

Organizer: Susan Conard, *U.S. Forest Service, USA, sgconard@aol.com.*

Climatic effects on endemic insect herbivory in forests of northern Europe. Kozlov, M.V., Zvereva, E.L. (*University of Turku, Finland; mikoz@utu.fi; elezve@utu.fi*).

Forest ecologists have a long history of research on insect outbreaks. In contrast, very little is known on the consequences of relatively minor but constant damage of trees by insect herbivores. Shortage of quantitative information in particular hampers accounting for endemic (meaning, non-outbreak) herbivory in vegetation models. To link the effects of endemic herbivory with climate, during 2004–2009, we monitored abundances of insect herbivores and measured foliar damage on principal forest-forming species along three latitudinal transects in the Northern Europe. Foliar losses due to endemic herbivory increased in birches from 1–2% at 70° N to 5–7% at 60° N; this trend was best explained by mean temperatures in July. Latitudinal patterns differed between tree species: abundances of aphids on birches in southern (60–64° N) sites were four times as high as in northern (65–69° N) sites, while on Scots pine and Norway spruce aphid densities did not differ between these regions. Defoliation experiments demonstrated that minor losses of foliage (2–16% annually) accumulated over 5 years significantly reduced growth of birch saplings. Modelling suggested that relatively minor changes in non-outbreak insect damage, which can be expected due to temperature increase, are likely to cause pronounced effects on vegetation in Northern Europe.

Long-term trends in wood production of Siberian spruce and Scots pine in the Komi Republic (northwestern Russia Federation). Lopatin, E. (*Russian Academy of Sciences, Russian Federation; eugene.lopatin@joensuu.fi*), Kolström, T. (*University of Eastern Finland, Finland; taneli.kolstrom@uef.fu*), Spiecker, H., Kahle, H.P. (*University of Freiburg, Germany; instww@uni-freiburg.de; Hans-Peter.Kahle@iww.uni-freburg.de*).

The adaptation of forest management strategies to changing environmental conditions needs to be based on a better understanding of the response of unmanaged natural forests to changing climate. Komi Republic is a region of northwestern Russia where large areas of natural boreal forest still exist. Apical and radial growth of Scots pine (*Pinus sylvestris* L.) (108 trees, 529 disks) and Siberian spruce (*Picea obovata* Lebed.) (88 trees, 423 disks) were analyzed using the stem analysis technique. Based on this material we found a statistically significant increase in mean single tree volume of Siberian spruce in the northern taiga zone by 9% and in the middle taiga zone by 20% between the periods 1901–1950 and 1951–2000. Mean single tree volume of Scots pine in the middle taiga zone increased by 10%. We assume that the main causes of the increase in diameter increment are reduced precipitation (–7.3% during the 20th century) and increased temperature (+1.4° K during the 20th century). Prolongation of growing season is considered to be a major driver of site productivity increases in the boreal forest.

Climate change and variation of air-filled porosity in boreal forest soils: a model approach. Mäkitalo, K., Heiskanen, J. (*Finnish Forest Research Institute, Finland; kari.makitalo@metla.fi; juha.heiskanen@metla.fi*).

To understand possible impacts of climate change in boreal forests it is important to know the current variation in climate and ecosystems. Air-filled porosity (AFP) of 20% needed for good root growth of conifers occasionally is not reached in wet boreal forest soils. We studied the effect of precipitation sum and mean air temperature on AFP during growing seasons using 30-year climate data from Finnish Lapland. We calibrated the CoupModel to 32 soil profiles representing four till soil types (USDA): sand, loamy sand, sandy loam, and silt loam. The increase in mean air temperature by 2.3 °C did not affect AFP in topsoil, when precipitation was the average (ca. 250 mm). When the precipitation sum was doubled from 126 mm to 249 mm and again to 490 mm, the proportion of days with AFP <20% increased in sand from 0% to 1% and finally to 7%. In loamy sand the figures were 5%, 12%, and 26%; in sandy loam 6%, 16%, and 38%; and in silt loam 25%, 47%, and 72%. The results indicated that if climate change will result in increased precipitation during growing seasons, the growth of conifers may decrease on sites with fine-textured soils in northern boreal forests.

Recent impacts of climate change in Alaska and other boreal regions. McGuire, A.D. (*University of Alaska Fairbanks, USA; admcguire@alaska.edu*).

Over the past 50 years, Alaska has experienced some of the most dramatic warming in the boreal forest zone with an increase of 1.9 °C annual average temperature. The higher temperatures are already contributing to earlier spring snowmelt, hotter and drier summers, and permafrost warming. Observed impacts include (1) substantial declines in white spruce tree growth, (2) increasing wildfires and insect problems, and (3) a decline in the area of closed-basin lakes. These changes, which have also been seen in other regions of the boreal forest, are particularly well documented in Alaska and have implications for climate regulation and provisioning ecosystem services. Summers are getting hotter and drier, with increasing evaporation outpacing increased precipitation. As a result, white spruce trees in Alaska's interior are experiencing declining growth due to drought stress. The area burned in North America's northern forest that spans Alaska and Canada tripled from the 1960s to the 1990s. During the 1990s, south-central Alaska experienced the largest outbreak of spruce beetles in the world. Across the southern two-thirds of Alaska, the area of closed-basin lakes (lakes without stream inputs and outputs) has decreased over the past 50 years.

Potential effects of climate change on tree distribution in eastern North America. Périé, C. (*Natural Resources and Wildlife Ministery, Canada, catherine.perie@mrnf.gouv.qc.ca*), De Blois, S. (*McGill University, Canada, sylvie.deblois@mcgill.ca*).

The aim of this study is to determine the effects of climate change on spatial distribution of 117 tree species in eastern North America. Current distribution is assessed as a function of 15 climatic, topographic and edaphic characteristics using eight state-of-the-art statistical modelling techniques. Data were randomly partitioned into calibration (70%) and evaluation (30%) datasets; this data splitting procedure was replicated 10 times. Calibrated models were then used to generate projections of future potential distributions under each seven GCM × GES combinations for 2050 and 2080 scenarios. A weighted average consensus method was used to combine the probability of occurrence of each species predicted by the 80 (current) and the 560 (future; 80*7 climatic scenarios) different projections. Species turnover, richness and their change in distribution in 2050 and 2080 were calculated. At this spatial scale, average annual temperature was the most important factor limiting tree species distribution. As anticipated, potentially suitable habitat for most tree species is expected to undergo an important northerly shift. For example, southern Quebec (Canada) will offer potentially suitable habitat for 15 currently endemic species to the U.S. These results will inform decision makers on how to adapt management practices to rapid climate changes.

Dramatic forest vegetation changes with short-term climate oscillations during the past 90,000 years in the Lake Baikal region, Russia Federation. Shichi, K. (*Forestry and Forest Products Research Institute, Japan; shichi@ffpri.affrc.go.jp*), Kashiwaya, K. (*Kanazawa University, Japan; kashi@kenroku.kanazawa-u.ac.jp*), Takahara, H. (*Kyoto Prefectural University, Japan; takahara@kpu.ac.jp*).

We reconstructed vegetation change during the past 90,000 years in southeastern Siberia based on the fossil pollen record from core BDP-99-1 extracted from Lake Baikal. The ages of core sediments were determined by correlation between the fluctuation of the non-arboreal pollen ratio and the oxygen isotope curve from Greenland ice cores. The pollen assemblage of the core shows that coniferous forests of *Pinus*, *Picea*, *Larix*, and *Abies* expanded widely in the interglacial periods, corresponding to marine isotope stages (MIS) 5a and 1 (Holocene). On the other hand, semi-desert vegetation such as *Artemisia* and Chenopodiaceae species mainly covered the area in the glacial periods, corresponding to MIS 4 to 2. In these glacial periods, however, broad-leaved and coniferous forest cover dramatically fluctuated in response to the millennial-scale climate events known as Dansgaard-Oeschger cycles. Herb vegetation dominated during the cool phases, but the distribution areas of broad-leaved vegetation such as *Alnus* and *Betula* and of coniferous forests expanded during the warm phases. In particular, *Picea* forests rapidly expanded at the beginning of warm phases, suggesting the expansion of the wet area as glaciers melted in the mountains surrounding Lake Baikal.

Productivity of northern Eurasian forests in a changing world: a synthesis. Shvidenko, A., Schepascaschenko, D. (*International Institute for Applied Systems Analysis, Austria; shvidenk@iiasa.ac.at; schepd@iiasa.ac.at*).

The paper contains an analysis of the major indicators of productivity of Russian forests (dynamics of growing stock volume and live biomass, gross and net growth, mortality, and net primary production) during recent decades based on diverse information sources (forest inventory, remote sensing, selected process-based models, and *in situ* measurements). The information was updated to make the definitions more compatible and to eliminate biases. The approach included *inter alia* (*i*) an attempt to exclude the bias of growing stock volume assessed by forest inventory; (*ii*) development of a regionally distributed set of multi-dimensional models of live biomass; (*iii*) development of an unbiased "semi-empirical" method to assess net primary production; (*iv*) harmonization and multiple constraints of the results obtained by different methods; and (*v*) balance of wood production and consumption of the country's forests. The approach used allowed us to gain consistent data presented in a spatially explicit form (resolution 1 × 1 km). Among the major results were: (i) a trend of increasing productivity of Russian forests at the level of 0.2–0.6% per year during the last 3–4 decades and (*ii*) the significant impact of weather anomalies of individual growing seasons on net primary production for large regions (up to 20–25%).

Potential land cover change in Siberia in a warmed climate and its feedback to surface albedo. Tchebakova, N.M., Parfenova, E.I. (*Russian Academy of Sciences, Russian Federation; ncheby@ksc.krasn.ru; lyeti@ksc.krasn.ru*).

The objective was to highlight interactions and possible feedbacks between climate change and vegetation across Siberia in the 21st century. We simulated vegetation change in Siberia by 2080 coupling our large-scale bioclimatic model SiBCliM with two Hadley Centre climate change scenarios that reflect the largest (HadCM3 A2) and the smallest (HadCM3 B1) temperature increases. Simulations indicate that Siberian vegetation would be severely altered by 2080 according to the extreme HadCM3 A2 scenario: tundra, forest-tundra, and taiga would decrease from 81.5% to 30%, with forest-steppe, steppe, and semidesert prevailing on 67% of Siberia. A moderate change in vegetation was predicted from the B1 scenario: habitats for northern biomes would decrease from 81.5% to 50%, enabling habitats for southern biomes to expand from 18.5% to 50%. Albedo would increase in the south due to forest retreat and would decrease in the north and highlands due to forest expansion into tundra. The result would be some cooling in the taiga and warming in tundras in the north and highlands, totaling in net radiation increase: 10% in the A2 climate and 6% in the B1 climate. This pattern of land cover change may enhance an even greater warming than predicted by GCMs.

Importance of seasonal precipitation quantities on tree growth in the Alaskan taiga forest. Yarie, J., Valentine, D. (*University of Alaska Fairbanks, USA; jayarie@alaska.edu; dvalentine@alaska.edu*).

The seasonality of soil water recharge may have a significant effect on the growth dynamics of tree species present in the taiga forest in interior Alaska. A long-term study designed to remove all the summer throughfall precipitation from an upland and floodplain hardwood/conifer ecosystem in interior Alaska resulted in unanticipated results. There was no difference in tree growth observed in upland ecosystems, but floodplain white spruce (*Picea glauca* (Moench) Voss) did show a significant reduction in basal area growth. This result was unexpected due to the presence of shallow ground water on the floodplain. Based on these results a second study was installed that will allow for the removal of winter snow pack prior to spring snow melt. This treatment will eliminate the soil moisture recharge that results from spring snow melt. Results from the first year of the snow melt removal treatment in upland sites showed a significant reduction in basal area growth for aspen (*Populus tremuloides* Michx.), birch (*Betula neoalaskana* Sarg.), balsam poplar (*P. balsamifera* L.), and white spruce. These preliminary results suggest the importance of the seasonal dynamics related to soil moisture recharge and its effects on tree growth in the boreal forest.

Posters

Potential impact of climate change on tree abundance in eastern North America; a species distribution modeling approach. Chambers, D. (*McGill University, Canada; dominic.chambers@mail.mcgill.ca*), Perie, C. (*Quebec Natural Resources and Wildlife Ministry, Canada; catherine.perie@mrnf.gouv.qc.ca*), Casajus, N. (*Université du Québec à Rimouski, Canada; nicolas_casajus@uqar.qc.ca*), Lambert, M.C. (*Quebec Natural Resources and Wildlife Ministry, Canada; marie-claude.lambert2@mrnf.gouv.qc.ca*), DeBlois, S. (*McGill University, Canada; sylvie.deblois@mcgill.ca*).

Trees are expected to move their distribution in response to climate change with important consequences on forestry management practices, ecosystem services, and forest biodiversity. The aim of this research was to determine the potential impacts of climate change on tree abundance in eastern North America. Among 117 tree species, we selected 15 species by a cluster analysis approach based on the similarities of their climate envelope. Then we computed 15 climatic, edaphic, and topographic variables within a spatial grid (6,271 cells of 400 km² each) from the Quebec Natural Resources and Wildlife Ministry and from the U.S. Forest Service. To capture projection uncertainties, we related species abundance to explanatory variables using five statistical models and seven different climatic simulations. The selection of these climatic simulations originates from a cluster analysis of 70 possible simulations (11 GCMs coupled to three Greenhouse Gas Emission scenarios). We projected current and future potential abundance and calculated, for each species, a weighted average consensus among projections for each time horizon. As expected, most potential species distributions shifted north and therefore significant abundance alteration was observed. These results will have important consequences for decision makers and for conservation and mitigation measures in a changing climate.

Annual fluctuation in climatic factors influencing shoot length of *Abies mariesii* canopy trees in these three decades in the Hakkoda Mountains, northern Honshu, Japan. Seki, T. (*Forestry and Forest Products Research Institute, Japan; sekitak@ffpri.affrc.go.jp*).

Climatic factors influencing the length of the main stem and branches might change the pattern of crown expansion under fluctuating climatic conditions. Using shoot elongation in the main stem and primary-branch leaders from 1978 to 1990, climatic factors influencing shoot length in the upper part of the crown in *Abies mariesii* canopy trees were detected. Annual fluctuation patterns of the detected climatic factors from 1980 to 2009 were examined for the potentiality of change in crown expansion under fluctuating climatic conditions. A weak positive effect of monthly precipitation in July in the year of shoot elongation was found for the main-stem length. Regarding the length of the primary-branch leaders, positive effects of the mean monthly temperature in July in the year of shoot elongation and the mean monthly temperature in September 1 year before shoot elongation were found. In these three decades, there was a trend toward a gradual increase in the mean monthly temperature in September, but none was noted in the other two climatic factors in the study site. These findings suggest that changing climatic conditions during the period influence the balance between the vertical and horizontal expansion of the upper part of the crown in *A. mariesii*.

Forest monitoring for greenhouse-gas information in northeastern Asia. Swinnen, E., Dong, Q., Eerens, H., Van Roey, T., Claes, P., Schoeters, K. (*VITO, Belgium; else.swinnen@vito.be; qinghan.dong@vito.be; herman.eerens@vito.be; tom.vanroey@vito.be; patrick.claes@vito.be; karla.schoeters@vito.be*), Bojkov, B. (*ESA ESRIN, Italy; bojan.bojkov@esa.int*).

The boreal forest, one of the largest ecosystems on Earth, is considered a key regulator element in overall equations to mitigate effects of man-made carbon emissions. Earth observation (EO) data can contribute to monitoring of the forest state. The ESA GLOBCARBON project aims specifically to provide EO data for observing terrestrial carbon-cycle dynamics. We present a service based on the GLOBCARBON data for the Centre for Marginal Land-Affairs for Northeastern Asia (MLAP-ASIA) (the end-user) to provide boreal forest state information to monitor growth and anomalies (including fires) of forests in northeastern Asia, where two thirds of the global boreal forest can be found. The service consists of regular updates of the state of the forest and the extent of forest fires, focusing on the delivery of net primary productivity (NPP), NPP anomalies against a reference year, burnt areas, and burnt areas history products. The core service structure is organised around a web-based application consisting of: (a) an image viewer providing a spatially detailed overview of a service product at a certain moment; and (b) a database viewer that shows the time evolution of a service product (e.g., NPP) for a certain spatial unit and for a specific land cover class.

A-02 Biodiversity and climate change: direct and indirect linkages in adaptation and mitigation

Organizers: Eckehard Brockerhoff, *Scion/New Zealand Forest Research Institute, New Zealand, eckehard.brockerhoff@scionresearch.com*; Jean-Michel Carnus and Hervé Jactel, *National Institute for Agricultural Research, France, jean-michel.carnus@pierroton.inra.fr, herve.jactel@pierroton.inra.fr.*

Will silvicultural adaptation strategies to climate change create conflicts with nature conservation? Bauhus, J., Brucker, U., Kratzer, R., Reif, A. (*Silviculture Institute, University of Freiburg, Germany; juergen.bauhus@waldbau.uni-freiburg.de; ulrike.brucker@waldbau.uni-freiburg.de; raffael.kratzer@waldbau.uni-freiburg.de; alber.reif@waldbau.uni-freiburg.de*), Schmiedinger, A. (*Warmensteinach, Germany; agrobiol.schmiedinger@t-online.de*).

Owing to the long-term nature of forestry, there is an urgent need to develop and implement silvicultural adaptation strategies to maintain or enhance stability and adaptability of forests in the face of climatic change. We conducted a study across Germany, to identify whether and to what extent current silvicultural adaptation strategies may conflict with nature conservation goals. Our study, based on interviews, showed that most silvicultural adaptation strategies are rather unspecific in relation to expected stresses or disturbances and that the scientific bases for some of the elements of these strategies is weak. The bases for potential conflict with nature conservation goals is in the fact that silvicultural strategies aim to change ecosystem structure and composition to maintain important functions, whereas nature conservation mostly aims to maintain historical reference conditions that are

defined by a certain structure and composition. Specific conflicts arise from the introduction of non-native species and the shortening of production cycles. Agreement exists in the promotion of close-to-nature forestry approaches. Silvicultural options to reduce these conflicts at the stand and landscape scales will be discussed. Our study indicates that a focus on desired future ecosystem functioning may reduce conflict in development of silvicultural adaptation strategies.

Natural solutions: role of forest protected areas in climate change adaptation and mitigation. Belokurov, A. (*WWF International, Switzerland; abelokurov@wwfint.org*), Dudley, N., Stolton, S. (*Equilibrium Research, UK; nigel@equilibriumresearch.com; sue@equilibriumresearch.com*), Krueger, L. (*WCS, USA; lkrueger@wcs.org*), Lopoukhine, N. (*IUCN-WCPA, Canada; nik.lopoukhine@pc.gc.ca*), MacKinnon, K. (*The World Bank, USA; kmackinnon@worldbank.org*), Sandwith, T. (*The Nature Conservancy, USA; tsandwith@tnc.org*), Sekhran, N. (*UNDP, South Africa; nik.sekhran@undp.org*).

Protected areas remain the most important tool for biodiversity conservation and also provide vital climate change mitigation and adaptation benefits. Protected areas are helping address the cause of climate change by reducing greenhouse gas emissions. Deforestation and forest degradation are seen as key drivers of climate change. It is widely recognised that protected areas could and should have a key role in reducing forest loss and degradation. Protected areas are also helping society cope with climate change impacts by maintaining essential services upon which people depend. But the potential of protected areas is still only partially realised and their integrity remains at risk; indeed, research shows that unless protected area systems are completed and effectively managed they will not be robust enough to withstand climate change and contribute positively to response strategies. Increasing protected area size, coverage, connectivity, forest restoration, management effectiveness, and inclusive governance would enable a scaling up of the potential of the global protected areas system and serve as a model for other resource management programmes. Our study clearly summarises for the first time how protected areas contribute significantly to reducing impacts of climate change and what is needed for them to achieve their full potential.

Potential effects of climate change mitigation on forest biodiversity: risks and opportunities. Brockerhoff, E.G. (*Scion / New Zealand Forest Research Institute, New Zealand; eckehard.brockerhoff@scionresearch.com*), Jactel, H., Carnus, J.-M. (*INRA, France; herve.jactel@pierroton.inra.fr; carnus@pierroton.inra.fr*).

Carbon forests and plantations of biofuel feed stocks are key strategies in our efforts to counter rising greenhouse gas concentrations. A main objective will be to maximise carbon sequestration by planting fast-growing trees (and other plants), potentially exotic species. Such plantations could result in biodiversity loss, particularly if they replace 'natural' vegetation. Compared with diverse mixed forests, single-species plantations may be more susceptible to pest damage and other stressors, and they may less adaptable to a changing climate. As an introduction to this session, we will provide an overview of the potential conservation issues associated with carbon and biofuel forests, explore some considerations concerning the functional role of biodiversity, and suggest opportunities for combining carbon sequestration and biodiversity conservation objectives. Mixed forests of native tree species may be suitable to achieve carbon sequestration goals while potentially providing better habitat for native flora and fauna. However, even plantations of exotic trees can provide valuable forest habitat if biodiversity conservation objectives at the stand and landscape-scale are considered among the criteria for species selection and forest management.

Intensive management of native forests for bioenergy: quantify trade-offs between forest productivity and biodiversity. Flaspohler, D., Webster, C., Roth, A. (*Michigan Technological University, USA; djflaspo@mtu.edu; cwebster@mtu.edu; amroth@mtu.edu*).

Problems associated with the use of fossil biofuels have led to renewed interest in using plants as bioenergy. Although forests have been managed to produce wood for bioenergy for eons, many governments have recently adopted new goals calling for a dramatic expansion in the production of biofuels, much of which will come from forests. Demand for a high volume of a uniform forest product has often led forest managers to replace diverse native forests with plantations of a single or few species, with a resulting loss of native biodiversity. Similarly, diverse native forests may face intensification of management as demand for bioenergy grows. Expanding markets for plant-based biofuels have the potential to intensify forest management in ways that harm native species. Yet, models exist in which intensively managed forests sustain many of the ecosystem services furnished by unmanaged native forests. We will provide an assessment of what is known about how management intensity affects native forest biodiversity, and discuss how to measure trade-offs between the sometimes competing goals of forest productivity and biodiversity conservation. Examples of a range of potential forest biofuel feedstocks and management regimes will be compared in terms of productivity and wildlife habitat quality.

Climatic adaptation in Norway spruce: molecular dissection of a novel epigenetic memory mechanism. Lee, Y.K. (*Norwegian University of Life Sciences, Norway; yeonkyeong.lee@umb.no*), Yakovlev, I.A., Kvaalen, H., Fossdal, C.G., Johnsen, Ø. (*Norwegian Forest and Landscape Institute, Norway; Igor.Yakovlev@skogoglandskap.no*; *Harald.Kvaalen@skogoglandskap.no; Carl.Gunnar.Fossdal@skogoglandskap.no; oystein.Johnsen@skogoglandskap.no*), Olsen, J.E. (*Norwegian University of Life Sciences, Norway; jorunn.olsen@umb.no*).

Forests are ecologically and economically important in our ecosystem. Considering world climate changes, it is worth understanding climatic adaptation of trees. The temperature level experienced during zygotic embryogenesis and seed maturation in Norway spruce (*Picea abies*) affects epigenetic memory and vital phenological traits in the progeny. Timing of bud burst as well as growth cessation and bud set occurs early if the embryo temperature is low, whilst late if temperature is high. We intend to identify and characterise genes involved in this epigenetic memory based on temperature, as well as in traits where the epigenetic memory is expressed in plants and embryos. To recognize molecular mechanisms in epigenetic phenomenon, we isolate micro RNA from seedlings and embryos that show distinct differences in epigenetic phenotypes. In seedlings, four selected genes—*PaLPT4*, *PaGaMYB, PaMYB10*, and *PaSPB13*—regulated by miRNAs may be involved in epigenetic memory regulation. Although the functions of these genes are not elucidated yet, these findings imply these miRNAs may involve or at least affect the molecular mechanisms underlying the temperature-sensitive epigenetic memory in Norway spruce.

Climate change mitigation and forest biodiversity conservation: the role of CDM in Bangladesh. Miah, M.D. (*University of Chittagong, Bangladesh; dansforestry@yahoo.com*), Koike, M. (*Shinshu University, Japan; makoike@gipmc.shinshu-u.ac.jp*), Shin, M.Y. (*Kookmin University, Republic of Korea; yong@kookmin.ac.kr*).

Afforestation/ reforestation (A/R) and forest biodiversity conservation efforts seem to be conflicting with each other. Formulating the A/R policy both for carbon sequestration and biodiversity conservation is critical to the development of the forestry sector of Bangladesh. The main objective of this study is to review the two processes, that is, to reduce the global warming through carbon sequestration by A/R; and to conserve forest biodiversity in Bangladesh. How these two processes can be incorporated positively has been recommended in this study. Results show that A/R in Bangladesh store 190 t C ha^{-1} of 13 frequently planted tree species, ranging in age from 6 to 23 years. On the other hand, all tree tissues including natural forests, stores 92 t C ha^{-1}. The study confirms the huge atmospheric CO_2 offset by forests if the degraded forestlands are reforested by CDM projects, indicating the potential of Bangladesh to participate in carbon trading for both its economic and environmental benefits. The study has formulated management recommendations both for carbon sequestration and biodiversity conservation in the CDM forests in Bangladesh. The findings of the study can lead the policy makers to go ahead achieving carbon credits as well as biodiversity conservation progress.

Tree species adaptation to climate change and carbon stock dynamics in Akure Forest Reserve (Permanent Sample Plot 29), Ondo State Nigeria. Olagoke, A.O., Onyekwelu, J.C. (*Department of Forestry and Wood Technology, Federal University of Technology, Nigeria; adewoleolagoke@gmail.com; onyekwelujc@yahoo.co.uk*).

Tree adaption to climatic change and carbon stocks dynamics were investigated in the permanent sample plot (PSP 29) in Akure Forest Reserve, Ondo State Nigeria. Six sample plots of 50 × 50 m were systematically laid in clusters to collect data on tree species. All tree species with dbh ≥ 10 cm encountered on each plot were identified and the diameters at breast height were measured. The diameters of all tagged tree species, whose size has been repeatedly measured from the period of 1934 to 2001, were recorded. Data on climatic variables were obtained from the Nigeria Metrological Agency. Tree biomass and carbon stocks were calculated using equations. Correlation analysis was done to determine the relationship between the forest data and climatic variables. The results showed a change in climatic conditions across the study period. Sixty-one (61) tree species in 24 families were encountered. The dbh increment and general increase in mean biomass and carbon stocks were noticeable in the period of observation. Apart from rainfall, the impact of other variables was not significant. Temperature had a weak negative but not significant correlation with tree variables. A better understanding of our forests' adaptive capacity to climate change is highly imperative.

Assessment of woody species diversity and the natural potentials for its conservation in semi-arid areas: case study in Burkina Faso. Ouedraogo, A., Thiombiano A. (*University of Ouagadougou, Burkina Faso; o_amade@yahoo.fr; adjima_thiombiano@yahoo.fr*).

In Burkina Faso and other low-income countries in West Africa, human pressure on plant resources is strong. That situation worsens the threat on phytodiversity because of the fragile ecological balance due to climate change. To address this problem there is a need to know actual plant diversity and assess the potential of regeneration for further conservation planning. We carried out woody vegetation inventories in eastern Burkina Faso, along a climatic transect. We evaluated species richness and analyzed juvenile floristic composition and population structure. Results showed a total of 204 woody species distributed into Sahel and Sudan climatic zones. Species richness decreased from global inventory to the juvenile stratum. Few species were frequent in the juvenile stage and most had degraded population structure due to bush fire, pasture, drought, and agriculture. Species richness and regeneration potentialities were strongly linked to climate zones and local habitats. The actual diversity of woody species was important but threatened because of lack of regeneration. Many plant species and/or families could rapidly disappear from semi-arid areas if urgent conservation programs are not established. These programs should, for example, include conservation of portions from high diversity lands and enriching of protected areas with threatened species.

Possible effects of climate change on forest ecosystems in Lithuania. Ozolinčius, R., Belova, O., Stakėnas, V., Ruseckas, J., Gedminas, A., Aleinikovas, M. (*Lithuanian Forest Research Institute, Lithuania; miskinst@mi.lt; m.apsauga@mi.lt; v.stakenas@mi.lt; jruseckas@gmail.com; m.apsauga@mi.lt; m.aleinikovas@mi.lt*).

Aiming to develop region-specific climate prediction models, this study compared the decade means for climatic data, tree species composition, game and pest populations, tree growth and condition, and water table level during 1930–2010. Scots pine reaction to temperature increase was also modeled in provenance tests to predict possible effects of climatic change. Climatic prediction models indicate that local climate shift to that of 2,3–2,5 degrees of latitude to the south. Over the last two decades, the following main observations were made: 2- to 3-day advance in start of growth period; ca. 10% increase in wood yield; large-scale fungal-pest infections (most hard on ash), increased defoliation, and increased attacks of earlier rare pests (e.g., *Dendrolimus pini*); tendency of increase of roe deer and decrease of moose population; increase of water table depth; higher precipitation during cold period; and species shift in favor of broadleaved species mainly at the cost of Norway spruce. Scots pine provenance transfer to 1–2 °C warmer climate caused 5–10% decrease in stem diameter, slight increase in survival, and better stem quality. Effects of temperature and photoperiod are discussed.

Seasonal change of altitudinal occurrence of birds at Mt. Hallasan: escalator effects? Park, C.R., Kim, E.M. (*Warm-temperate Forest Research Center, Korea Forest Research Institute, Republic of Korea; park@forest.go.kr; kptta@naver.com*), Kang, C.W. (*Jeju Wildlife Research Center, Republic of Korea, jejubirds@hanmail.net*).

Climate change moves distribution ranges of plants to higher altitudes. Locomotive animals can adapt to changing environments by climbing or expanding distribution ranges. We surveyed altitudinal occurrences of breeding birds at Mt. Hallasan from January to October, 2009. Birds were surveyed from 0700 to 1800 by road-count methods at each 100 m interval of altitude from Seongpanak via the summit to Gwanumsa. Tits showed clear separation of altitudinal occurrence in breeding season; coal tits prefer *Abies koreana* stands, but great and varied tits were more distributed at deciduous and evergreen stands. White-backed

woodpeckers and magpies occurred below 1,000 m, and olive-backed pipits and white-rumped swifts at more than 1,800 m. Brown-eared bulbuls and jungle crows distributed across the altitudes. Migrants such as the alpine accentor were observed at high altitudes; Japanese waxings were observed at low altitudes during the non-breeding season, and altitudinal separation was not apparent. Shrinking of *A. koreana* stands due to climate change might influence distribution ranges of coal tits and interaction among tits at Mt.Hallasan. Increasing eco-tourism can strongly influence ubiquitous birds to climb to high altitudinal areas easily. Therefore, anthropogenic effects will accelerate the effect of global warming at Mt. Hallasan.

Management of forest genetic resources to respond climate change. Rawat, G.S. (*Indian Council of Forestry Research and Education, India; rawatgs@icfre.org*).

Changes in environmental condition results in changes in selection pressure acting on the forest genetic resources, leading to differentiation in adaptive genetic variation. Genetic diversity has an important role in maintaining the sustenance of forest ecosystems to threats associated with climate change in India. Widely distributed species in India are unlikely to face extinction but may face deterioration in health, stocking and productivity. However, the locally distributed tree species are likely to decline, being more vulnerable to climate change than widely distributed tree species. Climate change may alter the composition of tree and other plant species and this may adversely affect the ecosystem. Maintenance of high levels of within-species diversity across the country should be a priority. Appropriate use of genetic diversity will provide flexibility with respect to forest management and thus help to reduce risks associated with climate change. Management of forest genetic resources requires serious consideration to increase the adaptive genetic variation within the forests to meet the challenges with regard to climate change. Adaptation strategies to accommodate climate change include promotion of natural regeneration and genetic diversity in the forests through silvicultural operations, and use mixture of species and provenances in plantations and restocking of managed natural forests.

Nature-based adaptation and mitigation strategies. Sayer, J., Magginis, S. (*IUCN, Switzerland; jeff.sayer@iucn.org; stewart.maginnis@iucn.org*).

Climate change and variability change poses unprecedented challenges to biodiversity conservation programmes. Biodiversity will also be of great value as a resource in climate change adaptation. In addition the investments planned in forest conservation as a mitigation measure under Reduced Emissions from Deforestation and Degradation (REDD) may provide financial resources for conservation. These new opportunities and needs will present challenges for conservation organizations. Biodiversity management will need to be more hands-on. Species and communities will need to be managed on the basis of greater knowledge of their ecology. Many of the world's forests and other natural habitats will see fundamental changes in their species composition and conservationists will need to understand, anticipate and mediate these changes. IUCN has developed guidelines for biodiversity conservation in managed forests and for landscape scale forest conservation which show how silvicultural management can favour the retention of native biodiversity and the exclusion of invasive exotic species. The opportunities and needs for management interventions will grow with climate change and will this will require renewed research efforts and enhanced professional skills for forest managers.

Posters

Impacts of climate change on forest biodiversity and sustainable development. Adegoke, I.A., Aguda, L.O., A., Bayewu, R. A.. (*Forestry Research Institute of Nigeria, Nigeria; adegokeabimbola4u@yahoo.com*; *laryall2000@yahoo.com; rabaiyewu@yahoo.com*).

Forests play an important role in regulating Earth's climate. They are an essential link in the global carbon cycle because they take up CO_2 for growth. Incidence of climate change in Africa is alarming. It is expected that climate change will cause forest ecosystems to change in various ways, such as in animal and plant species distribution, and changes in tree physiology and stability. The impact on other environmental factors—such as natural water scarcity, air pollution, intensive management, etc.—can be exacerbated by climate change, leading to particular threats that are more readily perceived by the public as being problematic. As a result of this, the much needed benefits of the forest would be at the verge of disappearing. Such roles include providing environmental services and biodiversity conservation. Therefore, the conservation and enhancement of biodiversity in forests represent a major contribution to global ecological balance and sustainable production of raw materials, as well as other goods and services. The continuation of this contribution is under threat for several reasons, among them and becoming ever more important–climate change. To this end, the need to achieve greater synergies between climate change and biodiversity policies are enunciated in this paper.

Woody invader in a wood deficit country: the case of *Prosopis juliflora* in Ethioipia. Desta, D.S. (*Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, Ethiopia; dmsertse@yahoo.com*), Teketay, D. (*University of Botswana, Harry Oppenheimer Okavango Research Centre, Botswana; demelteketay.fanta@orc.ub.bw*).

Prosopis juliflora is an extremely hardy tree species that thrives in harsh environmental elements that are hardly tolerable by other species. If not properly managed, it can become an invasive weed. In the Afar and Dire Dawa regions of Ethiopia, it is highly condemned for invading large areas of land and constraining the livelihoods of local communities. It has also threatened the biodiversity of these areas. On the other hand, the tree is versatile in its uses, providing fodder, fuel, timber, shade, and food for people; and playing a role in soil fertility improvement, reclamation of salt-affected soils, and fixation of sand dunes. The tree is the source of income for many in the aforementioned regions, generating a substantial amount of money as fuel wood. Nevertheless, *Prosopis* is still highly underutilized and its further invasion has become inevitable. Use of *Prosopis* as alternative wood source not only reduces the rampant deforestation that has critically endangered the country's forest but also increases wood supply in a country that is reportedly in deficit of more than 30 million m^3. This paper attempts to draw a picture on the current status of *Prosopis* and suggests its exploitable options to control invasion in Ethiopia.

The effect of elevated CO_2 and temperature on the seed germination and seedling growth in three coniferous trees. Kim, D.H., Han, S.H., Lee, J.C. (*Korea Forest Research Institute, Republic of Korea; dkim@korea.kr; simhee02@forest.go.kr; jaeclee99@forest.go.kr*).

Impacts of elevated CO_2 and temperature were studied for three coniferous trees. The seeds of three conifers—*Pinus densiflora, Larix kaempferi*, and *Abies koreana*—were germinated and grown in controlled-environment growth chambers under either ambient CO_2 (400 µl l^{-1}) or elevated CO_2 (700 µl l^{1}) at 24 °C or 30 °C for 60 days. Seed germination and mean germination time were tested both in the soil and germination kit. Germination decreased at 30 °C, and elevated CO_2 at 30 °C induced lowest germination in the soil. However, elevated CO_2 at 30 °C had no effect on germination when seeds were germinated in the germination kit; only warmer temperature (30 °C) decreased germination. Seedlings grown under ambient CO_2 at 30 °C had significant decrease of dry weight. However, the seedlings under elevated CO_2 at 30 °C had similar biomass of unwarmed (24 °C) seedlings. Chlorophyll content increased at 30 °C and decreased at 30 °C with elevated CO_2, but anthocyanin content decreased at 30 °C and increased at 30 °C with elevated CO_2. Carbon content showed similar results with dry weight. These results indicate that climate change variables (increased CO_2 and temperature) directly influence seed germination and the seedling growth of three coniferous trees.

Is it possible to combine adaptation to climate change and maintenance of forest biodiversity? Kolström, M., Vilén, T., Lindner, M. (*European Forest Institute, Finland; marja.kolstrom@efi.int; terhi.vilen@efi.int; marcus.lindner@efi.int*).

An EU-level review of the climate change adaptation measures in forestry shows that there are adaptation measures that support maintaining biodiversity, but other adaptation measures have the potential to decrease the level of biodiversity. A choice of the adaptation measure might thus involve trade-offs between efficient adaptation and maintenance of biodiversity at the stand level. Consequently, planning and management of the adaptation measures should be carried out at the landscape level. The landscape approach allows building a combination of highly adaptive stands with a simultaneous high level of biodiversity and stands where adaptation measures do not support biodiversity. This is, however, a complex task and gets even more complicated since economic and social standpoints also have to be taken into account. Identifying suitable landscape-level management strategies can be facilitated with decision support systems that include necessary simulation models. A successful realisation is possible only if all policy makers at different levels, affected stakeholder groups, forest owners, and forest workers are aware of what measures are suitable and why they are used. The presentation gives an overview of suitable adaptation measures for boreal, temperate, and Mediterranean forests as identified from past and ongoing reviews covering many European countries.

High relationship between ant distribution and temperature. Kwon, T.S. (*Korea Forest Research Institute, Republic of Korea; insectcom@korea.kr*), Kim, S.S. (*Research Institute for East Asian Environment and Biology, Republic of Korea; nabifri@chol.com*), Chun, J.H., Lim, J.H., Kim, Y.K. (*Korea Forest Research Institute, Republic of Korea; chunjh69@korea.kr; limjh@korea.kr;YOUNGKUL@forest.go.kr*).

It had been reported that ant species occurred in limited vertical distribution ranges in high mountains in Korea. Temperature gradually decreases as altitude increases in the high mountains. This phenomenon suggests that temperature may be a main factor for distribution of ant species. This study was carried out to test the hypothesis. Ant communities were surveyed using pitfall traps at about 300 sites, which included most high mountains in South Korea. As predicted, temperature was the most important factor for the distribution of ant species. Abundance of six species—*Paratrechina flavipes, Myrmica kotokui, Pachycondyla javana, Pristomyrmex pungens, Camponotus atrox,* and *Crematogaster osakensis*—had the highest relationships with temperature. Among the ant species, *M. kotokui* and *C. atrox* were predicted to be declined in abundance and distribution ranges on the Korean peninsula as temperature increases, whereas that of other four species—*P. flavipes, P. javana, P. pungens*, and *C. osakensis*—was predicted to be increased. Distribution models were made for four of the six species, and distribution maps of the species were made from the models. These models will be used for prediction of distribution change of the species caused by global warming.

Recent expansion of occurrence of invasive animals in Jeju experimental forests: climate change or anthropogenic effects? Park, C.R., Kim, E.M., Chung, Y.G., Kim, C.M., Byeon, G.O. (*Warm-temperate Forest Research Institute, Republic of Korea; park@forest.go.kr; kptta@naver.com; YGCHUNG99@forest.go.kr; helmin@forest.go.kr; BN1212@forest.go.kr*).

We studied the expansion of distribution of invasive animals from 2007 to 2009 in Jeju Experimental Forests (JEFs). We recorded five exotic animals— elk (red deer) (*Cervus elaphus*), Sika deer (*Cervus nippon*), feral dogs (*Canis familiaris*), feral cats (*Felis catus*), and feral rabbits (*Oryctolagus caniculus*). We conducted seasonal field surveys (April-May, August-October, December–February) by road-count methods, and night surveys, to reveal the occurrence point of invasive species. Among five species, two—elk and Sika deer—showed characteristics of invasion, and we recorded the highest individuals up to 5 Sika deer and 12 red deer. Distribution ranges of red deer have expanded since 2007, and the deer formed family groups in the winter season. Red deer foraged soft leaves of *Hedera rhombea* with tall height where roe deer could not reach. Forest tending provided enough space for red deer to move and forage food resources in JEFs. Climate change could accelerate distribution of invasive species with the aid of anthropogenic effects such as forest tending and construction of forest trails. We speculate that warmer winters and forest tending can accelerate the expansion of invasive species and deteriorate interaction networks among wildlife at JEFs in near future.

Climate change mitigation: potential effects of future plantation management on saproxylic beetle communities. Pawson, S. (*Scion/New Zealand Forest Research Institute, New Zealand; Steve.Pawson@scionresearch.com*), Brin, A. (*Purpan, France; antoine.brin@gmail.com*), Jactel, H., Van Halder, I. (*INRA, France; herve.jactel@pierroton.inra.fr; Inge.VanHalder@pierroton.inra.fr*).

A major component of proposed climate change mitigation strategies is the greater use of wood products as feedstock for bioenergy and carbon sequestration. Mitigation strategies are predicted to result in increased afforestation rates (which could be beneficial for biodiversity); however, concurrent increases in land use intensity, such as stump removal and complete tree

harvesting, may ultimately be detrimental to biodiversity. In a combined France-New Zealand study we tested the impact of increasing harvest intensity and clearfell age on saproxylic beetle diversity at a landscape scale. Clearfell age was included to assess whether clearfells are ecological traps if saproxylic beetles are destroyed by pre-planting site preparation. Studies were undertaken in *Pinus pinaster* forests in the Lande region of France and in *P. radiata* forests in New Zealand's central North Island. We hypothesize that decreased availability of mature forest habitat (increasing habitat fragmentation created by clearfell harvesting) will result in lower species richness and saproxylic communities dominated by open habitat generalist species. Beetle communities were sampled by flight intercept trapping in multiple replicates of model landscapes (radius of 3 km) that had <10, 10–20, and >30% mature forest stands remaining. The study is ongoing, and preliminary results are presented.

Ecological and forestry assessment of forest plantations in Eastern Rhodopes, Bulgaria. Yangyozov, B.T. (*Forest Research Institute-BAS, Bulgaria; forestin@bas.bg*).

The influence of civilizations of ancient Greece, Rome, Byzantium and Turkey is connected with extensive deforestation of the Balkan Peninsula, as a result of mining, extensive agriculture and stock-breeding activities. In the second half of the 20th century reclamation of degraded lands began through engineering facilities and large-scale reforestation. Ecological-and-forestry assessment of reforested areas in the vicinity of the town of Kardzhali, in Eastern Rhodopes, Bulgaria, was made with the help of field-measurement and analytical methods, to determine the influence of climate change on forest plantations. Trends in the change of basic climatic factors – air temperature and precipitation through the years – were investigated. The study focussed on mixed and single-species plantations of various forest tree species of different ages and at different altitudes. Silvicultural processes in these plantations, were determined, with focus on vulnerability and adaptability to aridization. Results from the analysis give direction to future management of plantations with the objectives of biodiversity conservation as well as selection of forest tree species for future reforestation activities accordingly to the specific climatic characteristics of the region.

A-03 Can forestry and forest sector activities contribute to mitigating climate change?

Organizer: Werner Kurz, *Natural Resources Canada, Canada, Werner.Kurz@nrcan.gc.ca.*

Climate changed induced forest production in north-central Sweden and potential substitution effects. Gustavsson, L., Poudel, B.C., Sathre, R., Bergh, J. (*Mid Sweden University, Sweden; leif.gustavsson@miun.se; bishnu.poudel@miun.se; roger.sathre@miun.se; Johan.bergh@ess.slu.se*).

In this study, we perform an integrated analysis to calculate the potential feedback effects of climate change on increased forest carbon stock and on forest biomass production used to mitigate climate change. First we estimated the effects of climate change on forest production in north-central Sweden, and then we calculated carbon stocks in standing forest biomass, forest soils, harvested wood products, and the substitution benefits of using wood products instead of non-wood products. Our results show that an average regional temperature rise of 4 °C increases annual forest production and potential harvest by 46% over the next 100 years. This increased biomass production, used to substitute energy-intensive construction materials and fossil fuels, will result in a significant net carbon emission reduction. The carbon stock in forest biomass, forest soils, and wood products increases but the carbon benefit is less significant than for substitution. A total net reduction in carbon emissions of up to 125 million Mg C may occur, depending on harvest level and reference fossil fuel.

Life cycle assessment of forest bioenergy production. Kilpeläinen, A., Kellomäki, S., Ashraful, A. (*University of Eastern Finland, Finland; antti.kilpelainen@uef.fi; seppo.kellomaki@uef.fi; ashraful.alam@uef.fi*).

The main objective of this work is to study the integrated production of energy wood (logging residues, small-dimensioned trees and roots) and timber (sawlogs, pulpwood) in boreal conditions in Finland. The impacts and possibilities of various forest management regimes are studied in the present climate but also in changing climatic conditions by using a life cycle assessment tool. The environmental effects of energy wood harvesting are included in the growth simulations to study the sustainability of the production in terms of balance of nutrients. Furthermore, the carbon balance calculations of the forest include the biomass of trees and emissions from soil processes, but also the machinery carbon emissions of the harvesting. With this information, reasonable alternatives to produce energy wood integrated with timber are achieved also from the atmospheric point of view. Better understanding is achieved on how forests have to be managed in the present and changing climatic conditions to produce energy wood for fossil fuel substitution and how to maintain the sustainability in the joint production of energy wood and timber. This kind of comprehensive assessment is needed in comparisons of energy wood with other bioenergy sources and in forest policy for climate change mitigation.

Forests and forestry beyond 2012: integrated management and policy as an adaptation and mitigation tool. Kraxner, F.T., Obersteiner, M., Fritz, S., Havlik, P., Boettcher, H., McCallum, I., Aoki, K. (*International Institute for Applied Systems Analysis, Austria; kraxner@iiasa.ac.at; oberstei@iiasa.ac.at; fritz@iiasa.ac.at; havlikpt@iiasa.ac.at; bottcher@iiasa.ac.at; mccallum@iiasa.ac.at; aoki@iiasa.ac.at*).

Any international post-2012 agreement will need to consider the sinks from forest carbon management as an efficient and low-cost abatement tool and an essential element for tackling climate change. In this article, we show that forest management needs to be seen in a much broader context by incorporating global issues such as carbon and nitrogen management, tropical deforestation, (forest-based) bioenergy, or (indirect) land-use change. Through bioenergy use and avoiding deforestation, potential emissions of some 9 GtC yr-1 might be substituted in the future. A major future need in order to achieve such cost-effective emission reduction to tackle climate change is to incorporate adequate cross-sectoral policies that focus on biofuel policies that are well-balanced with international trade regulations and REDD policies that are accompanied by improved governance. Further,

the study shows that new opportunities are arising, such as for the recognition of certified sustainable forests in requirements for carbon-offset projects and in national programmes for REDD, which may be integrated into an international agreement to replace the Kyoto Protocol. Socio-economic issues such as tenure and forest certification need to be part of a future carbon and nitrogen management scheme as an effective adaptation and mitigation tool.

Optimizing management strategies for carbon stored in both forests and wood products. MacLean, D.A., Hennigar, C.R. (*University of New Brunswick, Canada; macleand@unb.ca; chris.hennigar@gmail.com*).

Forests play a major role in removing CO_2 from the atmosphere; however, the role of actively managed forests in sequestering carbon (C) remains unclear. Only C sequestered "in the forest" is now considered legitimate sequestration, but it is possible that higher C stored "on the stump" may result in lower overall C because less is moved into enduring wood products. We modeled C storage in forest, wood products, and substitution benefits for three large industrial landbases in New Brunswick and Maine, under objective functions to maximize volume harvested, forest C, and/or wood product C. Maximizing total C resulted in mean (200 year) harvest and C storage 173% and 5% higher than maximizing forest C (218% and 6% higher, including substitution benefits). In many cases, C storage in product pools (especially in landfills) plus on-site forest C exceeded forest C storage resulting from reduced harvest. Accounting for only forest C may result in spurious C maximization strategies; all forest-sector C debits and credits should be included in developing sound policies to maximize forest reductions of greenhouses gases.

Developing a national-level system for simulating the forest carbon dynamics of planted forests in Japan. Mitsuda, Y., Kanomata, H., Matsumoto, M. (*Forestry and Forest Products Research Institute, Japan; mitsuda@ffpri.affrc.go.jp; kanomata@ffpri.affrc.go.jp; machan@ffpri.affrc.go.jp*).

Systems for simulating the forest carbon dynamics at the national level are useful for drawing up forest policies on climate change. We developed a national-level system for simulating the forest carbon dynamics of planted forests in Japan, consisting of a forest database and a stand-level carbon cycle model. The system is based on a 1-km resolution forest database containing data on age, species, size, density, and biomass of four pools (foliage, branch, stem, and root) of stands. We developed a process-based stand-level carbon cycle model to simulate carbon dynamics under various climatic conditions and forestry regimes. In our simulation system, this model was applied to each stand recorded in the forest database using climatic values (radiation, temperature, and vapor pressure deficit) and forest operation schedules (clear cutting and thinning) as inputs. We simulated the carbon dynamics of planted forests for the whole of Japan from 2005 to 2050 for several scenarios of forest policy. These simulations yielded time-series trajectories of total living stock biomass, annual change in biomass, and spatial distributions of both, enabling us to compare the effects of forest policy on national-level carbon dynamics in the near future.

The economics of forestry and agriculture offsets under proposed U.S. climate legislation. Ohrel, S.B. (*U.S. Environmental Protection Agency, USA; ohrel.sara@epa.gov*).

Greenhouse gas (GHG) mitigation possibilities in U.S. agricultural and forest sectors represent various means to meet national and possibly global climate change policy targets. This presentation focuses on the role of forestry and agriculture offsets, domestic and international, as found in the U.S. EPA economic analysis of the American Clean Energy and Security Act of 2009 (and possibly results from analyses conducted early 2010). This analysis explores the economic potential of major domestic and international mitigation offset strategies–including afforestation, forest management, soil carbon sequestration, and avoided deforestation/REDD–over a range of carbon price paths. Domestic results, derived from economic simulations of land use allocations over time to competing activities in forest and agricultural sectors, show possible consequences for relevant commodity markets and net GHG emissions. Coupled with global economic model results, which include global forestry land use, management, and trade responses to climate change policies, we estimated total mitigation potential and offset availability under certain carbon policy scenarios. Ultimately, offsets availability, especially of international offsets, has a strong impact on cost containment of attaining GHG mitigation goals. Forestry-based activities, specifically afforestation domestically and reduced deforestation internationally, are crucial for forestry and agriculture in U.S. GHG mitigation efforts.

Posters

Climate change and mitigation options in a boreal ecosystem with implication for forest management practices. Alam, A., Kilpeläinen, A., Kellomäki, S. (*University of Eastern Finland, Finland; Ashraful.Alam@uef.fi; Antti.Kilpelainen@uef.fi; Seppo. Kellomaki@uef.fi*).

Energy wood production to replace fossil fuels and carbon capture in the forest ecosystem are the measures available in forestry to mitigate global climate change. Expected changes in climate could increase the production potential of slow-growing boreal forests and thus could add a new dimension to current forest management practices. The aims of this study were to assess (i) how warmer climate could affect energy wood production and carbon stocks in forest ecosystems, and (ii) whether current management practices need to be changed to adapt to changing climatic conditions. Analyses were done utilizing an ecosystem model and simulated for a 100-year time period for the whole of Finland. Management regimes were selected by changing both basal area thresholds when the thinning is performed and remaining basal area after the thinning. Results indicated that productivity of Finnish forests could increase by the end of the century, with higher effects being found in northern Finland compared to the south. It was also found that in order to utilize the benefits that climate change could provide in terms of enhanced productivity, there might be a need to change current management practices to maintain higher tree stocking.

Dynamics of organic matter and nutrient return from litterfall under different tropical forest restoration strategies in Costa Rica. Celentano; D. (*CATIE, Costa Rica; danicelentano@yahoo.com.br*), Zahawi, R.A. (*Organization for Tropical Studies, Costa Rica; zahawi@ots.ac.cr*), Finegan, B. (*CATIE, Costa Rica; bfinegan@catie.ac.cr*), Ostertag, R. (*University of Hawaii, USA; ostertag@hawaii.edu*), Cole, R.J., Holl, K.D. (*University of California, USA; rcole@ucsc.edu; kholl @ucsc.edu*).

Tropical deforestation provokes key changes in global carbon and nutrient cycles. Restoration strategies may accelerate reestablishment of nutrient cycling and carbon stock in degraded areas. We studied rates and patterns of carbon and nutrient fluxes in litterfall under four treatments: plantation (entire area planted), islands (planting in six patches of three sizes), control (natural regeneration), and young secondary forest. Treatments (50 m × 50 m plots) were established in June 2004 at six replicate sites in Costa Rica and litterfall was measured during 1 year. Planted species included two timber-producing hardwoods (*Terminalia amazonia* and *Vochysia guatemalensis*) intercropped with two nitrogen-fixing species (*Inga edulis* and *Erythrina poeppigiana*). Litterfall production and carbon input did not differ significantly between secondary forest and plantation. Both planted restoration strategies recovered the function of litter production and nutrient inputs more quickly compared to the control. However, litter quality indicators were better in treatments recovering under natural process due to higher plant diversity. Natural processes take longer than technical strategies, but higher litter quality can compensate. Accordingly, restoration strategies with more heterogeneous planting design as the islands may promote faster increase in plant diversity and litter quality, and then accelerate the reestablishment of nutrient cycling.

Urban heat island reduction effect of urban forests in Seoul. Jeong, B.G., Oh, C.H., Lee, S.M., Jang, J. (*Dongguk University, Republic of Korea; hoban6865@hanmail.net; ecology@dongguk.edu; woorinuri@nate.com; jinimi0903@nate.com*), Lee, K.O. (*Seoul Green Trust Foundation; kangolee@naver.com*).

This study was conducted to establish the need for a management plan that can mitigate the urban heat island effect through the urban forest in Seoul. From June to August in 2009, 7 regions of cold island and 9 regions of heat island were measured by an automatic meteorological observation system. We found that the minimum temperature of the day was 16.67 °C in Gwanaksan forest. The maximum temperature of the day was 38.00 °C in Wangsimni station area. The highest difference of temperature was 12.00 °C at the same time: at 4:40 pm, August 16, 2009, the temperature of Suraksan forest was 26.34 °C, and it was 38.34 °C in Wangsimni station area. The minimum average temperature was 22.64 °C in Suraksan forest, and the maximum average temperature was 26.67 °C in Teheran Street during the research period. In conclusion, urban forests were affected highly in reduction of urban heat island. Also there is the distinct difference of temperature between the same land use areas, because of the green area ratio around the site. Therefore, it is necessary to prepare a management guide to make and manage urban forests.

Biomass production of plantation forest in Sabah, Malaysia. Kawai, S. (*Kyoto University Japan; skawai@rish.kyoto-u.ac.jp*), Matsumoto, Y., Yoshida, Y., Sato, Y. (*KM Hybrid Plantation SDN BHD, Japan; matsumoto-yoshikatsu@koshiiwoods.com; yoshida-yutaka@koshiiwoods.com; sato-yutaka@koshiiwoods.com*).

This study introduces the biomass production of industrial plantation forest in a tropical area. A tree plantation company called KM Hybrid Plantation SDN BHD (KHP) in Sabah, Malaysia, started to establish its acacia plantations in 2005 on unproductive sites formerly dominated by *Imperata* grassland or secondary forest of *Acacia mangium*. A total of 1,400 ha have been planted mainly with *Acacia* hybrid. The plantation will be harvested to feed round logs to sawmill/plywood mill for timber utilization. An inventory data of 20 selected sample plots collected by KHP is used for the allometric analysis of the above-ground biomass from the points of sustainable management and carbon sequestration function of the plantation forest. Each sampling plot provides the area of 0.0324 ha (18 m x18 m), and the inventory data of planted stands since 2006 were recorded. The annual recorded data consisted of stand density, tree height, stem diameter at breast height (dbh), and standing tree volume. The total biomass of the standing tree—stem, root, branch, and leaf—was investigated from the 2- and 3-year tree samples. As original vegetation of the plantation sites, the above-ground biomass of grassland and the secondary acacia forest were investigated as well.

Greenhouse gas inventory in the Korean forest sector. Lee, K.H., Son, Y.M., Kim, R.H., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; kyeobghlee@forest.go.kr; treelove@forest.go.kr; rhkim@forest.go.kr; shkim@forest.go.kr*).

Forests account for 64% of total land area and play a role as significant net sinks of CO_2 in Korea. To address the requirements of the current UNFCCC and the Kyoto Protocol as well as measurable, reportable, and verifiable commitments/actions in the post-2012 climate regime, it is needed to develop a greenhouse gas inventory based on IPCC Good Practice Guidance 2003. The new national forest inventory system has been being implemented since 2006. It adopted a systematic cluster sampling design with around 4,000 permanent plots (16,000 sub-plots) and is expected to provide substantial activity data for estimating emissions/removals in the forest sector. A set of 150 plots for 12 major tree species were surveyed to collect the data for developing country/province- and species-specific emission factors including wood basic densities, biomass expansion factors, and shoot-root ratios. Their uncertainty assessment was also implemented. The process of data collection, management, and analysis is under a quality control program. Further improvements will be needed in some areas, including a forest soil carbon model, time series and recalculation, uncertainty assessment, and QA/QC.

Carbon sequestration by Korean forests from 1954 to 2007. Li, X.D., Yi, M.J., Jeong, M.J., Heo, U.Y. (*Kangwon National University; Korea; xiao-dongli@hotmail.com; mjyi@kangwon.ac.kr; sky4887@hanmail.net; makia7@nate.com*).

Estimation of carbon sequestration by Korean forests is a challenging task because Korean forest landscape underwent massive changes during the first half of last century due to historical reasons and major reforestation during the second half of the century. Nevertheless, systematically forest inventories and field measurements make it possible to estimate the carbon (C) sinks in Korea. Simple linear relationships between stand biomass and stand volume were developed for Korean forests based on direct field measurements. These relationships were used to estimate the C sequestration by aboveground and total biomass from 1954 to 2007 based on forest inventories. The results indicated that the sequestration by Korean forests have significantly increased during the past 53 years. The mean C density (Mg C/ha) and C stock of aboveground and total biomass for Korean forests increased significantly, especially in the past three decades. Korean forests have a higher mean C sequestration rate than the average of the major northern countries since the early 1990s. Such a large C uptake in Korea mainly resulted from successfully implemented reforestation and consecutive forest management practice over the past three decades.

Optimization of stand-level management taking into account climate benefits of harvested wood products. Lyhykainen, H.T. (*University of Helsinki, Finland; henna.lyhykainen@helsinki.fi*).

In this study, management of Scotch pine (*Pinus sylvestris*) is optimized at the stand level simultaneously taking into consideration climate benefits of using wood products instead of fossil carbon-intensive products and fossil fuels, carbon sequestration of the standing stock, and harvesting revenues. Forest growth is predicted using process based growth model PipeQual. Using branch and growth predictions from the growth model as an input, proportions of sawn wood grades and by-products of harvested stems are predicted with models developed in the previous study. Combining the predictions of sawn wood grade proportions to the information of the end uses of different sawn wood grades and average life cycle lengths of the products, carbon storage of the harvested wood products can be incorporated to stand-level analysis. We also investigate both material and substitution effects of end products to see whether taking into account reductions of the CO_2 emissions due to increased use of wood material or biofuels instead of more carbon-intensive products results in optimal forest management compared to cases where only timber management or/and carbon storage is taken into consideration. Sensitivity analysis is made for several factors.

Quantifying *Eucalyptus fastigata* carbon sequestration for an emissions trading scheme in New Zealand: a practical example. Meason, D.F., Beets, P., Dungey, H., Nicolas, I. (*Scion, New Zealand; dean.meason@scionresearch.com; peter.beets@scionresearch.com; heidi.dungy@scionresearch.com; ian.nicolas@scionresearch.com*).

Establishment of new forest is key for reducing New Zealand's carbon emissions. However, encouraging new plantings under an emission trading scheme (ETS) is difficult. Landowners need to evaluate the profitability of a species sequestrating carbon in an user-friendly manner. *Eucalyptus fastigata* is a species that has good potential for sequestration. However, it is sporadically planted throughout New Zealand and little is known about its productivity. Scion was commissioned by Ministry of Agriculture and Forestry to answer these questions. *E. fastigata* productivity was found to vary throughout New Zealand due to a range of factors. Mean annual temperature was the strongest predictor. Mean top height, mean tree basal area, and number of stems per hectare were used to assess productivity throughout New Zealand. Outer stemwood core density at 1.3 m had a strong correlation with whole tree density. No difference in stemwood core density was found between high and low productivity sites. The carbon sequestration model C_Change was used to model *E. fastigata* sequestration with stand development over a range of establishment scenarios. A web tool was then developed. This approach is a practical example of creating a connection between scientists, government agencies, landowners, and potential investors in an ETS scheme.

National inventory of carbon stock in dead wood, litter, and soil in Japanese forest. Miura, S., Ugawa, S., Morisada, K., Inagaki, M., Kaneko, S., Takahashi, M. (*Forestry and Forest Products Research Institute, Japan; miura@ffpri.affrc.go.jp; ugawa@ffpri.affrc.go.jp; morisada@ffpri.affrc.go.jp; inagaki@ffpri.affrc.go.jp; kanekos@ffpri.affrc.go.jp; masamiti@ffpri.affrc.go.jp*).

We started a 5-year national inventory project in 2006 to evaluate three carbon pools in dead wood, litter, and soil of Japanese forest, which aims to establish an accurate estimate for carbon sink in forests for the Kyoto Protocol. We systematically selected 3,000 investigation points out of 16,000 fixed observation points of national Forest Resources Monitoring Survey, which began in 1999 to evaluate two carbon pools of above- and below-ground forest biomass. Dead wood was measured along two lines crossed on a plot (0.1 ha). Litter samples were taken at four points in the plot, separated into twigs, L-, F-, and H-horizons; soil samples were taken at the same four points. Samples both for dry bulk density and for carbon concentration were picked up from three layers of 0–5, 5–15, and 15–30 cm in depth. We also considered volumetric ratio of gravels in evaluation. Preliminary mean organic carbon density was 7 kg/m^2 for 2006–2007 data. Very low dry bulk density of upper most layers was a distinctive characteristic of forest soils in Japan. This national inventory will provide an objective basis for future soil carbon monitoring and will be useful to develop prediction models for soil carbon change in forest.

Effects of P addition on CO_2, N_2O, and NO emissions from a tropical secondary forest soil of South Sumatra, Indonesia. Mori, T., Ohta, S. (*Kyoto University, Japan; taikki@a04.mbox.media.kyoto-u.ac.jp; otasei@kais.kyoto-u.ac.jp*), Ishizuka, S. (*Forestry and Forest Products Research Institute, Japan; ishiz03@ffpri.affrc.go.jp*), Konda, R. (*Kyoto University, Japan; rkonda@kais.kyoto-u.ac.jp*), Wicaksono, A., Heriyanto, J. (*PT. Musi Hutan Persada, Indonesia; eiger_2007@mhp.co.id; ikkonkeiz@yahoo.com*).

Although some studies suggest that P addition increases CO_2 emissions from soils in tropics, effects of P addition on N_2O and NO emissions are rarely reported. We conducted an incubation experiment to examine the effects of P addition on CO_2, N_2O, and NO emissions from a tropical secondary forest soil of South Sumatra, Indonesia. The soil was incubated for 30 days with and without adding P ($Ca(H_2PO_4)_2$; 2 mg P g·soil^{-1}) after adjusting water-filled pore space (WFPS) to 75% or 100%. P addition increased CO_2 emissions in both WFPS condition. N_2O and NO emissions also increased by P addition in both WFPS condition, attributed to some possible reasons as follows. At first, P addition stimulated the N cycling and inorganic N usable for nitrification and/or denitrification became larger. Secondly, P addition stimulated nitrifying and/or denitrifying bacteria due to the relief for their P shortage. Our results suggest P addition in tropical forests could increase not only CO_2 but also N_2O and NO emissions. We also suggest P limitation in tropical forests might be suppressing the emissions of CO_2, N_2O, and NO by restricting the microbial activities.

The effects of the carbon market for the regional forest CO_2 emission throughout Japan. Nakajima, T., Hiroshima, T., Tsuyuki, S., Tatsuhara, S., Shiraishi, N. (*University of Tokyo, Japan; nakajima@fr.a.u-tokyo.ac.jp; hiroshim@fr.a.u-tokyo.ac.jp; tsuyuki@fr.a.u-tokyo.ac.jp; tatsu@fr.a.u-tokyo.ac.jp; siraishi@fr.a.u-tokyo.ac.jp*).

We developed a simulation model for forestry income by combining the Local Yield Table Construction System and wood conversion algorithm under the actual forest area formally identified in the Japanese carbon market. This simulation model was also applied to planted forests throughout Japan. Based on this model and harvesting records in the study site, we also estimated harvesting costs. This allowed us to estimate the economic merit of timber harvesting and carbon credit in the study area. Economic value given for forest carbon sequestration would affect economically optimal rotation length and total carbon stock in

the forest area. An increase in timber prices and carbon prices shortens and lengthens the optimal rotation age, with the carbon prices having the greater effect in increasing rotation age depending on Japanese region and planted tree species. In the main targeted area, the total effect of carbon price 2,500 yen on forestry profits is positive (538 thousand yen) but that of carbon price 500 yen was negative (−1,530 thousand yen). Therefore, it might be more important to consider the stand age distribution, allocating harvesting area and carbon price fluctuation into long-term forest management under the Japanese carbon offset accounting system.

Carbon and financial potency of *Pometia pinnata,* an endemic Papuan species. Panji Asmoro, J.P., Setiadi, A. (*Forestry Research Institute of Manokwari, Indonesia; pandumail@gmail.com; abdi_setiadi@gmail.com*).

Papua has many endemic species of vegetation with the potential for carbon sequestration. One of them is *Pometia pinnata* J. R. Forst. & G. Forst, which has been planted by local people in Papua as yard trees and its wood used for construction for long time. The purpose of this study was to measure the potential carbon of *Pometia pinnata* and calculate that financial value. After that, the result was compared with financial value if "business as usual" were done by local people. Located in Anggresi Forest Research Centre, Manokwari-West Papua, a sample of 373 trees of *P. pinnata* was taken to measure and calculate the carbon potential, which was analyzed based on tree diameter by using the allometric equation founded by Ketterings. The result shows *P. pinnata* has 283.7 ton C/ha potential with financial value US $6,085.40. However, it has only financial value US $ 2,425 under "business as usual" from its logs and fruits. In conclusion, *P. pinnata* has higher financial value if it is planted for carbon trading by using the REDD mechanism; in addition to the carbon content of the trees, local people can use all part of that species for their needs.

Carbon sinks in Korean forest ecosystems. Park, Y.J., Son, Y.H., Noh, N.J. (*Korea University, Republic of Korea; lgv32000@hanmail.net; yson@korea.ac.kr; treeworld@nate.com*).

Recently, an interest in the forest as greenhouse gas sink has increased dramatically following the Kyoto Protocol, dealing with global climate change. To account for the total forest ecosystem carbon sink in Korea, we analyzed the data on biomass and carbon sink from the literature. Total forest ecosystem C sink (above- and below-ground vegetation, forest floor, and soil) increased with age of the dominant tree species. The relative partitioning of vegetation (above- plus below-ground), forest floor, and soil to the total ecosystem C sink was 51.5%, 8.3%, and 40.2%, respectively. Also total ecosystem C sink was estimated to be 287 TgC for coniferous forests, 171 TgC for deciduous forests, 174 TgC for mixed forests, and 0.4 TgC for bamboos, respectively. By province, it was also estimated to be 45 TgC in Gyeonggi, 86 TgC in Gangwon, 63 TgC in Chungcheong, 116 TgC in Geongsang, and 70 TgC in Jeolla, respectively. More intensive studies on sinks of below-ground biomass, forest floor mass, and soil C contents are needed to estimate total C sinks in Korean forests accurately.

Accumulation of carbon and macroelements in humus forms after forestry treatments and tree species change. Podrázský, V. (*Czech University of Life Sciences, Prague, Czech Republic; podrazsky@fld.czu.cz*).

Sequestration of carbon and retention of nutrients are assumed to be key functions of forest ecosystem compartments, including the forest soils. There is crucial lack of data concerning the carbon and nutrient fixation potential of forest stands, especially forest soils in the Czech Republic. The presented study summarizes the main forestry effects on the carbon pools within the representative forest ecosystem: tree species change from natural (mixed) tree species to conifer monocultures and the regeneration of forest through shelter and clear-cut process. The site conditions are typical for the majority of the territory of the Central Bohemia (Central Europe). Carbon sequestration was quantified in: aboveground forest biomass, surface humus layers, and uppermost part of the mineral soil. In commercial monocultures, the amount of carbon fixed was roughly double compared to natural and close-to-nature forests, both in the biomass as well as in the soil ecosystem compartment. The amount of carbon fixed decreased in the stage of forest stand regeneration. The results enable us to compare carbon fixation potential in forests with traditional and close-to-nature management and to manage the forest stands in the desired direction.

Climate change mitigation of the three mangrove communities in Quezon, Philippines. Pulhin, F.B., Gevana D.T. (*University of the Philippines Los Banos, Philippines; yaybpulhin@yahoo.com; wuweidix@yahoo.com*), Lasco, R.D. (*World Agroforestry Centre, r.lasco@cgiar.org*).

The role of mangroves in climate change mitigation has been recognized because they have high biomass and litter production. In the Philippines, areas covered by mangroves declined 72–78% over the 81-year period. As of 2001, total mangrove areas cover around 112,000 ha. This study aimed to estimate quantitatively the amount of carbon stored in three mangrove communities (*Rhizophora community*, *Avicennia* community, and *Rhizophora-Avicennia-Sonneratia* community) in Quezon, Philippines. To estimate the amount of carbon in each mangrove community, sample plots measuring 20 m × 100 m were established. In each of the sample plots, above-ground and soil carbon pools were measured. Results of the study show that the three mangrove communities store substantial amounts of carbon (*Rhizophora* – 92.36 Mg/ha, *Avicennia* – 78.91 Mg/ha, and *Rhizophora-Avicennia-Sonneratia* – 70.18 Mg/ha). Aside from the mitigation role of mangrove areas, they also play important ecological roles. For instance, high rates of primary production and rapid decomposition of litter provide an important energy source for aquatic organisms and are beneficial to coastal productivity, including the culture of commercial shellfish and fishes.

Estimation of the effect of forest management on the carbon stocks in Japanese planted forests using CENTURY-jfos: a modified CENTURY model. Sakai, H., Hashimoto, S., Ishizuka, S., Kaneko, S., Takahashi, M. (*Forestry and Forest Products Research Institute, Japan; sakai03@affrc.go.jp; shojih@affrc.go.jp; ishiz03@affrc.go.jp; kanekos@affrc.go.jp masamiti@affrc.go.jp*).

We examined the potential effect of forest management practices on the carbon stocks in deadwood, litter, and soil organic carbon using CENTURY-jfos, which is a CENTURY model modified for Japanese planted forests. Thinning and clear-cutting practices affected the subsequent time course of the carbon stocks in deadwood, litter, and soil. Deadwood carbon stock rapidly increased

immediately after clear-cutting because of the occurrence of dead coarse root; however, it subsequently decreased to the greatest extent during the following 20 years. The increase and decrease in litter and soil carbon stocks after clear-cutting and thinning were relatively small. The forest harvest periods change the average carbon stock levels in deadwood, litter, and soil according to the model predictions at a steady state, which was obtained by a repeated forest rotation cycle. A short-term (20-year) forest rotation would cause the largest decrease in deadwood, litter, and soil carbon stock levels, whereas a long-term rotation (80- and 100-year) would lead to a slight reduction in them because net primary production decreases in older stands. We concluded that the practice of clear-cutting largely affects the short-term carbon stock change in deadwood but does not greatly affect the carbon stocks in litter and soil.

Contribution of FSC certification to reducing GHG emissions. Salvador, S., Karmann, M. (*Forest Stewardship Council, Germany; s.salvador@fsc.org; m.karmann@fsc.org*).

Given global demand for forest products, improving management of productive forest lands will be essential to addressing climate change and forest conservation. Mixing protective and extractive management practices can significantly reduce forest degradation when carried out to internationally accepted social and environmental standards such as those of the Forest Stewardship Council (FSC). Established to address concerns about deforestation and forest degradation in production forests around the world, FSC is widely recognized as the leading international forest certification scheme. FSC's multi-stakeholder governance model with its rigorous standards, adaptability of indicators and verifiers for national and regional forest management conditions, and tight third-party controls is offering the most credible and most comprehensive tools available to keep the world's remaining forests standing and intact. Based on a case study of the Maya Biosphere Reserve Guatemala, the paper demonstrates FSC's mechanisms to define, implement, verify and reward responsible forestry, how the FSC principles and criteria provide a framework for long-term retention of forest carbon, how certification of production forests complements forest climate projects, and how the FSC scheme can be applied to REDD-plus.

Building social scenarios for sustainable forest management in the Champagne and Aishihik Traditional Territory, southwest Yukon. Waeber, P.O. (*University of British Columbia, Canada; powaeber@gmail.com*), Nitschke, C.R. (*Melbourne School of Land and Environment, Australia, craig@unimelb.edu.au*), Innes, J.L. (*University of British Columbia, Canada; john.innes@ubc.ca*).

The 2006 Strategic Forest Management Plan (SFMP) of the Champagne and Aishihik Traditional Territory (CATT), a framework for sustainable forest management, was developed through a collaborative process involving the Yukon Territorial Government, the Champagne and Aishihik First Nation Government, and the Alsek Renewable Resource Council. The main objectives of the SFMP are to reduce fire hazard, promote forest renewal, increase or maintain economic benefits, and preserve wildlife habitat over a 10-year time horizon. In its current form, the SFMP has utilized a hierarchical planning approach to initiate the salvage harvesting of beetle-killed white spruce (*Picea glauca*) and fuel-abatement treatments to reduce current and future fire risk around local communities. Interestingly, the SFMP does not purvey a clear long-term strategy to direct how sustainable forest management will be achieved in the CATT. Here, we analyze and balance potentially contradicting values listed in the SFMP by applying an Analytical Hierarchy Process and using focus group interviews to develop a set of socially balanced forest management strategies. These are being used to provide an understanding of the long-term impacts of strategic forest management within the CATT.

The carbon stock and its potential of subtropical forest ecosystem in China. Wang, H., Zhang, W., Yang, F., Ma, Z. (*Chinese Academy of Sciences, China; wanghm@igsnrr.ac.cn; zhangwj@lreis.ac.cn; yangft@igsnrr.ac.cn; mazq@igsnrr.ac.cn*).

The mid- and low-latitude region in the northern hemisphere is generally characterized as drought climate and mainly covered with arid and semi-arid ecosystems. But on the eastern Eurasia continent, evergreen ecosystems are well-developed due to a humid and warm monsoon climate. China owns the largest subtropical area, about 2.4 million km^2. Tropical and subtropical regions are believed to have the largest potential for carbon assimilation on Earth. Beginning in the 1970s, China launched a campaign to plant forests nationwide, and rapidly improved forest coverage from 12.98% to 18.21% in 2008. As a result, the forest carbon stock in China improved from 4.38 PgC in the 1980s to 4.75 PgC in 1998, an increase of 0.37 PgC. In the 12 provinces, which cover 71% of subtropical area and 36.57% of forest in China, the net increase in carbon stock was as much as 0.267 PgC, about 72% of the total increment of carbon stock in China at the same period. Obviously, the subtropical forest is a dominant carbon sink in China. However, the low carbon stock of forest in subtropical China due to extensive management practices implies great potential in carbon assimilation and more potential for mitigating climate warming.

A study on biomass calculating factors of Japanese red pine (*Pinus densiflora*) forests. Yi, M.J., Li, X.D., Jeong, M.J., Heo, U.Y. (*Kangwon National University, Republic of Korea; mjyi@kangwon.ac.kr; xiao-dongli@hotmail.com; sky4887@hanmail.net; makia7@nate.com*).

Biomass calculating factor methods are commonly used to estimate forest biomass and account for carbon budget analyses at national or regional scales, and are also highly recommended by the Intergovernmental Panel on Climate Change (IPCC). In this study, we calculated biomass conversion and expansion factors (BCEF), the ratio of root to shoot (R), biomass expansion factors (BEF) and ecosystem biomass expansion factor (EBEF) for Japanese red pine forests based on direct field measurements and publications from Korea. We compared the mean values of BCEF, BEF, R and EBEF with the default values given by the IPCC (2003, 2006). The values of biomass calculating factors in this case more accurately estimate Japanese red pine forest biomass in Korea. We also used the main types of function forms to fit the non-linear relationships between biomass calculating factors and main stand factors. BEF is expressed as a simple reciprocal equation of DBH (diameter at breast height) or A (stand age) for Japanese red pine forests. BCEF is also expressed as a reciprocal equation of stand volume. EBEF is considered a simple method to estimate the understory biomass in Japanese red pine forest ecosystems.

A-04 Competing roles of forests in climate change mitigation

Organizers: Lauri Valsta, *University of Helsinki, Finland, lauri.valsta@helsinki.fi;* Birger Solberg, *Norwegian University of Life Sciences, Norway, birger.solberg@umb.no.*

The provision of environmental services under climate change: how to evaluate the role of forests on a landscape level? Fürst, C., Lorz, C. (*Dresden University of Technology, Germany; fuerst@forst.tu-dresden.de; carsten.lorz@tu-dresden.de*), Pietzsch K. (*Leipzig, Germany, kp@pisolution.de*), Makeschin, F. (*Dresden University of Technology, Germany; makeschin@t-online.de*).

Climate Change impacts the stability and resilience of ecosystems and especially of forests. This entails structural changes within a single (forest) ecosystem and on the landscape level. Landcover changes can be driven directly by unfavorable climatic frame conditions, such as shortening of the precipitation or temperature increase and the resulting impact on the survival of ecosystems. On the other hand, climatic changes can force people to change the landscape structure; for example, to manage the regional water balance with regard to drinking water provision. In the case study "REGKLAM," the question is raised as to which landcover scenarios are most suitable to mitigate regional climate change effects in Saxony, Germany. Therefore, the software "Pimp your landscape" is adapted to simulate the interrelations between climate change and landcover impact on environmental services. This includes services such as the provision of drinking water and biological resources; the protection against extreme events (drought, erosion, floods); and the maintenance of the ecological and aesthetical value of the landscape. Regarding forestry, the effects of establishing climate-change-adapted stand development types in existing forest areas and potential future forest areas are tested. On this basis, recommendations on regional development strategies considering priority areas for forestry are given.

Timber harvest versus carbon sequestration: an analysis using production possibility frontiers based on a large scale matrix model. Hanewinkel, M., Zell, J. (*Forest Research Institute of Baden-Wuerttemberg, Germany; Marc.Hanewinkel@forst.bwl.de; Juergen.Zell@forst.bwl.de*).

The goal of the study is the prediction of harvested volume and simultaneous carbon stocks on a large scale forest for an area of almost 7.5 Mio ha. A matrix model based on the permanent national forest inventories in Germany was constructed and used for predictions of carbon stocks and harvesting volume for the forest area of former West Germany. The starting point of the simulation was the time of the second national forest inventory in 2002. The prognosis is for 30 years. Net present values were formulated as an objective function in a linear program including subsidies for carbon storage. Production-possibility frontiers between carbon sequestration and net income were generated assuming different interest rates and subsidies (€/tC). These frontiers show the marginal effects of valuing carbon storage in forests with respect to losses in net income from harvesting activities. Plausible scenarios were used to analyze forest management practices, resulting in a range of 650-1.120 [Mio. tC] stored in living biomass in 2030. Prolonging business as usual would increase carbon stocks until 2026, on a level above the CAP given by the Kyoto Protocol. The effect of the risk of storm damage is depicted using a statistical storm risk model.

The impact of U.S. and European biofuel policies on land-based carbon sequestration. Kim, Y.H., Sohngen, B. (*Ohio State University, USA; kim.1933@osu.edu; sohngen.1@osu.edu*).

There is widespread debate about ethanol, and whether the indirect land-use effects suggest that ethanol production is likely to lead to a net increase in greenhouse gas emissions. This paper addresses this question by developing an integrated global land use model to account for the implications of diverting crops from food to fuel. To conduct the analysis, we link two existing models, the Global Trade Analysis Project general equilibrium model of land-use and a dynamic optimization model of global forest and land use. U.S. and European biofuel policies are simulated in the GTAP model to calculate the change in land used for crops in all agro-ecological zones. These shifts in supply are then incorporated into the forestry and land use model. As a result, the future path of timber harvests, inventory, management and area will shift, thus altering the quantity of carbon sequestered in forests. Based on current laws passed by the U.S. and European countries, our estimates indicate that forest area will decline by 4.9 million hectares, which will result in an additional 17 million tons of CO_2 emissions per year. Land use changes and emissions are shown to be sensitive to land supply elasticity parameters.

Anticipating traps of carbon sequestration schemes: socio-economic and political consequences. Nurrochmat, D.R., Darusman, D. (*Bogor Agricultural University, Indonesia; dnrochmat@yahoo.com; akecuina@cbn.net.id*).

Nowadays, carbon sequestration schemes are very popular and commonly proposed to solve the problem of deforestation and forest degradation. Despite containing some promising elements, however, carbon trading also holds some oddness: for example, the complex-additional concept, perverse incentives for non-polluters, and operated under artificial and immeasurable markets. Economically, the proposed carbon sequestration schemes are mostly also not attractive. A recent study in Riau Indonesia reported that the compensation rate of USD 6 to 12 per ton CO_2-e is not secure enough to avoid conversion of natural forests to pulp plantation forest, since the price of logs at the same place is about USD 100 to 130 per m^3. The value of carbon will be much less competitive if the added value of the timber-chain is considered. In Indonesia, the forward linkage of timber placed the second highest compared to the other 21 economic sectors. Consequently, sizing-down the timber cutting will potentially violate the other economic sectors. Moreover, considering the existing problem of large-gap between lacking timber supply and high domestic demand, cutting down the timber sources drastically will create illegal logging practices. This paper is intended to discuss the socio-economic and political consequences of carbon sequestration schemes.

Integrated carbon analysis of forest production and utilization in north-central Sweden. Poudel, B.C., Sathre, R., Gustavsson, L., Bergh, J. (*Mid Sweden University, Sweden; bishnu.poudel@miun.se; roger.sathre@miun.se; leif.gustavsson@miun.se; Johan.bergh@ess.slu.se*).

The regional climate scenarios based on IPCC B2 scenario project a 4 °C temperature increase in north-central Sweden in the next 100 years. The forest will grow faster with increasing temperature, thus more forest biomass will be available for harvest. With increased biomass, its use in place of carbon-intensive fuels and materials can result in net reduction of carbon emission. Here we analyze the potential increased forest production due to climate change in north-central Sweden, and estimate the overall carbon balance if the potential harvest is utilized to substitute non-wood products. Substitution analysis is performed for the use of forest biomass as construction material instead of concrete and for bioenergy instead of fossil energy. The results show that increased temperature will significantly increase forest biomass production and a large net reduction in carbon emission is possible if wood replaces concrete, and if biomass residues including slash and stumps replace fossil fuels. Carbon stock also increases in forest tree biomass, soil and in wood products. Therefore, intensive management of boreal forests in the future may help to reduce net carbon emission and mitigate climate change.

Integrating forest management, wood product use, and biofuel use for mitigating climate change. Valsta, L. (*University of Helsinki, Finland; lauri.valsta@helsinki.fi*), Solberg, B. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*), Pingoud, K. (*VTT Technical Research Centre of Finland, Finland; kim.pingoud@vtt.fi*).

Forests and forest use affect atmospheric carbon dioxide concentrations through carbon storage in forests and wood products as well as through avoided emissions due to biofuel and wood product use. Which kind of balance between these functions yields the greatest climatic benefits is still largely an open question. Additionally, the economic implications of these functions affect their societal desirability. We review existing studies and demonstrate by case studies how an integrated analysis of the question can be done. The case studies include biofuel production in Finland; forest management alternatives in Nordic conditions; and regional, sectoral analyses in Norway. Our studies show how partial analyses lead to incorrect conclusions about the effects of forest and wood biomass utilization in view of climate change mitigation.

The contribution of European forests to climate change mitigation and its effects on forest goods and service provisioning. Verkerk, H., Lindner, M. (*European Forest Institute, Finland; hans.verkerk@efi.int; marcus.lindner@efi.int*).

Policies can affect the demand for certain goods and services from forests and this may conflict with the provisioning of others. We provide an overview of approaches developed in Europe to assess the role of forests in climate change mitigation as well as in the provisioning of other goods and services. The EFISCEN model projects European forest resource development, including carbon storage and various indicators for important goods and services. It has been applied (1) to project the future carbon storage by European forests as input to international climate negotiations, and (2) to assess the effects of alternative options (intensified forest biomass utilisation or maximizing carbon storage in forest biomass and soil). The projections suggest that European forests remain acting as a carbon sink and that the rate can be significantly affected by policies. Furthermore, maximising carbon storage is in conflict with intensifying the use of biomass for renewable energy production. There may be also clear trade-offs with other goods and services; for example, intensifying the use of forest biomass will negatively affect forest biodiversity and recreation. The impact of alternative policy options can differ among countries, which should be considered when developing policies.

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Tropical forests and the carbon credit market. Barua, S. (*University of Helsinki, Bangladesh; sepul175@gmail.com*), Uusivuori, J. (*Finnish Forest Research Institute, Finland; jussi.uusivuori@metla.fi*), Kuuluvainen, J. (*University of Helsinki, Finland; jari.kuuluvainen@helsinki.fi*).

We study optimal policies in terms of land income tax and carbon compensation under carbon credit markets to attain socially optimal stock of tropical forests, and analyze trade-offs between optimal consumption and level of deforestation from an intergenerational perspective. We use an infinite time horizon expected utility maximization model, which incorporates a multi-level (international and national levels) carbon compensation. The model highlights the fact that carbon compensations would increase the value of a standing forest and also create option values for forests in the future. The results suggest that a tax is needed to correct the discrepancy between privately and socially optimal stocks of tropical forests when private and social preferences for forest amenities are different. However, under identical social and private preferences, no such tax is needed. We show that an effective carbon compensation policy for national governments exists, which can be used to enforce socially optimal levels of deforestation in privately held tropical forests under a carbon market, and this policy is time consistent. Our results also suggest that the socially optimal level of deforestation, among other factors, depends on society's aversiveness to inequality in consumption, on preference for forest resources amenity, and on choice of time-discount rate.

Biofuels or biodiversity: an analysis of the goal conflict between reduced climate impact and biological diversity. Geijer, E., Bostedt, G. (*Swedish University of Agricultural Sciences, Sweden; erik.geijer@sekon.slu.se; goran.bostedt@sekon.slu.se*), Brännlund, R. (*Umeå University, Sweden; runar.brannlund@econ.umu.se*), Hjältén, J. (*Swedish University of Agricultural Sciences, Sweden; joakim.hjalten@vfm.slu.se*).

Dead wood is recognized as being one of the most important factors for forest biodiversity for many organism groups. One of the Swedish official environmental objectives is therefore to increase dead wood volume. However, reducing climate impact through increased use of forest biofuels is likely to work against this objective. This paper analyzes the potential goal conflict between these two Swedish environmental objectives, reduced climate impact and a rich diversity of plant and animal life. The analysis is based on a regional economic forest sector model that includes suppliers and major users of roundwood and ecological results on management effects on conservation of biodiversity. The econometric results are based on a data set spanning 40 years. We simulate the effects of increased Swedish forest cuttings in northern Sweden based on an increased demand for wood fuels. This will have effects on all major roundwood markets in the region. It will also lead to negative effects on biodiversity, mainly through reduced amounts of dead wood, loss of forest continuity, and fragmentation in northern Swedish forests. Thus, a clear goal conflict exists and we evaluated how an increased use of biofuels from forestry could influence dead wood availability and consequently biodiversity.

Carbon neutral indicator of the South Korean urban forest. Lee, J.H. (*Kangwon National University, Republic of Korea; fatih@kangwon.ac.kr*) Lee, G.G. (*Kangwon National University, Republic of Korea; gglee@kangwoan.ac.kr*), Hong, J.K. (*Policy Cordination Division, Republic of Korea; jkhong@korea.kr*).

Carbon emission mitigation and the carbon neutral concept have recently come to be among the most important key tasks at the international level. The South Korea government has also had national core policies such as "the Low Carbon Green Growth." This study focused on developing an indicator that can assess the level of carbon neutralality through comparing with the amount of carbon discharge of each city in Korea and the amount of carbon that the forest in the city can absorb. The amount of carbon that a city discharges could be calculated by the statistics of each carbon-discharging factor according to the method IPCC suggested. The sequestration amount of the urban forest could be calculated by CO_2 uptake-coefficients conducted through several biomass equations from existing researches. Using the methodology of this study, the amount of CO_2 discharge and the amount of CO_2 absorption in all the cities in Korea were able to be calculated, by which the urban forest management goal to neutralize carbon could be suggested in each city. These results could be used as the fundamental data for relevant police-decision making when the planning for urban forest expansion or management is needed.

A-05 Plantation forestry under marginal conditions: water use and water use efficiency in a changing climate

Organizers: Nathalie Long, *Murdoch University-CSIRO, Australia, Nathalie.long@csiro.au;* Andrew Merchant, *University of Sydney, Australia, a.merchant@usyd.edu.au.*

Genetic determinism of water use efficiency in pedunculate oak. Brendel, O., Dreyer, E. (*INRA, France; brendel@nancy.inra.fr; dreyer@nancy.inra.fr*).

Genetic diversity in intrinsic water use efficiency (W_i), as estimated by carbon isotope composition ($\delta^{13}C$), has been studied in pedunculate oak (*Quercus robur*) and sessile oak (*Quercus petraea*), two sympatric European forest tree species. Diversity of Wi in wild populations has been shown between and within species. Genetic determinism for W_i has been evaluated using a genetic mapping/Quantitative Trait Loci (QTL) approach and several regions have been detected on the genetic map. Phenotypes of this family have been investigated intensively and partitioning of W_i has shown a strong influence of stomatal conductance, whereby diversity in W_i was related to variation in stomatal density and stomatal sensitivity to diurnal courses of irradiance. A modelling approach has been used to detect more details of functional differences among genotypes. A complementary molecular biology approach was used to create a list of possible candidate genes related to the variability of W_i, using differential gene expression, as well as the study of a selected gene, ERECTA, which is known to be related to variation in W_i in *Arabidopsis thaliana*.

Water-use efficiency of tropical tree seedlings under elevated carbon dioxide. Cernusak, L. (*Charles Darwin University, Australia; lucas.cernusak@cdu.edu.au*), Winter, K. (*Smithsonian Tropical Research Institute, Panama; winter@si.edu*).

Seedlings of eight species of tropical trees were grown at ambient (400 ppm) and elevated (700 ppm) carbon dioxide in two glass houses at the Smithsonian Tropical Research Institute, Republic of Panama. Plant water use was determined at weekly to sub-weekly intervals by weighing pots, and dry matter production was determined by destructive harvest after 3 months growth. Plants grew in unfertilized forest topsoil under well-watered conditions. Mean final plant dry mass was 12% higher in elevated compared to ambient carbon dioxide ($P = 0.14$, $n = 93$), consistent with previous observations of a moderate growth stimulation in response to elevated carbon dioxide for tropical tree seedlings in unfertilized soil. On the other hand, mean cumulative water use was 25% lower in elevated carbon dioxide compared to ambient carbon dioxide ($P < 0.001$, $n = 93$). As a result, mean whole-plant water-use efficiency, calculated as dry matter production during the experiment divided by cumulative plant water use, was 54% higher in elevated compared to ambient carbon dioxide ($P < 0.001$, $n = 93$). Mean values were 2.4 and 1.6 mmol C mol^{-1} H_2O, respectively. Results suggest that reduced transpiration may be a more important functional response to elevated carbon dioxide than enhanced growth in tropical forest trees subject to low nutrient availability.

Genetic variability in water use efficiency in *Eucalyptus globulus.* Long, N. (*CRC for Forestry, Murdoch University and CSIRO, Australia; Nathalie.long@csiro.au*).

Traits that confer drought sensitivity to *Eucalyptus globulus* have been shown to vary between families but also more broadly between provenances. Individuals originating from well-watered environments tend to be fast growing and drought-sensitive, whereas individuals originating from dry environments appear to be more slow growing and drought-tolerant. However, past studies did not determine whether the observed differences were due to variation in water-use efficiency or water uptake. In dry environments, such as south-western Australia, it is essential for the timber and pulp industry to identify and use genotypes that are water efficient, since rain-fed ground water resources are becoming more scarce with climate change. In the present glass-house experiment, water use efficiency of containerised seedlings of three provenances of *E. globulus*, sourced from diverse habitats, were studied under three watering treatments: replacing 100%, 75%, or 60% of the daily water used by the plants, representing a well-watered condition and mild and severe drought treatments, respectively. After 4 weeks of treatments, water use efficiency for each provenance under each condition was calculated using water potential and gas exchange measurements, morphological parameters, and $\delta^{13}C$ discrimination analysis. The water use efficiencies of the provenances will be discussed in detail.

Water use efficiency of central and marginal provenances of European beech. Müller, J., Czajkowski, T., Bolte, A. (*Johann Heinrich von Thuenen-Institute, Germany; juergen.mueller@vti.bund.de; tomasz.czajkopwski@vti.bund.de; andreas.bolte@vti.bund.de*).

European beech (*Fagus sylvatica* L.), the main species in deciduous forests in Central Europe, is the most competitive tree species on most sites. However, beech is reputed to be drought-sensitive and its future role in European forests is rather unclear. In experiments and field studies we have studied the reaction of beech to drought events that are probably increased in future. We used different beech provenances from the central and marginal beech distribution range covering a climatic east-west-gradient of decreasing precipitation and increasing July temperatures from northern Germany to central Poland. A higher soil water use efficiency and better adaptation to drought was evident for the beech marginal provenances compared to the central ones. Particularly, a prolonged water exploitation option of the marginal provenances must be considered as an advantage for survival and competition under conditions of intensified drought events. These studies are continued in an open field laboratory ('Drylab') under controlled precipitation conditions (mobile roofing system) using eight lysimeters equipped with soil moisture sensors and rhizotrone technique. Focused on soil water and rhizospheric processes, we will discuss the adaptive potential of beech provenances to drought and future interactions between forest management, soil water availability, and productivity in beech forests.

Comparison of YieldSAFE and CABALA, two process-based models with contrasting parameter requirements. Palma, J. (*ISA-UTL, Portugal; joaopalma@isa.utl.pt*), Bruce, J., Almeida, A., Battaglia, M. (*CSIRO-Hobart, Australia; jody.bruce@csiro.au; auro.almeida@csiro.au; michael.battaglia@csiro.au*).

Forest growth models are the basic algorithms to support forest management decision tools, which are becoming more and more complex, especially with the use of high "algorithm-consumption" process-based-models. Such models are developed under different contexts and objectives resulting in different complexities and difference equations. However, from the simplest to the most complex models, predictions should converge into similar results. CABALA and YieldSAFE are respectively a high and low parameterized process-based-model for forest growth. Both models were compared against observed data of *Eucalyptus globulus* Labill from several experimental parcels in Australia under different water regimes. YieldSAFE is able to predict forest productivity with similar estimates of CABALA, except for complex soil characteristics such as salinity or high fertility rates. Due to the wide climatic scope of the measured data, with different VPD, slight corrections to the parameters related to water use should be made to achieve better estimates. In a certain way, results support the fact that the more complex the models are (e.g., CABALA), the more general applications they can have, whilst simple models (e.g., YieldSAFE) can be applied to more local applications in the cases where data for calibration and data to supply model inputs are not available.

Growth, biomass and water use efficiency of one-year-old *Ulmus pumila* seedlings under different irrigation intervals and from different seed sources. Park, G.E., Lee, D.K., Park, Y.D. (*Seoul National University, Republic of Korea; hellogracia@gmail.com; leedk@snu.ac.kr; forest_park@hanmail.net*), Batkhuu, N.O., Jamsran, T., Tserensodnom, E. (*Institute of Geoecology, Mongolian Academy of Sciences, Mongolia; bnyamosor@yahoo.com; Tsogtbaatarj@magicnet.mn; enkhii_smile@yahoo.com*).

Siberian Elm (*Ulmus pumila* L.) is a deciduous species expected to be useful for rehabilitation of arid and semi-arid regions in Mongolia. This study aims to compare the growth characteristics and photo-physiological response of *U. pumila* seedlings under water deficit condition and from different seed sources. *U. pumila* seeds from Mongolia were sown in the greenhouse, and irrigated at different intervals. Other seeds of *U. pumila* were obtained from three regions in Mongolia, namely: Khyalgant in the northern part of Mongolia (humid region), Bayan Gobi in the western part of Mongolia (less dry), and Gurvantes in the southern part of Mongolia (dry region). Seedlings were also grown in the greenhouse nursery and were subjected to measurement of growth, biomass allocation characteristics, and water use efficiency. In this study, one-year-old seedlings of *U. pumila* showed adaptation to water deficit condition by decreasing water loss, thereby decreasing leaf biomass and transpiration rate. Seedlings from Gurvantes, where it is dry, were superior in growth and biomass allocation among studied three seed sources. It is assumed that seedlings from a mother tree that have adapted to dry conditions might have morphological and physiological advantages under water deficit conditions.

Potential productivity of eucalyptus in Brazil: the key role of water supply. Stape, J.L. (*North Carolina State University, USA; jlstape@ncsu.edu*), Binkley, D. (*Colorado State University, USA; dan@cnr.colostate.edu*), Ryan, M. (*U.S. Forest Service, USA; mgryan@fs.fed.us*).

The Brazil Eucalyptus Potential Productivity (BEPP) Project used irrigation and rainfall exclusion treatments across a 1,000-km geographic gradient to examine constraints on short-rotation productivity. Clonal plantations differed by almost 2-fold in productivity (average MAI of 46 m3 ha-1 yr-1 MAI). These high rates of production depended on sustaining high operational rates of fertilization; with no fertilization, production declined by 28%. Irrigation (along with operational fertilization) increased growth by 32%. Growth during the dry season (without irrigation) was about 20% lower than in the dry season, from the combined influence of shorter days, limited water, and high vapor pressure deficit. Water use efficiency was high in all cases; at some sites, higher water use in irrigated plots was associated with higher efficiency of water use (up to 28% increase), whereas irrigation left water use efficiency unchanged at other sites. Exclusion of rainfall (reducing ambient by 1/3 to 1/2) was variable, as a result of relatively high soil water storage early in the rotation, and variable rainfall among years throughout the rotation. Continued work in phase 2 of the BEPP Project will continue to provide new insights on water use by intensively managed stands, supporting key silvicultural and management decisions.

Seasonal patterns in leaf and stand scale water-use-efficiency in a temperate woodland. Zeppel, M. (*Macquarie University, Australia; melanie.zeppel@uts.edu.au*), Taylor, D., Eamus, D. (*University of Technology, Sydney, Australia; daniel.taylor@uts.edu.au; derek.eamus@uts.edu.au*).

Estimates of the water balance of mining and waste disposal sites are important to minimise run-off from contaminated sites into local water bodies. Quantifying the water balance of remnant woodlands provided valuable baseline data to compare with the water balance of a nearby plantation on a waste disposal site. Leaf scale gas exchange, and whole tree and stand-level estimates of water use were measured in the plantation and woodland in Western Sydney, Australia, dominated by *Eucalyptus parramattensis* and *Angophora bakeri*. Leaf scale transpiration (Et) and assimilation (A) were used to determine instantaneous

water use efficiency (WUE). Additionally, whole tree water use was scaled to estimate stand water use. Soil and root properties were then measured and used to calibrate a mechanistic model of water and carbon fluxes in the low water and nutrient conditions found in Australian forests. Modelled carbon fluxes, together with stand water use, provided a crude estimate of integrated stand WUE. Seasonal patterns of WUE and soil water content were compared. By quantifying the water fluxes of the remnant woodland over numerous seasons, and drought/flooding conditions, we determined that plantation water fluxes were similar to those of a remnant woodland.

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Changes in germination characteristics, growth, leaf water relations, and pigments of *Eucalyptus meliodora* in response to drought stress. Assareh, M.H., Shariat, A. (*Forests and Rangelands Research Institute of Iran, Iran; asareh@gmail.com; shariat@rifr-ac.ir*).

Because of Iran's geographical situation and topographical features, about 80% of Iran's total area has an arid or semiarid climate. In this study, *Eucalyptus meliodora* is used as a model species to determine mechanisms of growth and survival under water deficit. Five potential osmotic levels (0, –0.1, –0.3, –0.6, and –1.2 MPa) treatments were used in five replications. Polyethylene glycol *6000* was used as diminutional osmosis in hydroponic culture in the greenhouse and induced gradual progressive declines in most of the growth criteria—radicule length, plumule length, vigour index, germination percentage, germination speed and germination index, leaf area, biomass, dry weight, relative water content, leaf water content per area, relative growth rate, adaxial and abaxial number of leaves, and Mg^{2+} and Ca^{2+} in leaves and roots in growing stages of 6-month-old plants—but amounts of K^+ and Na^+ did not change significantly with increasing stress. It also resulted in drastic decreases in the contents of chlorophyll a, b, and total chlorophyll because of decomposition enzymes activitiy. By measuring a suite of physiological parameters during an imposed 5-week drought, It was found that the optimal growth of *E. meliodora* occurred up to –0.6 MPa.

Osmoprotectants accumulation in *Eucalyptus sargentii* and *E. camaldulensis* under salinity stress. Assareh, M.H., Shariat, A. (*Forests and Rangelands Research Institute of Iran, Iran; asareh@gmail.com; shariat@rifr-ac.ir*).

The economics of tree growing on salt-affected land or with saline water irrigation will be considerably improved if sources of more salt-tolerant species can be identified and deployed. This research evaluates some physiological and biochemical traits of two *Eucalyptus* species under salinity stress. Four-month-old seedlings of *Eucalyptus sargentii* and *E. camaldulensis* grown in a greenhouse were watered by five NaCl level (0, 50, 100, 150, and 200 mM) treatments used in five replications in a factorial experiment design for 1 month. Salinity delayed and inhibited seedling growth and induced gradual progressive declines in most of the growth criteria of leaf area, relative water content, specific leaf area, and chlorophyll a, b, and total chlorophyll. In contrast to those mentioned above, salinity stress raised the content of each of soluble sugars, proline and glycine betaine. The optimal growth of *E. sargentii* occurred up to 200 mM NaCl. The mechanisms of salt tolerance in mentioned plants may be production of compatible solutes for maintenance of osmotic potential. This provides a physiological explanation for salinity tolerance and emphasizes the need to identify osmolytes that accumulate under stress in the genus *Eucalyptus*.

Physiological characteristics of *Acacia auriculiformis* A. Cunn. ex benth and *Acacia mangium* Willd. in Mt. Makiling and *Pterocarpus indicus* Willd. in La Mesa Watershed, Philippines. Combalicer, M.S. (*Nueva Vizcaya State University, the Philippines; marilyn_sabalvaro@yahoo.com*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*), Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Lee, K.W. (*Seoul National University, Republic of Korea; b20927@nate.com*).

This study was conducted to determine different patterns of response in physiological characteristics of the different age classes of *Acacia auriculiformis* and *A. mangium*, and *Pterocarpus indicus* to environmental factors in Mt. Makiling and La Mesa, respectively, in the Philippines. Chlorophyll content, stoma number and size, anatomical characteristics of the leaves, specific leaf area, and soil and weather characteristics were measured in the upper, middle, and lower parts of the sampled trees in each plot. Photosynthetic rate (*Pn*), transpiration rate (*E*), stomatal conductance (g_s), and water use efficiency (*WUE*) will be determined as well using Li-Cor 6400 Portable Photosynthesis System. Results of the study show that stomata size in the upper canopy of the 10-year-old *P. indicus* was highest compared to other age classes and species. However, the number of stomata was highest in the middle canopy of the 20-year-old *A. auriculformis*. The study shows that as the size of stomata decreases the number of stomata increases. On the other hand, the total chlorophyll content was highest (17.6 µg/ml) in the middle canopy of the 20-year-old *P. indicus* and lowest (2.1 µg/ml) in the lower canopy of the 20-year-old *A. auriculiformis*. Low chlorophyll content is associated with low light.

Water relations in native shrubs, northeastern Mexico. González, H., Ramírez-Lozano, R.G., Cantú-Silva, I., Gómez-Meza, M.V. (*Universidad Autónoma de Nuevo León, México; humberto@fcf.uanl.mx; roqramir@gmail.com; icantu@fcf.uanl.mx; marcovgmeza@hotmail.com*), Cervantes Montoya, J.R. (*Universidad Autónoma de Sinaloa, México; hgr1959@hotmail.com*).

Leaf water potentials (LWP) were evaluated in browse plants such as *Forestiera angustifolia* (Oleaceae), *Celtis pallida* (Ulmaceae), *Zanthoxylum fagara* (Rutaceae), and *Eysenhardtia texana* (Fabaceae). Collections were carried on at Linares County, a semiarid region of northeastern Mexico. The LWP (MPa) were estimated at 10-day intervals between July 10 and September 30, 2008, by using a Scholander pressure bomb, and were monitored in five different plants per species at 06:00 h (predawn) and 14:00 h (midday). Air temperature, relative humidity, vapor pressure deficit, precipitation, and soil water content were registered throughout. Data were subjected to one-way ANOVA and linear correlation analysis. It seems that air temperature and vapor pressure deficit negatively influenced LWP values in all species; conversely, LWP values augmented as relative humidity increased. *F. angustifolia* and *C. pallida* achieved higher predawn and midday LWP values under water stress, suggesting these species may be considered as drought-adapted species, while *Z. fagara* and *E. texana*, which acquired lower values, may be less adapted to drought and in physiological disadvantage under limited water conditions. The ability of shrub species to cope with drought stress depends on the pattern of water uptake and the extent of control water loss through the transpirational flux.

Resource use efficiency in hinoki cypress plantations with different stand densities in Shikoku Island, southern Japan. Inagaki Y., Kuramoto, S., Noguchi, K. (*Forestry and Forest Products Research Insitute, Japan; yinagaki@affrc.go.jp; shkura@affrc.go.jp; kyotaro@ffpri.affrc.go.jp*), Fukata, H. (*Kochi Prefectural Forestry Technology Research Center, Japan; hidehisa_fukata@ken4.pref.kochi.lg.jp*).

Nitrogen and water availability in soil can affect above-ground production and the pattern of biomass allocation to leaves, stems, and others. In hinoki cypress plantations, higher stem growth for timber and lower production of male flowers, a cause of pollen allergy, are required. We investigated the resource use efficiency and biomass allocation in six hinoki cypress plantations with different stand densities at two altitudes in Shikoku Island, southern Japan. The ratio of above-ground production to nitrogen taken up by trees was used for nitrogen use efficiency (NUE). Carbon 13 in leaves was used as an index of water use efficiency (WUE). For the six forests, NUE was negatively correlated with WUE, suggesting that one of the resources affects productivity and that plants utilize the resource more efficiently. NUE was positively correlated with biomass allocation to stems and negatively correlated with that to leaf or male flowers. A forest with higher NUE is less water-limited and allocates more biomass to stems. By contrast, a forest with lower NUE is strongly water-limited and allocates more biomass to leaves and flowers. Thinned forests had generally higher biomass allocation to flowers but there was no clear relationship between stand density and resource use efficiency.

Water use of *Albizia lebbeck* on saline soil in Kalasin Province, northeast Thailand. Luangjame, J. (*Acid Deposition and Oxidant Research Center* (*ADORC*)*, Japan; jesada@adorc.gr.jp*).

Water use of *Albizia lebbeck* (L.) Benth. was carried out on moderate saline soil in Kalasin Province, Northeast Thailand. Heat pulse velocity technique (HPV) was used to monitor these trees. *A. lebbeck* was planted in 2000 and was 6 years old when randomed to measure for 26 stems, which were selected at 2 stems/month. Each tree stem was installed with probes on the sapwood at the north, east, south, and west directions in order to investigate the water flow in xylem from root through tree canopy by using the sapflow logger of the Greenspan Technology. The average diameter at breast height and sapwood area of *A. lebbeck* were 7.45 cm and 19.96 cm^2, respectively. Water use of *A. lebbeck* was recorded from January 24, 2006 till April 22, 2007, a total of 454 days continuously. The results were found that the water use of *A. lebbeck* was 31.64 litre/day or 1.51 mm/day of standard water use in the area. Moreover, it was shown that water use was increased when the sapwood area increased.

Climate index to estimate the productivity of *Pinus radiata* plantations in Chile. Promis, A., Caldentey, J. (*Universidad de Chile, Chile; alvaro.promis@gmail.com; jcaldent@uchile.cl*).

Pinus radiata plantations are the mainstay of the Chilean forestry industry. The relationships between 22 climatological parameters and the productivity of *P. radiata* plantations in the Chilean Cordillera de la Costa (between 32º21′ and 40º24′ south latitude) were studied. A simple estimation index (PI) was developed, based on climatic predictors, to estimate the yearly mean biomass potential accumulation of 12-year-old plantations. The biomass of 182 stands, situated at seven different latitudes, were determined by the harvest method. The productivity data of each stand were correlated with its climatic variables, using the statistical method step by step. A potential equation with the variables winter total precipitation (June, July and August) and the length of the frost-free period was chosen as the best predictor index. The index was calculated for a grid of weather data every 5 minutes in latitude and longitude, to draw isoproductivity lines. In the study area, the PI generally increases from north to south and was significantly influenced by the topography, showing maximum values in the mountaintops. When the aridity of the studied locations increased, forest stand productivity decreased. The reduction of global radiation was not a limiting factor for biomass production.

The possibility of improving forest plantations in dry lands through spate irrigation: a case study. Negahdarsaber, M., Kowsar, S.A., Mortazavi Jahromi, S.M. (*Center of Agriculture and Natural Resources, Iran; saber@farsagres.ir; kowsar@farsagres.ir; mortazavi@farsagres.ir*).

The Kowsar Floodwater Spreading, Aquifer Management, Training and Extension Station—located in the Gareh Bygon Plain at 1,140 m above mean sea level, with arid climatic conditions,190 km southeast of Shiraz, Iran—was established in 1982. Thirteen spate irrigation systems covering 2,445 ha were designed and constructed during the 1983–2003 period for the artificial recharge of groundwater (ARG). Exotic trees, mainly *Eucalyptus camaldulensis* Dehnh. and *Acacia salicina* Lindl., cover about 100 ha of the systems. The eucalypt wood yield ranges1.37 to 4.04 m^3/ha year depending on the location in the ARG systems, with the overall mean yield of 2.19 m^3/ha year. This indicates the unsuitability of this species for afforestation in this area. However, a thriving bee-keeping enterprise, and leaf production for medicine and browsing by livestock, cannot be ignored. Moreover, the area attracts many eco-tourists, particularly during the Iranian New Year holidays in March and April. As *E. camaldulensis*. is a prodigious water consumer, and panting this tree negates the principal objective of such projects, we propose replacing it with less water-demanding, deep-rooted indigenous trees if the main objective is wood production. A methodical species trial is the first step in this undertaking.

Photosynthetic traits, water and nitrogen use efficiency of acacia and eucalypt seedlings as criteria for plantation materials. Novriyanti, E., Watanabe, M. (*Hokkaido University, Japan; keenove@for.agr.hokudai.ac.jp; nab0602@for.agr.hokudai.ac.jp*), Kohda, H., Takeda, T. (*Oji Paper Co. Ltd., Japan; hideho-koda@ojipaper.co.jp; takayoshi-takeda@ojipaper.co.jp*), Hashidoko, Y., Koike, T. (*Hokkaido University, Japan; yasu-h@abs.agr.hokudai.ac.jp; tkoike@for.agr.hokudai.ac.jp*).

Acacia and eucalypt are commercially important fast-growing species that have a wide range of adaptability. Therefore we need to know the criteria as afforestation materials. We studied the ecophysiology of two acacia and four eucalypt seedlings grown in a greenhouse. We measured gas exchange rate, leaf mass per area (LMA), and nitrogen concentration of their leaves. Light saturated net photosynthetic rate (A_{sat}) was different between the genera; the eucalypts had higher A_{sat} than the acacias. Acacias had higher LMA than eucalypts. Moreover, acacia tended to have higher water use efficiency (WUE) than eucalypts. The area-based nitrogen concentration (N_{area}) of acacias was higher than that of the eucalypts, while the mass-based nitrogen

concentration (N_{mass}) showed no tendency between the genera. Thus, the photosynthetic nitrogen use efficiency (PNUE) was higher in eucalypts than that in acacias. Although a positive correlation is generally observed, we found negative correlation between A_{sat} and N_{area}. Meanwhile, A_{sat} and PNUE was positively correlated. PNUE and LMA showed a negative tendency of high correlation. Thus, acacia, which has higher LMA, does not allocate N to photosynthetic system, so it has lower A_{max} and PNUE but it has relatively higher WUE as compared to eucalypts.

Improving drought tolerance of eucalypts by glycine betaine application and selection. Shariat, A., Assareh, M.H. (*Forests and Rangelands Research Institute of Iran, Iran; shariat@rifr-ac.ir; asareh@gmail.com*).

Plants accumulate a variety of organic osmoprotectant solutes through a biochemical mechanism that improves their ability to withstand stresses. Of these solutes, glycine betaine appears to play a major role in conferring resistance to drought stresses. This research was carried out to estimate drought tolerance of four *Eucalyptus* species: *Eucalyptus camaldulensis*, *E. microtheca, E. meliodora*, and *E. viminalis.* Polyethylene glycol *6000* was used as diminutional osmosis in hydroponic culture in five potential osmotic levels (0, –0.1, –0.3, –0.6, and –1.2 MPa) in a greenhouse. Selection for higher glycine betaine species has the potential to speed up breeding for drought tolerance. Sampling was carried out from stamen leaves of different treatments. The highest quantity of glycine betaine belonged to *E. camaldulensis.* The mechanisms of drought tolerance in mentioned plant maybe production of compatible solutes for maintenance of osmotic potential. This provides a physiological explanation for aridity tolerance and emphasizes the need to identify osmolytes that accumulate under stress. Further work is essential to determine whether higher glycine-betaine-accumulating ability could be used as a reliable index of stress tolerance in the genus *Eucalyptus*.

Species effect on the water use efficiency of a mixed forest of beech (*Fagus sylvatica* L.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), and Silver fir (*Abies alba* Mill.) in Belgium Ardennes. Soubie, R. (*Université Catholique de Louvain, Belgium; remy.soubie@uclouvain.be*), Heinesch, B., Aubinet, M. (*Gembloux agro bio tech, Belgium; bernard.heinesch@ulg.ac.be; marc.aubinet@ulg.ac.be*), Vincke, C. (*Université Catholique de Louvain, Belgium; Caroline.Vincke@uclouvain.be*).

Induced by climate change, intensity and frequency of droughts should be more important for the next century. How does water availability affect the physiology of woody plants at the species and stand scales? Carbon and water vapour flux measurements of a mixed forest were performed for more than 10 years by the eddy covariance method in Belgian Ardennes. Improving analysis of water vapour fluxes and monitoring species transpiration will contribute to the estimation of the water use efficiency (WUE) for different scales. WUE allows evaluating the sensitivity of temperate woody species to drought. The species concerned are beech (*Fagus sylvatica* L.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), and silver fir (*Abies alba* Mill.). Since summer 2009, we monitored and analyzed each species water use by measuring sap flow. Results at the species level will then be upscaled and compared to stand water vapour fluxes measurements. Transpiration of each species will be analyzed in relation with their own phenological and ecophysiological attributes, ecosystem soil and atmospheric conditions, to clarify among others their behaviour in case of water deficit. Data are actually analysed; the presented results will concern the 2009 and a part of the 2010 growing seasons.

Changes in leaf water-use efficiency and growth traits with maturation among four tree species planted in a semi-arid land of the Loess Plateau, China. Tanaka-Oda, A. (*University of Tokyo, Japan; ayumin@nenv.k.u-tokyo.ac.jp*), Kenzo, T. (*Forestry and Forest Products Research Institute, Japan; mona@affrc.go.jp*), Koretsune, S., Sasaki, H., Fukuda, K. (*University of Tokyo, Japan; satomi@nenv.k.u-tokyo.ac.jp; asa3ki@nenv.k.u-tokyo.ac.jp; fukuda@k.u-tokyo.ac.jp*).

Several tree species planted in the Loess Plateau of China suffer from occasional dieback of the top shoots and growth reduction after their maturation, while some native species rarely suffer from it. In a semi-arid region of Loess Plateau, we compared stable leaf carbon isotope ratio (δ13C) as an indicator of leaf water-use efficiency (WUE), leaf mass per area (LMA), nitrogen content and diameter growth rate between juvenile, young and mature trees (tree height classes: 1, 5, 10 m) of susceptibile species (*Populus hopeinsis*, *Robinia pseudoacacia*) and resistant species (*Ulmus pumila*, *Zizyphus jujuba*) to dieback. The susceptible *Populus hopeinsis* and *R. pseudoacacia* showed decreasing diameter growth rate, and their WUE and nitrogen content decreased with maturation. In contrast, resistant species (*U. pumila* and *Z. jujuba*) showed increasing and/or stable WUE, nitrogen content and the diameter growth rate through the maturation. These differences among species in leaf WUE and LMA changes with tree maturity may be reflecting their growth patterns and susceptibility to drought stress. These leaf traits could be new criteria for selection of tree species for plantation in semi-arid region.

A-06 Assessment of forest management strategies for facilitating adaptation and mitigation in rapidly changing forest systems

Organizers: Anne-Helene Mathey, *University of British Columbia, Canada, mathey@interchange.ubc.ca.*

Proxy indicators of thermodynamic efficiency and ecosystem resilience to environmental change in contrasting old-growth and managed forests. Hobson, P.R., Mickleburgh, P. (*Writtle College, United Kingdom; peter.hobson@writtle.ac.uk; peter.mickleburgh@writtle.ac.uk*), Ibisch, P. (*University of Applied Sciences, Germany; pibisch@fh-eberswalde.de*).

The structural patterns and functional self-organization of natural vegetation are fundamental to maintaining ecosystem complexity, functionality, and resilience. These ecological phenomena also influence climatic conditions. Complex ecosystem processes and patterns can be more simply described and understood using principles of non-equilibrium thermodynamics. Specifically, forests under more natural patterns of disturbance, characterised by a multi-cohort structure and an abundance of dead wood, are likely to exhibit characteristics of complex functional and resilient ecosystems, and can be described as thermodynamically efficient. Vegetation structure and microclimatic temperature are used and analysed as proxy measures of thermodynamic efficiency across a range of semi-natural and managed forests. The evidence from this study suggests there is greater attenuation

of local temperatures in forests that are structurally more complex. Furthermore, a combination of increased forest structure and woody biomass promotes temperature capacitance across a range of scales including point-focus sites with downed logs. Finally, managed forests appear to exhibit greater fluctuations in both diurnal and seasonal temperatures, and this corresponds to lower structural diversity and woody biomass. This paper proposes the use of these proxy indicators of thermodynamics to produce a predictive framework for the promotion and improved management of functional and resilient forest landscapes.

Optimization of cork debarking rotation for sites of different cork productivity and quality. Paulo, J., Tomé, M. (*Technical University of Lisbon, Instituto Superior de Agronomia, Portugal, joanaap@isa.utl.pt; magatome@isa.utl.pt*).

Cork debarking rotation is one of the most important management variables in cork oak stands since it influences not only the economic results from forest management but also tree growth, resistance to fire, diseases, etc. Annual weather variation and cork price fluctuation, especially in the past few years, have contributed to the increase of the cork extraction period in some regions. On the other hand, other landowners claim that the legal minimum interval of 9 years between two consecutive cork extractions is too restrictive and should be shorter in sites that correspond to high cork growth rates. A new methodology for the estimation of cork biomass growth at tree level was recently developed. This methodology was incorporated in the SUBER growth model for cork oak stands. In this presentation, this new version of the SUBER model was used to analyze the optimization of the cork debarking rotation in stands characterized by different cork growth rates and quality. The results were analyzed and discussed considering the cork production net present value, different climate scenarios, cork price variation, and stand health conditions.

Different scale approaches to forest and water interactions in the NW-European ForeStClim headwater catchments. Schüler, G., Caspari, T. (*Research Institute for Forest Ecology and Forestry Rheinland-Pfalz, Germany; schueler@forestclim.eu; caspari@forestclim.eu*), Nisbet, T. (*Forestry Commmission, United Kingdom; tom.nisbet@forestry.gsi.gov.uk*), Scherzer, J. (*UDATA–Umweltschutz und Datenanalyse, Germany; info@udata.de*), Huemann, M., Mueller, C., Casper, M. (*University of Trier, Germany; M.Huemann@uni-trier.de; cmueller@uni-trier.de; casper@uni-trier.de*).

Within the European INTERREG project (ForeStClim, www.forestclim.eu), forest, soil, and water interactions are investigated and modelled by different scale approaches. Getting better understanding of these interactions and the relationship to water behaviour at different scales is the basis for adaptation management strategies in response to climate impacts with changing occurrences of extreme weather events. The level of the regarded scale depends highly upon the specific target and decisions needed. Adaptation management needs insights from plot-scale to catchment scale. Hence, measurements of soil moisture, of subcatchment discharge, and of catchment discharge are used to calibrate different water balance models on smaller scales as well as other types of catchment discharge models on larger scales. Downscaling and upscaling possibilities will be discussed. Integrating climate change scenarios on larger temporal scales can be used to assess the selection during tree competition processes and the threat of drought stress to forest tree species and to forest stands. Additional sprinkler-irrigation experiments at the plot-scale and discharge measurements in the headwater catchments allow development of dynamically reacting forest site survey methods and also production of runoff and flood generating maps as a basis for environmental management plans to mitigate the danger of flash floods.

Climate change challenges to management. Stanturf, J.A., Gardiner, E.S., Dey, D.C. (*U.S. Forest Service, USA; jstanturf@fs.fed.us; egardiner@fs.fed; us ddey@fs.fed.us*), Madsen, P. (*University of Copenhagen, Denmark; pam@life.ku.de*).

Effective response to global change requires greater emphasis on restoring resilient forest ecosystems following disturbances. Managers will be challenged to adapt to both gradual changes in growing conditions and to abrupt changes from extreme weather events. This has important implications for forest management, requiring a rethinking of current strategies and guidelines for artificial and natural regeneration. Research is required now to better understand the physiological basis for growth responses to extreme weather events and to test provenances at the limits of their ecological range and beyond. Planting stock will be needed not only with pest resistance and wide tolerances for climate stress but also optimized for carbon sequestration and early masting. For bioenergy plantations especially, we must develop genotypes with high water and nitrogen use efficiencies. Nurseries must provide stock for non-commercial as well as currently commercial species with drought-tolerant genotypes to be planted into novel environments. Artificial regeneration will require provenances with wide amplitude or that stock from a range of provenances be planted at a site. Under natural regeneration regimes where advance regeneration of desirable species is lacking, we will need to underplant genotypes of these species adapted to the new climatic conditions.

Vulnerability assessment of mountain ecosystems in the Philippines using a geospatial-based environmental vulnerability index: case study of the Makiling Forest Reserve. Tiburan, C., Kobayashi, S., Saizen, I., Mizuno, K. (*Kyoto University, Japan; cltj_uplbcfnr@yahoo.com; shin@kais.kyoto-u.ac.jp; saizen@kais.kyoto-u.ac.jp; kmizuno@kais.kyoto-u.ac.jp*).

Vulnerability studies are imperative because of their valuable contribution in the development of mitigation measures and adaptation strategies to climate change. Similarly, they can also be used to determine management alternatives for a given landscape. However, the effectiveness of these options also requires reliable assessment and sufficient information to better provide the appropriate decisions needed. Hence this study aimed to develop a geospatial-based approach for vulnerability assessment of watersheds and related ecosystems in the Philippines to climate change. The research initially involved the development of an environmental vulnerability index, which was composed of 22 indicators under three major components—climate variability, exposure and sensitivity, and adaptive capacity. Threshold levels and scales for each indicator were determined using statistical and spatial-based methods. The developed index was then utilized to evaluate the vulnerability of the Makiling Forest Reserve, a potential carbon sink located 65 km south of metropolitan Manila. Results generally classified the reserve under category 3, which can be described as a vulnerable ecosystem. Detailed information on the evaluation were also summarized in a template that includes the vulnerability map, profile of the indicators, most resilient and vulnerable indicators, and the overall vulnerability points, among others.

Managing forests to maintain ecological integrity and social acceptability under climate change–a case study from the Champagne and Aishihik Traditional Territory, southwest Yukon. Waeber, P.O. (*University of British Columbia, Canada; powaeber@gmail.com*), Nitschke, C.R. (*Melbourne School of Land and Environment, Australia; craig@unimelb.edu.au*), Innes, J.L. (*University of British Columbia, Canada; john.innes@ubc.ca*).

To bridge the gap between managing ecosystems based on static measures and the need to consider the role of changing processes, we present a new methodology for determining and implementing sustainable forest management (SFM) strategies: the Integrated Dual-Filter Model (IDFM). IDFM utilizes an adaptive cycling technique that takes into account different spatial and temporal scales, processes, and changes to ecological services and socio-economic values. IDFM is composed of both qualitative and quantitative components: (i) an ecological simulation model toolkit (comprising LANDIS-II, TACA, and the Canadian Forest Fire Danger Rating System) that evaluates changes in ecosystem structure and function under different management actions and disturbance processes while accounting for climate change impacts; (ii) a decision-making tool that utilizes an analytical hierarchy process and focus group interviews to determine management strategies and objectives based on local and regional values; and, (iii) a monitoring tool to measure management effects and their impacts at multiple scales under changes in climate and/or other values. We present the results of a case study that under predicted climate change assesses alternative SFM strategies for managing the forests of the Champagne and Aishihik Traditional Territory, southwest Yukon following a recent spruce bark beetle (*Dendroctonus rufipennis*) epidemic.

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Proposal of the strategy of adaptation and mitigation measures from the viewpoint of the impact of climate change on forest ecosystems in Slovakia. Caboun, V., Tomas, B., Tibor, P. (*National Forest Centre-Forest Research Institute, Slovakia; caboun@nlcsk.org; bucha@nlcsk.org; priwitzer@nlcsk.org*).

We present draft strategy, adaptation, and mitigation measures and concrete measures for time horizons 2007, 2045, and 2075 as output from the research task, "Impact of global climate change on the forests of Slovakia." Data regarding a broad range of newly obtained knowledge about the effects of global climate change on the forests, and resultant proposal of measures for beech, oak, spruce, fir, larch, and pine, which are growing in respective altitudinal vegetation zones, were elaborated into tables. Prognosis is based on the synthesis of the results of analyses of individual classes of conditions suitability, which were determined for given tree species on the basis of the frequency of current occurrence and growth responses in respective altitudinal vegetation degrees. We used the results of tree growth simulation by means of growth simulator SIBYLA to analyse the effects of climatic changes on the production, ecological stability, and vitality of tree species, vegetation phenology, and structure of stands using the models of climate change for respective tree species. Forest ecosystem response to climate change is continually monitored by using satellite data. For this purpose vegetation indices derived from MODIS are analysed in relation to ground assessment of forest vegetation phenology.

Plantation density management as a tool to enhance the adaptability to climate change: a case study in ponderosa pine plantations in NW Patagonia, South America. Fernández, M.E., Gyenge, J. (*CONICET, INTA EEA Bariloche, Argentina; ecologia_forestal@yahoo.com.ar; javier_gyenge@yahoo.com*), Varela, S., De Urquiz, M. (*INTA EEA Bariloche, Argentina; svarela@bariloche.inta.gov.ar; murquiza@bariloche.inta.gov.ar*).

An ecophysiological study was carried out in *Pinus ponderosa*, to estimate the effect of different plantation densities (open and closed stands) on the response of this species to severe drought conditions. The following variables were studied: growth rate and period, sapflow density, water status, hydraulic conductance and conductivities, anatomy of new formed wood, and water use efficiency (WUE). In spite of ponderosa pine's being a summer-drought adapted species, high intraspecific competition severely affected growth (from 12 to 1 mm of dbh increase) as well wood quality. In this regard, C limitation led to the formation of thinner cell walls (with a similar lumen diameter) in the closed stand trees, maintaining similar proportion of early and late wood. Changes in growth period and magnitude can be explained by the different gas exchange rates between open and closed plantation trees, even before the decrease in soil water content was evident, indicating that chronic limitations are affecting productivity in the closed stand, even without water deficits. WUE was higher in the open stand trees compared to the closed stand. These results suggest that stand density management is a valuable tool to increase the adaptability of ponderosa pine to predicted conditions of climatic change.

Timber production, carbon storage, and biodiversity: matrix growth model and harvest scenario simulation for multiple uses of larch-spruce-fir forests. Lei, X.D., Xiang, W., Hong, L.X. (*Institute of Forest Resource Information Techniques, Chinese Academy of Forestry, China; xdlei@caf.ac.cn; xiangwcaf@gmail.com, honglx@caf.ac.cn*), Sun, J.J., Wang, P.Z. (*Anhui University of Technology, China; hunansunjianjun@163.com; pzhwang@ahut.edu.cn*).

The objective of our study is to develop a multispecies nonlinear matrix growth model for simulating the effects of harvest scenarios on timber production, carbon storage, and tree species and size diversity. The data are from 20 long-term larch-spruce-fir (*Larix olgensis–Picea jezoensis–Abies nephrolepis*) permanent plots with 5-year period observations in Jilin province, northeastern China. We found that mortality, upgrowth, and ingrowth probability was significantly affected by tree diameter, basal area, tree species and size diversity, number of trees at minimum diameter class, and elevation. The parameters of upgrowth, mortality, and ingrowth models are estimated through the ordinary least-square method and seemingly unrelated linear regression, but the differences in parameter estimate values between them were not significant. The model was validated in the short term by comparing the observed with predicted values by species groups, and was statistically reasonable and subsequently was applied to predict timber yield, above-ground carbon storage, tree species diversity, and tree size diversity under 13 management scenarios in 50 years. The simulation results showed that the scenario with long cutting cycle (15 years) and low intensity (5 percent of volume) could meet the need of timber yield, protecting biodiversity and increasing carbon stock simultaneously.

Climate adapted models for natural forest resources and climate change studies in northeast China. Lu, J., Zhang, H. (*Chinese Academy of Forestry, China; junlu@caf.ac.cn; huiru@caf.ac.cn*).

Global climate change studies have recently challenged many types of natural forest management, such as modeling species ranges shifts, forest productivity under climate change scenarios, or assessing forest productivity under current and potential future climates. In this study, we present a new methodology to generate scale-free climate data through the combination of interpolation techniques and elevation adjustments. Equations were developed to calculate biologically relevant climate variables including various degree-days, number of frost-free days, frost-free period, and snowfall from monthly temperature and precipitation data. Estimates of climate variables were validated using an independent dataset from weather stations that were not included in the development of the model. The models build a good match between tree species favorable climate and planting site climates by high-resolution climate models and precise modeling of species favorable climate in northeast China. They also indicate how the climate envelope of ecosystems shifts as a consequence of increased temperature, and how tree growth may respond to climate change. These climate models can assist forest planners and managers in determining where harvesting may occur now and in the future given any defined set of business and regulatory objectives under a changing climate.

Development of Japan's forest carbon accounting method and national forest resources database for the report under the Kyoto protocol. Matsumoto M. (*Forestry and Forest Products Research Institute, Japan; machan@ffpri.affrc.go.jp*).

For accounting and reporting emissions and removals under the Kyoto protocol, my team in the Forestry and Forest Products Research Institute developed Japan's forest carbon accounting method, respecting requirements from the Kyoto Protocol, Marrakesh Accord, and IPCC Good Practice Guidance. We apply the stock change method to estimate carbon stocks and carbon stock changes in forests using information such as species, age, stem volume in forest registers, and country-specific parameters for biomass expansion factor, root-shoot ratio, and wood density. We interpret land-use types at 500-m-interval grids from multi-temporal high-resolution images to estimate emissions and removals from afforestation, reforestation, and deforestation. We also monitor forest stands where forest management activities were practiced since 1990 to estimate removals under Article 3.4 of the Kyoto Protocol. To apply the methodology, we developed the National Forest Resources Database, which stores various information including forest registers, boundaries of forest compartments, land-use monitoring, systematic sampling for national forest inventory, forest management monitoring, orthophotos, and satellite images such as Landsat TM and SPOT. Using the methodology and the database, the Japan Forestry Agency estimated and reported that the total removals were 22.2 Mt-C/y and the removals under Article 3.4 were 10.9 Mt-C/y in 2007.

Management strategies for mitigating the impact of hurricanes on the landscape. Strimbu, B., Long, D., Palmer, W. (*Louisiana Tech University, USA; strimbu@latech.edu; dlong@latech.edu; wpalmer@latech.edu*).

Hurricanes are the main landscape disturbances in coastal region of the southern United States. Assuming an increase in climate variability, the present research aims to identify the management strategies leading to spatial structures that are prepared for hurricane mitigation and fast recovery of the landscape. The attributes considered as playing a significant role in landscape protection (i.e., forest clusters, stand composition and height, roads, pipelines, cheniers, and urban development) were identified using Landsat satellite images taken before and after hurricanes Danny (1985) and Rita (2005). The attributes defining the desired structure of the landscape were identified using principal component analysis. The spatial arrangement of the significant attributes was determined using the principal component results as input for a discriminant analysis based on five classes (water bodies, forest, urban development, agriculture, and linear structures). The results indicated that band 4 supplies the largest information, but not significantly different than the other five bands used in analysis (bands 1,2,3,5, and 7). The landscape elements identified as having a significant impact in maintaining the landscape relatively unaffected by the hurricane were tree clusters and linear structures (such as roads, pipelines, or cheniers).

Assessment of policies regarding adaptation to climate change in China's forestry department. Zhang, K., Hori, Y. (*Forestry and Forest Products Research Institute, Japan; zhangk@affrc.go.jp; horijas@affrc.go.jp*), Dai, G.C., Xie, C. (*China National Forestry Economics and Development Research Center of State Forestry Administration, China; daigc@forestry.gov.cn; xiechen@forestry.gov.cn*).

This paper assesses Chinese forestry policies to adapt to climate change, referring to broad literature reviews on studies and related policies on vulnerability, adaptation, and mitigation to climate change. It begins with introducing macro policy backgrounds of dealing with climate change on the national level and the forestry department especially, followed by policy assessments using a vulnerability-based approach. We found that China is still lagging behind on adaptation studies and favors more mitigation policy-making and implementation. There are not many socio-economic studies on vulnerability to climate change in forestry communities. The paper gives recommendations on the related studies and policy-making in the end. As a developing country, China should take planned adaptation to climate change as a long-run, cheaper way to relieve climate change damages. Because of climatic, social, and economic variation, the state (national) forestry department is suitable to organize and support national vulnerability and adaptation studies, and local governments are encouraged to propose local studies based on this. Concrete forestry policies should be made to support a series of scientific studies on techniques to protect special ecosystems and precious genes, socio-economic studies on climate change damages, and adaptation measure studies referring to other advanced experiences.

A-07 Is climate change leading to global increases in drought-induced forest die-off?

Organizers: Ted Hogg, *Natural Resources Canada, Canada, ted.hogg@nrcan.gc.ca;* Craig D. Allen, *U.S. Geological Survey, USA, craig_allen@usgs.gov.*

Drought-induced tree mortality: a global overview of patterns and emerging climate change risks for forests. Allen, C.D. (*U.S. Geological Survey, USA; craig_allen@usgs.gov*).

Forests are increasingly subject to pervasive global change effects, ranging from better growth in some regions due to longer growing seasons or CO_2 fertilization, to growth declines or increased tree mortality from droughts or warming temperatures. Anthropogenic climate change is projected to drive increases in mean temperatures and frequencies, durations, and severities of drought and heat in many regions, amplifying tree physiological stress and causing increases in both background tree mortality rates and episodes of rapid, broad-scale forest die-off. Collaborative work with many colleagues world-wide has enabled a global synthesis documenting >160 studies of tree mortality since 1970 attributed to drought/heat from all continents in forest types ranging from tropical moist forests and savannas to boreal forests. Temporal and spatial patterns of climate-induced forest mortality are presented using diverse data sources, including dendrochronological reconstructions, forest die-off mapping from historic aerial photographs, and long-term vegetation monitoring. These documented episodes may reflect increasing global risks of forest die-off in response to amplified drought and heat, even in environments not normally considered water-limited. However, large knowledge gaps currently hinder our ability to predict forest mortality in response to climate change, including the absence of a globally coordinated observation system.

Species response curves along rainfall gradient in Ghanaian forests: what can it tell us about the impact of climate change? Amissah, L. (*CSIR-Forestry Research Institute of Ghana; ewurakua.amissah@gmail.com*), Poorter, L., Bongers, F., Mohren, G.M.J. (*Wageningen University, The Netherlands; Poorter.lourens@wur.nl; Bongers.frans@wur.nl; Mohren.frits'wur.nl*).

Global climate change scenarios predict a drier climate for West Africa, including Ghana. Already, observed temperature and precipitation trends over the past 4 decades for Ghana show a rising temperature and declining precipitation in line with global predictions. These changes in climatic factors are likely to shape the dynamics of tropical forest ecosystems in this region. Water availability is one of the major limiting factors in the composition and distribution of tropical forests, implying that the distribution of species that are drought-sensitive are likely to be shifted. Species response to environmental gradient is therefore fundamental to predicting the potential impacts of climate change on forests. Using absence/ presence data from national forest inventory data of 2,500 1-ha plots and climatic data from *Worldclim*, responses of 20 selected species to annual rainfall, temperature seasonality, and rainfall seasonality was determined. A forward logistic regression was used in the analysis. Results show different species have different maximum probability of occurrence along the rainfall gradient. Thus species with their ecological optimum in high annual rainfall levels are likely to be negatively affected by climate change. Ex situ conservation measures are needed to ensure that such species are not lost.

Determining the impacts of climate change on iconic trees, woodlands and forest ecosystems in Western Australia. Brouwers, N., Lyons, T., Hardy, G. (*Murdoch University, Australia; n.brouwers@murdoch.edu.au; t.lyons@murdoch.edu.au; g.hardy@murdoch.edu.au*), Veneklaas, E., Renton, M. (*University of Western Australia, Australia; evenekla@cyllene.uwa.edu.au; michael.renton@uwa.edu.au*), Barber, P. (*Murdoch University, Australia; p.barber@murdoch.edu.au*), Stone, C. (*NSW Department of Primary Industries, Australia; christine.stone@dpi.nsw.gov.au*), Behn, G. (*Department of Environment & Conservation, Australia; graeme.behn@dec.wa.gov.au*), Dell, B., Evans, B. (*Murdoch University, Australia; b.dell@murdoch.edu.au; brad.evans@murdoch.edu.au*).

The State Centre of Excellence for Climate Change, Woodland and Forest Health (Murdoch University) is dedicated to provide up-to-date and scientifically sound science and information to underpin the protection, health and sustainable management of Western Australia's unique woodlands and forests. Eucalypt (*Eucalyptus* spp.) trees, woodlands and forest ecosystems have been declining rapidly across a range of climatic zones and terrestrial and riparian ecosystems. Global climate change and altered land use are suspected to be two of the key drivers in the declines of eucalypt species; however, the exact causes of these declines are largely unknown. This research program aims to determine correlations between historical declines of eucalypt ecosystems and climate variables, using a combination of temporal records of remote sensed data, mesoscale meteorological models, and field-acquired data. This project will focus on: (i) accurately mapping the spread and extent of tree declines, (ii) find correlations with abiotic factors, and (iii) detect indicators of canopy health. This project will specifically test the hypothesis that lower annual precipitation in combination with higher temperatures (i.e., drought stress) is the main driver of the observed declines. Preliminary results of this research will be presented and future steps and challenges will be discussed.

Drought-induced mass mortality of Atlas cedar forest (*Cedrus atlantica*) in Algeria. Chenchouni, H. (*University of Batna, Algeria; chenchouni@yahoo.fr*).

Algerian forests occur across a broad ecotone located between the Mediterranean Sea and the Sahara Desert. These forests are vulnerable to climate variability, especially tree species situated near the limits of their bioclimatic tolerance such as Atlas cedar (*Cedrus atlantica*), which is distributed in scattered mountain populations. Since the onset of severe drought during 1999–2002, cedar forests have undergone mass mortality, affecting all age classes. While all Algerian cedar forests are affected, mortality varies along a steep moisture gradient. Die-off has been greatest (up to 100%) in the drier mountains nearest the Sahara, dropping to lower mortality levels in the moister coastal mountains. Prolonged soil moisture deficits led to progressive decline and death of cedar trees over 1–3 years, and a variety of insects and fungi continued to kill weakened cedar trees since the drought eased after 2002. In the semi-arid, near-Sahara mountains, *Cedrus* mortality began as small patches of older trees on drier aspects, eventually coalescing into large patches affecting all ages on all exposures. However, in more mesic regions near the coast, only small patches of old trees on dry aspects have died. Since 2008, the *Cedrus* die-off appears to have ceased in response to significant precipitation.

Critical limits of soil water availability (CL-SWA) for central European forest trees. Czajkowski, T. (*Johann Heinrich von Thuenen-Institute, Germany; tomasz.czajkowski@vti.bund.de*), Ahrens, B. (*Goettingen University, Germany; bahrends@forst.uni-goettingen.de*), Bolte, A. (*Johann Heinrich von Thuenen-Institute, Germany; andreas.bolte@vti.bund.de*).

Due to climate change, heat waves and drought are expected to increase in frequency and intensity in Europe. Thus, assessments of critical constraints of water supply in forest trees are needed to develop adequate forest adaptation measures. We present a novel 'critical limit' approach to soil water availability (SWA) for the major central European forest tree species based on

physiological plant water status. Regarding conductivity of tree xylem, three thresholds of pre-dawn water potential (ψ_{pd}) were chosen, referring to (i) slight conductivity loss (10%), (ii) critical conductivity loss (50%) and (iii) complete conductivity loss (>90%). In times of drought, predawn water potential relates to the soil water potential at the lowest soil depth in which a plant's root system is able to deplete water resources (the 'effective rooting depth' (ERD)). The critical limit of soil water availability (CL-SWA) represents the proportion of plant-available water within the variable effective rooting depth (ERD) that meets both the critical soil water potential at the lower limit of the ERD and the critical plant water status. We discuss the results of this approach based on dynamic CL-SWA maps for the next decades in Germany as example.

Multi-scale approaches for assessing causes and extent of aspen (*Populus tremuloides*) dieback following drought in western Canada. Hogg, E.H., Michaelian, M., Hall, R.J., Arsenault, E.J. (*Natural Resources Canada, Canada; Ted.Hogg@NRCan.gc.ca; Michael.Michaelian@NRCan.gc.ca; Ron.Hall@NRCan.gc.ca; Eric.Arsenault@NRCan.gc.ca*).

Drought-induced forest dieback has emerged as a major global risk for the future under anthropogenic climate change. As part of a regional monitoring study, we have documented increasing mortality of western Canadian aspen forests following the exceptionally intense regional drought of 2001–2003. An aerial survey in 2004 revealed locally severe aspen mortality resembling the effects of fire, but there was considerable patchiness of both aspen forest cover and in aspen mortality levels across the landscape. Such patchiness poses a challenge for large-scale reporting of drought impacts on forest productivity and carbon cycling. We addressed this challenge through a multi-scale approach that includes tree-ring analysis, plot-based monitoring, remote sensing, modelling, and the application of a climate moisture index. A spatial analysis gave an estimated 45 Mt of dead aspen stem mass across a severely drought-affected, 11-Mha area. Regional aspen mortality has remained high since 2003, and stem damage by wood-boring insects has increased. This event shares features common to many other documented forest dieback episodes around the world, and our experience points to the need for a globally integrated, multi-scale monitoring system to address the critical question of how climate change is affecting the health and sustainability of the world's forests.

Rapid mountain range retractions of forest trees and their implications for dieback in lowland regions. Jump, A.S. (*University of Stirling, UK; a.s.jump@stir.ac.uk*).

Increases in temperature and drought linked to global climate change are having wide ranging impacts on forest tree species, from their ecology and distribution to their adaptation and survival. There is abundant evidence from mountain regions throughout the globe that tree species are shifting upwards in altitude. Populations are expanding at the upper limit of species, linked to rising temperatures, whilst at their lower limits, species show declining growth and increased mortality driven by rising temperatures and increased drought. Focusing on the retreating limits of temperate broadleaved forest in European mountains, I will discuss recent work on growth decline and dieback in forest trees, and predicted rapid future shifts in forest composition. Climatic changes that occur over small elevational increases in mountains can be compared with similar changes occurring over distances one thousand times greater in lowland regions (the altitude-for latitude model). I will conclude with a discussion of the implications of the findings of mountain-based studies for lowland forests, where an increase in the frequency and spatial extent of dieback events should be anticipated.

Global warming related dieback of evergreen coniferous forests in Korea due to high temperature and drought stress in winter season. Lim, J.H., Chun, J.H., Shin, J.H. (*Korea Forest Research Institute, Republic of Korea; limjh@korea.kr; chunjh69@forest.go.kr; kecology@forest.go.kr*).

Since the late 1990s, decline of evergreen coniferous forests in Korea has been increasing, especially after warm, dry winters. Following mass mortality of Korean red pines in 1998, 2002, and 2007, more than 1 million trees were dead in 2009 due to drought and warm winter temperatures, which promoted the pathogenicity of *Cenangium ferruginosum*, especially in southern areas of the distribution range. Mortality of Korean fir on Mount Halla increased linearly with increasing previous winter temperature. Physiological measurement showed that stress is induced at temperatures higher than 15 °C. These two cases support the hypothesis that heat accelerates drought stress, which is one of the major mechanisms of population dieback in the southern part of Korean red pine and Korean fir's distribution range by global warming. Korean climate has four distinct seasons with hot/humid summers and cold/dry winters and IPCC-SRES models have projected changes in seasonal climate patterns. The projected increase in air temperature will be more rapid in winter than summer, while projections for precipitation are more variable and uncertain. Thus evergreen coniferous forests in Korea are potentially vulnerable to future climate change impacts, primarily due to increasing of winter temperatures.

Direct and indirect effects of drought in large-scale pine dieback in the European Alps. Rigling, A. (*Swiss Federal Research Institute for Forest, Snow and Landscape WSL, Switzerland; andreas.rigling@wsl.ch*), Bigler, C. (*Swiss Federal Institute of Technology ETH, Switzerland; christof.bigler@env.ethz.ch*), Eilmann B., Engesser, R., Gimmi, U. (*Swiss Federal Research Institute for Forest, Snow and Landscape WSL, Switzerland; britta.eilmann@wsl.ch; roland.engesser@wsl.ch; urs.gimmi@wsl.ch*), Gonthier, P., Motta R., Nicolotti, G. (*University of Turin, Italy; paolo.gonthier@unito.it; renzo.motta@unito.it; giovanni.nicolotti@unito.it*), Wermelinger B., Heiniger, U., Polomski, J. (*Swiss Federal Research Institute for Forest, Snow and Landscape WSL, Switzerland; beat.wermelinger@wsl.ch; ursula.heiniger@wsl.ch; janina.polomski@wsl.ch*), Vacchiano, G. (*University of Turin, Italy; gvacchiano@inwind.it*), Weber, P., Wohlgemuth, T., Zweifel, R., Dobbertin, M. (*Swiss Federal Research Institute for Forest, Snow and Landscape WSL, Switzerland; pascale.weber@wsl.ch; thomas.wohlgemuth@wsl.ch; roman.zweifel@wsl.ch; matthias.dobbertin@wsl.ch*).

In the European Alps extended protection forests are formed by the sub-Boreal *Pinus sylvestris* L. growing on dry sites close to its southern range of distribution. In the past decades mortality processes in pine forests have been reported for the Swiss Rhone valley and other dry inner valleys of the Austrian and Italian Alps. A multi-disciplinary research approach was applied to disentangle the various forcing factors of pine decline. The studies were conducted in the Swiss Rhone valley, in the Italian Aosta valley, and the Northern Piedmont. The findings clearly show that predisposing factors such as stand competition, mistletoe infestation, and insect shoot-feeding affected the pine over decades and increased its susceptibility to short-term, inciting stresses

such as drought, insect breeding, or pathogenic blue stain fungi. Such inciting factors affected the physiological functioning of the pine and reduced its potential for pathogen defense. Finally, the pine's death depended on further contributing factors such as secondary opportunistic insects and pathogenic fungi and nematodes, which killed the stressed pines. As most of these investigated factors are directly linked with increasing temperatures, the observed pine dieback will increase in abundance with unknown consequences for forest goods and services.

Population-wide mortality in multiple forest types in western North America: onset, extent, and severity of impacts as indicators of climatic influence. Shaw, J.D. (*U.S. Forest Service, USA; jdshaw@fs.fed.us*), Long, J.N. (*Utah State University, USA; james.long@usu.edu*), Thompson, M.T. (*U.S. Forest Service, USA; mtthompson@fs.fed.us*), DeRose, R.J. (*Utah State University, USA; rjustinderose@gmail.com*).

A complex of drought, insects, and disease is causing widespread mortality in multiple forest types across western North America. These forest types range from dry *Pinus-Juniperus* woodlands to moist, montane *Picea-Abies* forests. Although large-scale mortality events are known from the past and considered part of natural cycles, recent events have largely been attributed to climate change. We use data from the Forest Inventory and Analysis program to assess the onset, extent, and severity of impacts of mortality events that have occurred since the mid-1990s. We examine progression of mortality from susceptible stand structures to less susceptible conditions, large-scale patterns within forest types as related to elevation and latitude, and the sequence of mortality onset among different forest types located along topo-edaphic gradients. We found that there have been synchronous insect outbreaks over millions of hectares, suggesting that broad-scale climatic factors are involved. However, at this point it does not appear that there have been significant range contractions such as might be expected from shifting climatic conditions, and local extirpations have been rare. Our current research includes improvement of methods we use to analyze mortality trends, so that population shifts can be detected when they occur.

Widespread increase of tree mortality rates in the western United States. Van Mantgem, P., Stephenson, N.L. (*U.S. Geological Survey, USA; pvanmantgem@usgs.gov; nstephenson@usgs.gov*), Byrne, J.C. (*U.S. Forest Service, USA; jbyrne@fs.fed.us*), Daniels, L.D. (*University of British Columbia, Canada; daniels@geog.ubc.ca*), Franklin, J.F. (*University of Washington, USA; jff@u.washington.edu*), Fulé, P.Z. (*Northern Arizona University, USA; Pete.Fule@nau.edu*), Harmon, M.E. (*Oregon State University, USA; Mark.Harmon@oregonstate.edu*), Larson, A.J. (*University of Montana, USA; andrew.larson@cfc.umt.edu*), McDowell, N. (*Los Alamos National Laboratory, USA; mcdowell@lanl.gov*), Smith, J.M. (*University of Colorado, USA; jmsmith@colorado.edu*), Taylor, A.H. (*Pennsylvania State University, USA; aht1@psu.edu*), Veblen, T.T. (*University of Colorado, USA; veblen@colorado.edu*).

Persistent changes in tree mortality rates can alter forest structure, composition, and ecosystem services such as carbon sequestration. Our analyses of longitudinal data from unmanaged old forests in the western United States showed that background (non-catastrophic) mortality rates have increased rapidly in recent decades, with doubling periods ranging from 17 to 29 years among regions. Increases were also pervasive across elevations, tree sizes, dominant genera, and past fire histories. Forest density and basal area declined slightly, suggesting that increasing mortality was not caused by endogenous increases in competition. Regional warming and consequent increases in water deficits are likely contributors to the increases in tree mortality rates. Increasing mortality rates in some cases could be symptomatic of forests that are stressed and vulnerable to abrupt die-back. We will present preliminary results from other work at our sites, including the reasons for declining forest basal area and patterns of tree-ring stable carbon isotopes from samples of living and recently dead trees, which provide evidence about the causes of mortality. Our work contributes to a growing body of evidence indicating that ongoing environmental changes may be driving both chronic and acute changes in forests worldwide.

Climate change impact on tree architecture may contribute to forest decline and dieback. Vennetier, M., Girard, F. (*CEMAGREF, France; michel.vennetier@cemagref.fr; francois.girard@cemagref.fr*), Ouarmim, S. (*CNRS, France; samira.ouarmim@cefe.cnrs.fr*), Thabeet, A. (*University of Alep, Syria; alithabt@yahoo.fr*), Ripert, C. (*CEMAGREF, France; christian.ripert@cemagref.fr*), Caraglio, Y. (*CIRAD, France; yves.caraglio@cirad.fr*), Cailleret, M. (*INRA, France; maxime.caillert@avignon.inra.fr*).

The impact of repeated droughts on tree architecture was studied in south-eastern France from 1995 to 2010. For all six studied species, branching rate decreased and for concerned species, a reduction of polycyclism rate occurred. The size and number of leaves were also significantly reduced. The simplified architecture limits the capacity of trees to explore available space and contributes to low LAI and crown transparency. For evergreen species, reductions in leaf size also limit the potential maximum LAI for 3 to 8 years according to their life span. Together, changes in light architecture and leaf size may cut the potential LAI by more than 50% for several years after repeated bad years. This may contribute to carbon shortage and starvation for many years following extreme climatic events. For some species, long measurement series allowed untangling of the relationship between architecture parameters and climate parameters (monthly or seasonal) from current and previous years. The models showed that crown development should be significantly reduced in the future. Architectural parameters appeared to be directly linked to tree vigour, and could be good indicators of tree health. The simplification of architecture can be considered as an early warning of potential dieback.

Chinese and global examples of drought and heat-induced forest mortality associated with insect pests and pathogens. Zhang, Z. (*Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, China; zhangzhen@caf.ac.cn*), Allen, C.D. (*U.S. Geological Survey, Jemez Mountains Field Station, USA; craig_allen@usgs.gov*).

Projected climate change increases in warm and dry conditions have potential to interact with biotic agents such as insect pests and diseases to markedly increase tree mortality in many regions. A recent global overview reported 88 documented examples of drought- and heat-induced tree mortality. Although quantitative comparisons among these highly diverse examples are subject to consistency and precision challenges due to the wide range of methods used in the original studies, along with variability in the amount of detail provided in the overview summary tables, it is observed that 56% (49 of 88) of these examples reported

associated biotic mortality agents. Among these cases, 94% (46) involved insect pests and 35% (17) noted pathogens. For the insect cases, 57% noted bark beetles, 33% mentioned other wood borer or engraver beetles, and 20% listed defoliators. Fungi dominated the pathogen examples, mentioned in 82% of cases. A review of Chinese drought-related tree mortality and associated forest pests is presented, further illustrating these patterns in greater regional detail. These findings highlight the global need for better knowledge on the interactions between drought and heat conditions, tree stress, and biotic agents like bark beetles and fungi in the development of broad-scale tree mortality.

Posters

Change detection and vegetation mapping of Korean fir stands around the peak of Mt. Halla, Korea. Chun, J.H., Lim, J.H., Kim, Y.K. (*Korea Forest Research Institute, Republic of Korea; chunjh69@forest.go.kr; limjh@forest.go.kr; youngkul@forest.go.kr*).

Korean fir (*Abies koreana*) is one of the important endemic tree species that has a localized distribution around the peaks of few high mountains in Korea. Relatively small population sizes of the remaining isolated Korean fir stands increase the possibility that they may be threatened with extinction. The aims of this remote sensing and GIS research were to identify the present Korean fir stands remaining around the peak of Halla Mountain, to describe species composition and map the pattern of the vegetation communities across the study site for continued monitoring in the future, and to detect changes over time. According to the results of change detection analysis based on the comparison of Landsat NDVI over time, little change was detected in the healthy stands mainly located on the north-eastern slope, but statistically significant ($p < 0.05$) differences were detected in the declining stands on the south-western slope. IKONOS imagery and an object-oriented classification method were utilized to produce the present vegetation map around the peak of Mt. Halla. The classification was found to be quite reliable, achieving an accuracy of about 90%. The results will provide support for the conservation planning of Korean fir habitat in the context of climate change.

Adaptation mechanism to water stress in *Fagus crenata* in Japan. Kawaguchi, T., Ikeda, T. (*Kyoto Prefectural University, Japan; s809632008@kpu.ac.jp; tikeda@kpu.ac.jp*).

It is predicted that the area with suitable site conditions for *Fagus crenata* in Japan will be contracted by global warming. We evaluated the adaptation mechanism to water stress in *F. crenata* growing in Kyoto City, where climatic conditions are hotter and drier than in native *F. crenata* stands. These urban trees often undergo dieback during summer. We examined the seasonal changes in water relation parameters, midday water potential and percent loss of conductance (PLC). Midday leaf water potential decreased significantly from July and August. Water deficits increased from August to September. On the other hand, leaf water potential at the turgor loss point showed a significant decrease from July to August. This indicates that *F. crenata* improved its drought tolerance during this season. There was no significant difference between leaf water potential at turgor loss point and midday leaf water potential. The cell wall elasticity significantly increased. PLC increased to 11%, which is not as high as the increase recorded in other species, and suggesting that xylem cavitation does not have a serious impact on water status. These results show that decline of midday leaf water potential to values near to the turgor loss point seems to result in dieback.

Increasing reports of unexplained die-back and death of native trees in Southern Africa. Roux, J., Van Der Linde, J., Mehl, J., Cruywagen, E. (*University of Pretoria, South Africa; jolanda.roux@fabi.up.ac.za; johan.vanderlinde@fabi.up.ac.za; james.mehl@fabi.up.ac.za; elsie.cruywagen@fabi.up.ac.za*), Van der Merwe, S. (*Lion Working Group, South Africa; mwnatura@mweb.co.za*), Malan, R. (*National Zoological Gardens Biodiversity Conservation Centre, South Africa; malanw@absamail.co.za*), Van Rooyen, G., Wingfield, M. (*FABI, University of Pretoria, South Africa; gretel.vanrooyen@up.ac.za; mike.wingfield@fabi.up.ac.za*).

During the past 2 decades, there have been many new reports of native trees dying in Southern Africa. In most cases, the causes of these deaths remain unknown, although climate change is commonly mentioned as a contributing factor. For example, the large-scale death of *Aloe dichotoma* in Namibia and South Africa, has been shown to be caused by climate change-driven range shift, while recently recorded deaths of native plants in the Outeniqua mountains has been attributed to higher than normal rainfall. The death of woody *Leucospermum* spp. and *Ocotea bullata* trees in the Western Cape Province is due to alien invasive pathogens. In many cases, such as those of dying *Acacia erioloba* and *Euphorbia ingens*, the cause of death remains unclear. Preliminary studies of declining *A. erioloba, Pterocarpus angolensis, Adansonia digitata*, and *E. ingens* has revealed numerous undescribed fungi, emphasising the limited information regarding microorganisms associated with trees in Africa. Surprisingly, a number of insects, possibly representing undescribed species, have also been collected. There is clearly a serious need to better understand large-scale mortality of native Southern African trees and there is a serious risk of extinctions of tree species. Such studies will require cross-disciplinary research initiatives.

Forest dieback and decline: what did we learn from a 10-year long anticipated occurrence of 2040 climate in South-eastern France? Vennetier, M., Ripert, C. (*CEMAGREF, France; mvennetier@cemagref.fr; christian.ripert@cemagref.fr*).

Southeastern France recently experienced an exceptionally hot and dry decade, equivalent to what should be the climate around 2040 according to the IPCC B2 scenario. Although adapted to drought, many Mediterranean tree species showed high levels of dieback from sea level to 1,500 m. According to elevation, site characteristics, stand age, and species, dieback patterns could be attributed to several causes including sunburn during heat waves, repeated water shortage, starvation after carbon stock depletion, insect attacks, and interaction between drought and fire impacts. Globally, no place could be considered safe from some form of forest decline or dieback. As many species of the undergrowth are also affected, the impact of climate change on biodiversity was analysed. A significant turnover of the flora was observed, leading to a shift towards drought-resistant species. At the regional level, the diversity of landscape mosaic and species mixture led to patchy and scattered mortality rather than large-scale dieback. High rainfalls in the two past falls and winters have stopped forest decline. But the remaining poor average health condition of most tree species indicates that forests as a whole could be at risk if the climate of the last decade continues in future.

A-08 Silviculture and global change: managing forests for ecosystem resiliency and carbon storage

Organizers: Kevin O'Hara, *University of California-Berkeley, USA, kohara@berkeley.edu;* Juergen Bauhus. *University of Freiburg, Germany, juergen.bauhus@waldbau.uni-freiburg.de.*

Silviculture to achieve multiple objectives in a changing climate. Bauhus, J. (*University of Freiburg, Germany; juergen.bauhus@waldbau.uni-freiburg.de*), O'Hara, K. (*University of California, USA; kohara@berkeley.edu*).

Emerging challenges for forestry include the need to jointly manage forests for a variety of new objectives. These include meeting increasing needs for wood products, facilitating "naturalness" in forest ecosystems, and providing forests adapted to future climate changes, as well as more traditional forest management objectives. This will require a new suite of silvicultural systems to meet these new challenges. Although silviculture has a history of providing solutions to conflicting objectives at the stand-level, these new objectives involve multiple spatial scales, managing for resistance and resilience to future perturbations, and the uncertainty of how future climate change will affect all these new challenges. We present a discussion of how to reconcile the complex and often conflicting demands in different types of forest ecosystems. We propose silvicultural approaches that include the flexibility to accommodate future uncertainty with climate while aiming to maintain or enhance the provision of ecosystem goods and services including forest products.

A mechanistic ecosystem model to derive forest carbon, nitrogen, and water balance. Hasenhauer, H. (*University of Natural Resources and Applied Life Sciences, Austria; hubert.hasenauer@boku.ac.at*).

In this study, we link forest inventory data and mechanistic ecosystem modelling theories to derive the carbon, nitrogen, and water balance and its interactions with forest management and climate change impacts. We use all the Austrian national forest inventory data, including some of our experimental sites, and have all daily climate data since 1960 across Austria. We compare different strategies (e.g., coppice versus high forests, etc.) and analyze the importance of forests as carbon storage.

Effects of elevated CO_2 on the aboveground growth of sprouts of deciduous broadleaved trees grown in FACE. Koike, T., Watanabe, M., Eguchi, N., Watanabe, Y., Satomura, T., Mao, Q., Takagi, K. (*Hokkaido University FSC, Japan; tkoike@for.agr.hokudai.ac.jp; nab0602@for.agr.hokudai.ac.jp; eguchi_717@yahoo.co.jp; youko@for.agr.hokudai.ac.jp; takami_satomura@yahoo.co.jp; maomerry@for.agr.hokudai.ac.jp; kentt@fsc.hokudai.ac.jp*), Funada, R. (*TUAT, Fuchu-Tokyo, Japan; funada@cc.tuat.ac.jp*), Sasa, K. (*Hokkaido University FSC, Japan; sasa@fsc.hokudai.ac.jp*).

Biomass production of sprouts was determined in deciduous broadleaved trees grown under elevated atmospheric CO_2 concentration with FACE (Free Air CO_2 Enrichment). To know the sustainable use of woody biomass from SATOYAMA, a traditional rural landscape of Japan, we harvested above-ground biomass of 10 broadleaved trees native to northern Japan in every autumn for 3 years from 2007 and estimated their biomass production. Nine species selected consisted of early successional species (alder, white birch, Monarch birch), late successional species (oak, basswood, maple), and gap phase species (elm, Kalopanax, ash). The CO_2 fumigation had been carried out on these species raised at fertile brown forest soil and infertile volcanic ash soil for every growing season for 5 years. No sprout was obtained from the stumps of alder and Monarch birch. Biomass of the remaining species at high CO_2 was greater than that at ambient CO_2], which was independent of soil fertility. No yearly fluctuation was found in biomass at between 2008 and 2009. Biomass production increased in ash while it decreased in basswood. From these results, wise use of SATOYAMA in a high CO_2 world is discussed.

Mixtures as a means of adapting Sitka spruce plantations to climate change–from fantasy to reality. Mason, B. (*Forest Research, United Kingdom; bill.mason@forestry.gsi.gov.uk*).

Plantation forests of Sitka spruce (*Picea sitchensis*) cover an area of 1.2 M/ha in the Atlantic region of northwest Europe, particularly in Great Britain and Ireland. Traditionally managed under patch clear-felling regimes, these plantations have high productivity by European standards (averaging 14–16 $m^3/ha^{-1}/y^{-1}$), support important wood using industries, and achieve high rates of carbon sequestration and storage. Current policies favour diversifying the species and structural composition of these plantations to provide a range of non-market benefits. Such diversification is also postulated to help adaptation to climate change. The paper presents growth-and-yield data from long-term mixture experiments, which suggest that the fast, sustained growth rate of Sitka spruce will suppress most admixed species over a period of 30–50 years. However, the resulting pure Sitka spruce stands have structural features that may confer greater resilience to wind disturbance and hence better adaptation to projected climate change in an oceanic environment. The potential impact of these results for future carbon sequestration and stocks will be considered as well as the wider implication for Sitka spruce silviculture.

Stand structures and silvicultural systems to maximize carbon storage. O'Hara, K., Jones, D., Caldwell, B. (*University of California/Berkeley, USA; kohara@berkeley.edu; dryw.jones@gmail.com; btcaldwell@berkeley.edu*).

Forest ecosystem carbon storage is becoming an increasingly important objective of forest management. Stand structure, or the horizontal and vertical arrangement of stand components, can have important effects on forest carbon and total carbon storage. Silvicultural practices that affect growth rates, species composition, or age structure can therefore have important implications for carbon storage. Generally, carbon content in forests is estimated from allometries with forest biomass and stand volume. Many growth-and-yield models are capable of generating estimates of carbon and can therefore provide comparative estimates of carbon storage with different silvicultural prescriptions. However, these estimates are based on the assumption that dry forest biomass is 50% carbon. Carbon content varies: (1) vertically and horizontally in tree stems, (2) with species, and (3) with growth rates as influenced by suppression. We demonstrate how variations in stand structure resulting from silviculture can affect carbon storage beyond the effects on stand volume or biomass. The effects of these variations are presented as a "carbon index," where carbon concentrations due to variations in stand structure can be easily assessed.

Silviculture in times of global change and uncertainty: achieving resiliency by managing forests as complex adaptive systems. Puettmann, K.J. (*Oregon State University, USA; Klaus.Puettmann@oregonstate.edu*).

Future challenges for silviculture include coping with increased variability and uncertainty of ecological, social, and economical conditions. At the same time, political, social, and economical pressures will likely limit or alter silvicultural opportunities and practices. In the context of a highly uncertain future, we propose that silvicultural goals are more likely to be achieved by reliance on ecosystem resilience, and that complexity science provides a conceptual framework for accomplishing such goals. The talk starts with basic ecological concepts describing how ecosystems adapt naturally to changing environmental and ecological conditions and how these concepts can be utilized in a silviculture context. Next, we discuss how silviculture can benefit from viewing forest ecosystems as complex adaptive systems. We provide specific examples on how to quantify impacts of silvicultural practices on resilience, such as by assessing response type diversity for various ecosystem functions and relating this diversity to a variety of possible future changes. The presentation also covers how these ideas influence the general approach to silvicultural manipulations, as well as examples of how silvicultural prescriptions can be modified to accommodate a focus on resilience.

Rehabilitation practices of degraded forests for carbon sequestration in Turkey. Sivacioğlu, A. (*Kastamonu University, Turkey; ahmets1973@gmail.com*).

Nearly half of Turkey's forests are not suitable for producing high quality wood products. For that reason, one of the main issues for Turkish foresters is improving degraded forests using rehabilitation practices. Some 2.3 million hectares of land in Turkey will be subjected to reafforestation, erosion control, and rehabilitation between the years 2008 and 2012. Increasing carbon sequestration and reducing rural poverty are only two of the important expected benefits. As of the 1990s, some methods of afforestation were widely applied for rehabiliting degraded forests, but these methods have been criticized for being too narrow in focus, concentrating on planting a few pine species that provide a limited number of goods and services. In recent years in Turkey, the rehabilitation concept has come to mean improvement of degraded forests, for which no practices have been offered in past management plans, by taking into consideration ecosystem integrity, biodiversity conservation, and use of growth dynamics of the stands to the maximal degree, with minimal labor and cost. In different regions of Turkey, varied techniques are being applied to rehabilitate forests. In this study, rehabilitation practices in Turkey were evaluated in the context of carbon sequestration.

Energy nurse crops: long-term effects on forest soil nutrient and carbon pools. Stark, H., Bauhus, J., Unseld, R. (*Freiburg University, Germany; hendrik.stark@waldbau.uni-freiburg.de; juergen.bauhus@uni-freiburg.de; ruediger.unseld@waldbau.uni-freiburg.de*), Schüler, G. (*Landesforsten Rheinland-Pfalz, Germany, gebhard.schueler@wald-rlp.de*).

Nurse crops of fast-growing tree species can be a silvicultural approach for afforestations or forest restoration after storm damage, providing short-term benefits through increased biomass production for bio-energy, while presumably favouring soil C storage, nutrient retention, hydrology, etc. We studied the effects of so-called energy nurse crops on soil nutrient and carbon dynamics relative to ordinary restoration practices. In 1990, 16 monoculture plots of birch (*Betula* spp.), aspen (*Populus* spp.), and oak (*Quercus petraea*) were established at two different sites, and in 1996 oak was planted beneath the sheltering birch and aspen canopies. In 2009, we determined soil nutrient and carbon concentrations, and quantified nutrients stored in above-ground biomass. Soil nutrient leaching has been monitored at six plots since 1996, and a water balance model had been calibrated for the sites. Here we report on differences in soil nutrient and carbon concentrations between oak monocultures and nurse crops, in soil nutrient leaching, above-ground nutrient storage, and atmospheric deposition, respectively. We hypothesize that nurse crops not only provide additional biomass to be used to offset fossil fuels, but they also increase soil carbon storage and reduce nutrient leaching.

Posters

Effects of *Pinus radiata* afforestation on soil carbon sequestration and soil quality in maritime dunes. Ares, A. (*Oregon State University, USA; adrian.ares@oregonstate.edu*), Amiotti, N., Zalba, P., Rossi, J. (*Universidad Nacional del Sur, Argentina; namiotti@criba.edu.ar; pzalba@uns.edu.ar; rossijavier@yahoo.com.ar*).

Afforestation of grasslands can increase carbon sequestration and provide additional environmental benefits. Pine plantations, however, can deplete soil organic carbon and have other detrimental effects on soils. We examined soil characteristics under a 45-yr old *Pinus radiata* stand and adjacent grassland on maritime dunes in temperate Argentina. Soil under the pine plantation had greater soil carbon (+ 93%), total nitrogen (+ 55%), and available phosphorus (+ 100%) concentrations than under grassland. Carbon was stored both in the organic and mineral horizons at an accretion rate of 0.64 Mg/ha yr. At 0- to 25-cm depth, soil carbon amounted to 61 Mg/ha under pine and 27 Mg/ha under grassland. Soil carbon accumulated more in dune slopes (35 Mg/ha) than in ridges (29 Mg/ha) and bottoms (12 Mg/ha). Compared with the grassland, soil acidity, cation exchange capacity, base losses (potassium > calcium = magnesium), and C/N ratio increased under pine topsoil. Spatial heterogeneity in soil characteristics was greater under pine than in grassland. Such variability was non-systematic and did not validate the "single-tree influence circle" concept. Afforestation contributed to develop carbon sinks in soil, forest floor, and tree biomass in maritime dunes with ustic climate regime.

Above-ground carbon stores in temperate coniferous stands subjected to fixed- and variable-density thinnings. Ares, A., Mulford, S., Puettmann, K. (*Oregon State University, USA; adrian.ares@oregonstate.edu; saramul@gmail.com; Klaus.Puettmann@oregonstate.edu*), Weiskittel, A. (*University of Maine, USA; aaron.weiskittel@umit.maine.edu*).

Alternative silviculture strategies can enhance ecosystem services including carbon sequestration. We examined thinning effects on above-ground carbon stored in trees in forests dominated by *Pseudotsuga menziesii* and *Tsuga heterophylla* in western Oregon, USA. Each site contained an unthinned control and thinning treatments selected to increase structural diversity (high, moderate, and variable density with 300, 200, and 100–300 trees/ha). We estimated above-ground biomass by tree component from overstory data collected 6 years (7 sites) and 11 years (4 sites) after thinning, and calculated carbon stores using regional

conversion coefficients. There was a strong linear relationship between total carbon storage and basal area 6 (r^2 = 0.95) and 11 (r^2 = 0.98) years after thinning, pointing to weak treatment effects on DBH-height ratios. Six years after thinning, above-ground carbon storage (208 Mg to 80 Mg/ha) was greater in controls than in thinning treatments. At similar stand densities, stands with fixed- and variable-density thinning stored similar amounts of carbon. Carbon accumulation rates between year 6 and 11 did not differ among treatments. Above-ground carbon stores appeared unaffected by thinning type (fixed versus variable density). Increased plant diversity after thinning should be integrated with carbon storage for a holistic assessment of thinning regimes.

Leaf area and wood growth efficiency in *Pinus elliottii* stands. Cabrelli, D.A., Rebottaro, S.L., (*University of Buenos Aires, Argentina; dcabrell@agro.uba.ar; rebottar@agro.uba.ar*).

Pinus elliottii is one of the most widely planted conifers in Argentina, due to its productivity and multiple uses. Conifer plantation management systems in Argentina are characterized by long rotations with thinning. These practices maintain high growth rates and allows intermediate harvests that increase the internal rates of return. Longer rotations are considered more sustainable, among other reasons for more effective nutrient recycling. Thinning not only changes the wood stock, but also leaf area index (LAI), which is a major determinant of stand productivity. Changes in the foliage produce changes in growth efficiency (GE). We evaluated the GE and its relationship with LAI in *P. elliottii*. The experimental work was conducted in three study areas, in managed and unmanaged stands covering an age range of 7–31 years. LAI was estimated through hemispherical photography and through destructive sampling. Wood productivity was estimated from annual inventories and calculation of current annual increase (CAI). The LAI varied between 0.85 to 3.41, GE between 70 to 1000 gr wood m^{-2} leaf $year^{-1}$, and CAI from 1 to 15 t ha^{-1} $year^{-1}$, depending on stand age and management. Relationships between foliage variables and stand density index were established.

Carbon sequestration potential of mangrove forests in the Philippines. Camacho, L.D. (*University of the Philippines Los Baños, Philippines; camachold@yahoo.com.ph*), Youn, Y.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*), Carandang, A., Camacho, S., Gevaña, D., Rebugio, L. (*University of the Philippines Los Baños, the Philippines, the Philippines; tony115858@yahoo.com; sonny_camacho@yahoo.com; wuweidix@yahoo.com; lucrebugio@gmail.com*).

The rehabilitation of mangrove ecosystems is considered to be very important in the Philippines to sustain their role in mitigating the impacts of climate change. This research aimed to provide reliable information on mangrove's potential for carbon sequestration as basis for effective forest management interventions. The study estimated the amount of carbon sequestrated by mangrove plantations and natural stands in Bohol Islands, Philippines. Modified quadrat sampling techniques and individual tree biomass measurements using destructive sampling by age were used. Tree biomass was estimated using allometric equations. The case of Banacon mangrove in the Province of Bohol is perhaps one of the best sites for assessing the potentials of mangroves in climate change mitigation. Results of the study indicated that more carbons is being stored by the plantations than by the natural stands. Carbon density in the plantation could reach as high as 371 ton/ha at the age of 40 years, as compared to 190 ton/ha in natural stand. Results of destructive sampling showed that carbon density and wood volume could be at least 75 kg and 0.50 m^3 per tree, respectively. Thus, there is a great potential to sequester more atmospheric carbon if plantations were to be established in open or degraded coastal areas.

Evaluation of productivity in volume and carbon fixation potential in mixed plantations in the Caribbean zone of Costa Rica. Cuenca, P., Uglade, L. (*CATIE, Costa Rica; pcuenca@catie.ac.cr; lugalde@catie.ac.cr*), Camacho, R. (*RTT, Costa Rica; rttcostarica@ice.co.cr*).

The existing experiences in plantations composed by a mixture of species in tropical zones are scarce, especially with respect to their silvicultural management to produce of timber and store carbon simultaneously. This study included a total of 18 systems of plantations in different species mixtures, and involved 8 species, of which 4 were native. Plantation systems were grouped for analysis according to the number of species and age, which included between 2 and 4 native and exotic species of ages 2, 5, and 9 years in two zones (Guápiles and Turrialba) located in the Caribbean zone of Costa Rica. The best systems contained the mixture of *V. guatemalensis*, *H. alchorneoides* and *A. hunsteini* species (213.9 m^3/ha total volume) at 9 years, followed by the system of four species (164.8 m^3/ha total volume) at 5 and 8 years of age. There were significant differences in MAI-VOL by the number of species, systems and sites. The monocultures were more productive in total volume in comparison to the main species in mixed systems. The results of this study can be considered as pioneering for mixed plantations managed for wood and carbon fixation in the Latin American tropics.

Effect of stand density on canopy health and tree drought stress. Grulke, N. (*U.S. Forest Service, USA; ngrulke@fs.fed.us*), Graves, A. (*University of California/ Davis, USA; adgraves@ucdavis.edu*).

A commonly held dogma is that high forest stand density reduces canopy health and increases tree drought stress. We tested this assumption in five locations distributed across 9 degrees of latitude in California, USA, with Jeffrey pine, one of the yellow pines that dominate montane forests in the Sierra Nevada. In all locations, drought stress (physiologically defined) was severe in 2007. In 2008, there was a gradient from average precipitation to continued severe drought stress, south to north. At each location, stand density in 6 plots was measured (3 dense and 3 thin stands). Canopy health attributes for 8 trees in each of the plots were assessed: level of foliar chlorotic mottle, needle and branch elongation growth, branch and bole diameter growth, needle retention, and presence of foliar and bark insects. In general, trees in higher stand densities exhibited reduced canopy health, but only in drought years. Insect attack occurred equally in thin and dense stands in northern populations, but was more common in thin stands in the southern to locations. With increasing frequency, severity, and duration of drought expected for California, we can expect reduced growth and deteriorating canopy health in dense stands.

Long-term forest biomass sequestration in deciduous broad- leaved forest. Hajime, U., Akira, U., Satoshi, K., Hirotuki, T., Shigeo, I., Shin, A., Hiroyuki, T. (*Forestry and Forest Product Research Institute, Japan; utsugi@ffpri.affrc.go.jp; akirauem@ffpri.affrc.go.jp; skitaoka@ffpri.affrc.go.jp; tobi@ffpri.affrc.go.jp; iida34@ffpri.affrc.go.jp; abeshin@ffpri.affrc.go.jp; tano@ffpri.affrc.go.jp*).

It is generally believed that net primary production (NPP) in a forest steadily increases to a maximum as the stands age and then declines gradually. Although both a simple asymptotic pattern and a simple peak pattern of NPP have been observed in even-aged stands, we have an incomplete understanding of the temporal changes in carbon accumulation during the transition of dominant trees from early-successional species to mid- or late-successional species in mature forests. We compare production between *Betula platyphylla*, *Quercus mongolica*, and other surveyed tree species, and discuss the role of mid- and late-successional species on changes in carbon sequestration with stand age. The study was conducted at the Sapporo Hitsujigaoka Experimental Forest of the Hokkaido Research Center, Forestry and Forest Products Research Institute. Long-term forest inventory data (1978 to 2003) showed that ANPP in the forest was almost constant, even though net biomass increment for stem (NBI_{stem}) of *B. platyphylla* had negative values from 1998 to 2003. NBI_{stem} of *Q. mongolica* and the other surveyed tree species had positive values from 1978 to 2003. Production by mid- and late-successional species including *Q. mongolica* compensated for the decline in production by *B. platyphylla* with increase in stand age.

Carbon pool of an *Acacia mangium* stand established on a degraded ecosystem. Ho, W.M., Ang, L.H. (*Forest Research Institute Malaysia, Malaysia; howaimun@frim.gov.my; anglh@frim.gov.my*).

The carbon (C) pool of a 10-year-old *Acacia mangium* stand established on sand tailings of an ex-tin mine was examined. Two trees selected from each dbh class (5, 10, 15 cm) were harvested and biomass determined. Trees with 5 cm dbh allocated more biomass in the roots (29%) compared to other trees (21%). The average above-ground biomass values were 18, 79, and 126 kg for the 5, 10, and 15 cm dbh classes, respectively. The average root biomasses were 6, 23, and 39 kg for the respective dbh classes. It was assumed that the C concentration of all tree components, forest floor litter, and vegetation was 50%. Litterfall was collected monthly in littertraps measuring 0.25 m^2 and averaging approximately 44 g/month, of which about 85% consisted of leaf. Forest floor litter samples were also collected, with an estimated value of 11.08 ± 2.36 t/ha or having 5t C/ha. Meanwhile, vegetation in the open area was estimated at 1.72 ± 5.21 t/ha and thus contributing to only about 15% C compared to the forest floor. Soil samples showed significantly higher ($p < 0.05$) soil organic carbon (SOC) compared to samples in the open at all levels of soil depth (0–5, 5–10, 10–15 cm), although SOC decreased with increasing soil depth.

Soil carbon dynamics of *Larix leptolepis, Pinus densiflora,* and *Pinus rigitaeda* plantations under a similar site condition. Jeong, J.Y., Kim, C.S., An, H.C., Cho, H.S., Choo, G.C., Park, J.H., Lee, C.K. (*Jinju National University, Republic of Korea; jy668@nate.com; ckim@jinju.ac.kr; sanahc@jinju.ac.kr; sanchs@jinju.ac.kr; sancgc@jinju.ac.kr; pjh@jinju.ac.kr; suam7@jinju.ac.kr*).

Evaluation of carbon (C) dynamics among forest plantations is a key process of the global C cycle. The objective of this study was to evaluate C dynamics of major coniferous plantations in Korea. The study was conducted in adjacent *Pinus densiflora, Larix leptolepis*, and *P. rigitaeda* plantations established in 1963. The mean C amounts by litterfall were higher in *P. densiflora* (2,683 kg C ha^{-1} yr^{-1}) or *P. rigitaeda* (2,592 kg C ha^{-1} yr^{-1}) than in *L. leptolepis* (1,937 kg C ha^{-1} yr^{-1}) plantations. Litter decomposition rates for 16 months was higher in *L. leptolepis* (282 g C kg^{-1}) than in *P. densiflora* (268 g C kg^{-1}) or *P. rigitaeda* (270 g C kg^{-1}) plantations. In contrast, root decomposition rates for 16 months was generally higher in *P. densiflora* (390–410 g C kg^{-1}) or *P. rigitaeda* (370–460 g C kg^{-1}) than in *L. leptolepis* (350–270 g C kg^{-1}) plantations. The mean annual soil CO_2 efflux rates were highest in *P. rigitaeda* (0.30 g CO_2 m^{-2} h^{-1}), followed by *P. densiflora* (0.27 g CO_2 m^{-2} h^{-1}) and *L. leptolepis* (0.24 g CO_2 m^{-2} h^{-1}) plantations. Results indicate that soil C dynamics were affected by tree species on similar site conditions.

Atmospheric CO_2 reduction by forest landscapes in middle Korea. Jo, H.K. (*Kangwon National University, Republic of Korea; jhk@kangwon.ac.kr*).

This study evaluated the role of forest landscapes for middle Korea in reducing atmospheric CO_2 levels against CO_2 emissions from energy consumption. Mean CO_2 storage per unit area by forest landscapes (including woody plants and soils) was greater in older age classes for the same forest types, and was greater in broadleaved forest than in coniferous forest for the same age classes. The CO_2 storage by broadleaved forest of age class V (41–50 years old) averaging 656.3 t/ha, which was the greatest of the age classes studied. Mean annual CO_2 uptake per unit area by woody plants also tended to be greater in older age classes for the same forest types. However, the CO_2 uptake for broadleaved forest was greater by 27.8 t/ha/yr in age classes III and IV compared to age class V with relatively lower tree density and annual growth rate. Total CO_2 storage by the study region's forest landscapes equaled approximately 4 times total CO_2 emissions. Woody plants annually sequestered about 20% of total CO_2 emissions. It is essential to preserve the forest types and age classes with greater CO_2 storage or uptake, and the role of offsetting CO_2 emissions can be favorably used for emission trading.

Influence of clear-cutting and thinning on soil respiration in red pine stands. Kim, C.S., Jeong, J.Y. (*Jinju National University, Republic of Korea; ckim@jinju.ac.kr; jy668@nate.com*), Son, Y.H. (*Korea University, Republic of Korea; yson@korea.ac.kr*).

The quantitative evaluation of soil respiration rates after forest management activities is a key process for understanding the carbon cycle because soil respiration can be affected by activities such as thinning and clear-cutting. The effect of clear-cut and thinning on soil respiration was evaluated in about 40-year-old *P. densiflora* stands. Soil respiration rates in the clear-cut plots were significantly higher than in uncut plots ($P < 0.05$) throughout the study period. Mean soil respiration rates were 0.52 g CO_2 m^{-2} h^{-1} for clear-cut and 0.37 g CO_2 m^{-2} h^{-1} for uncut pine plots. However, soil respiration rates were not significantly affected by thinning, although soil respiration rates during the growing season (May–October) were generally lower in thinned than in unthinned plots, whereas this pattern was reversed in the dormant season (December–March). The mean annual soil respiration rates were the same in the thinned (0.24 g CO_2 m^{-2} h^{-1}) and unthinned (0.24 g CO_2 m^{-2} h^{-1}) plots. The results indicated that soil respiration rates after forest management activities in Korean forest soils were significantly affected by clear-cut, but little changed by thinning.

Carbon storage of *Acacia auriculiformis* and *Acacia mangium* plantations in Mt. Makiling, Philippines. Lee, K.W., Lee, D. K., Kwon, K.C. (*Seoul National University, Republic of Korea; b20927@nate.com*; *leedk@snu.ac.kr; kkch30@yahoo.co.kr*), Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*).

This study was conducted to compare carbon contents between two *Acacia* (*A. auriculiformis* and *A. mangium*) plantations in Mt. Makiling, Philippines. The two species are fast-growing and well-known nursing trees adapted to nutrient-poor soils in humid tropics, especially after forest fire. To estimate carbon contents between two plantations, above-ground carbon, carbon of litter layers, and soil organic matter (SOM) were measured and analyzed. Leaf area index at both areas was measured as well. Dead wood and understorey were included in the above-ground. To calculate above-ground carbon contents, the allometric biomass equation developed by Brown (1997) was used and multiplied to 0.5. Understorey, litter, and soils were collected at four points in each plot. Seventy-two soil samples collected at depths of 10 cm up to 50 cm were analyzed using the loss-on-ignition method to obtain the SOM. Results of the study showed that above-ground carbon in the *A. mangium* and *A. auriculiformis* areas were 94.95 Mg C/ha and 94.86 Mg C/ha, respectively. In addition, SOM of *A. mangium* and *A. auriculiformis* in 0–10 cm soil layer was 102.55 Mg C/ha and 98.77 Mg C/ha, respectively. It was observed that SOM decreased with increasing soil depths in both plantation areas.

Effects of stand age and management on changes in the mineral and organic soil in pine plantations in Argentina. Rebottaro, S.L., Cabrelli, D.A., Rienzi, E. (*University of Buenos Aires, Argentina; rebottar@agro.uba.ar; dcabrell@agro.uba.ar; rienzi@agro.uba.ar*).

Pinus elliottii is an exotic species extensively planted in Argentina. However, little information exists about positive and negative impacts of these plantations on soils. In the present study, changes in the soil under 5- to 30-year-old *P. elliottii* plantations established on sandy soils with low CIC and organic matter were evaluated. The results showed that apparent density was not different between analyzed populations. Change in mechanical resistance was mainly attributed to roots in mature or high-density stands, and gravimetric soil moisture depended on canopy density. After clear cutting or immediately after thinning, significant decreases in soil moisture was recorded. Differences in accumulated litter were attributed to stand age. Litter improved water storage capacity, and capillary water loss. This indicates the importance of the retaining harvest residues on-site on these soils, principally during stages of greater impact (harvest and establishment). Organic carbon content of the mineral soil increased with the age of the plantation, though this effect was not permanent, since after clear cutting a decrease was recorded. While no significant changes in soil pH values were apparent, a tendency towards increases in CEC, N and Mg with stand age was found.

Effects of site, age, and thinning practice on the total biomass and dry matter content of roots, stem, and branches of European beech. Skovsgaard, J.P. (*Swedish University of Agricultural Sciences, Sweden; jps@ess.slu.se*), Nord-Larsen, T. (*University of Copenhagen, Denmark; tnl@life.ku.de*).

Fifty-eight whole-tree samples were collected in six plots of European beech located at three different sites, originating from three different age classes, and managed under contrasting thinning regimes. Thinning regimes included strictly unthinned stands and heavy thinning at regular intervals. Biomass was determined based on full-scale volume measurements of each biomass compartment (below-ground stump and roots, stem, and branches). Dry matter content was determined based on approximately 10 disc samples from each compartment. Tree size ranged from a dbh of 2 to 71 cm, a total stem volume of 0.1 to 5.2 m^3, and a belowground stump and root volume of 0.01 to 2.0 m^3. Results demonstrated a considerable potential for the management of biomass and carbon stocks. The study indicated an effect of thinning on the biomass and dry matter content of individual trees beyond that of tree size as reflected in dbh. Consequently, currently available models of whole-tree biomass may lead to significantly biased estimates when scaling-up to the regional or national level. In the future, models of forest dry matter should include variables reflecting stand conditions to directly adjust for variation in management practice whenever relevant.

Drought tolerance of Norway spruce (*Picea abies*) is increased by allocating more growing space to future crop trees. Sohn, J.A. (*University of Freiburg, Germany; julia.sohn@waldbau.uni-freiburg.de*), Gessler, A. (*Leibniz Centre for Agricultural Landscape Research* (*ZALF*)*, Germany; gessler@zalf.de*), Kohler, M., Bauhus, J. (*University of Freiburg, Germany; martin.kohjler@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de*).

The recent and predicted increases in extremely dry and hot summers emphasizes the need for silvicultural approaches to increase the drought tolerance of existing forests with the present species composition in the short term. Norway spruce, the most important timber species in Germany, is currently growing way beyond the species' natural distribution range, and thus is expected to be especially susceptible to negative effects of climate change. We aimed to investigate whether drought tolerance of Norway spruce crop trees, both in terms of resistance during droughts as well as recovery following drought, can be increased through allocating more growing space and thus more resources to individual trees. We combined methods of dendrochronology with analyses of stable isotopes of carbon and oxygen in tree-rings. Our results for both basal area growth and isotope ratios suggest that thinning has a positive effect on drought-impaired tree water status. Management implications and limitations of our findings are discussed and future research directions are outlined. Our study has produced evidence that thinning can help to alleviate severe drought stress in Norway spruce stands.

Allometric equations for the estimation of carbon stock in pine plantation forests in Vietnam. Vu Tan, P. (*Research Centre for Forest Ecology and Environment, Vietnam; Phuong.vt@rcfee.org.vn*), NguyenViet, X. (*Vietnam; Xuan.nv@rcfee.org.vn*).

In Vietnam, plantation forests cover a large area, about 2.8 million hectares, but there is insufficient basis for estimation of biomass and carbon stock of plantations in Vietnam, particularly pine plantations. The study was conducted to develop allometric equations for estimation of biomass and carbon stock of pine plantations using the destructive method. Two pine species of *Pinus merkussii* and *P. massoniana* were used. We harvested and measured 26 individuals for *P. merkusii* at the age of 14 to 19; and 26 trees of *P. massoniana* at the age of 6–26 for allometric equations. The results show that there is a close relation between stem, root, branch, above-ground biomass, and total biomass and DBH for both species. The correlation values are from 0.902 to 0.988. However, the coefficients between leaf biomass and DBH were low, 0.673 for *P. massoniana* and 0.786 for *P. merkusii* ($P < 0.05$). There is always correlation between carbon stock in biomass of different parts and DBH for two tree species; the closest correlations of carbon stock in biomass and DBH were found in the form of power equation.

Effect of thinning on belowground carbon storage in *Pinus densiflora* stands, central Korea. Yang, A.R., Son, Y.H., Noh, N. J., Lee, S.K., Jo, W.Y. (*Korea University, Republic of Korea; rami0130@hanmail.net; yson@korea.ac.kr; treeworld@empas.com; pedestrian119@empas.com; radiojwy@hanmail.net*), Kim, C.S. (*Jinju National University, Republic of Korea; ckim@jinju.ac.kr*), Bae, S.W., Hwang, J.H., Lee, S.T. (*Korea Forest Research Institute, Republic of Korea; BAE1144@forest.go.kr; jhwang@forest.go.kr; lst9953@forest.go.kr*).

This study was conducted to investigate the effect of thinning on belowground carbon (C) storage in *Pinus densiflora* stands, central Korea. We measured belowground C storage (forest floor, coarse woody debris and soil up to 30 cm depth) and soil characteristics (soil water content and pH) in four *P. densiflora* stands, central Korea: stand I and II (old and mature stands in Gangwon Province), stand III and IV (young and old stands in Gyeonggi Province). Study stands were thinned in 2008 with different thinning intensities by density (control, Ct: 0%, moderate, M: 33%, heavy, H: 51%). Total belowground C storage (ton C/ha) in thinned plots were higher than those in unthinned plots for the stand I and IV: 118.0 for H > 84.0 for M > 66.8 for Ct in the stand I, 60.5 for H > 55.8 for Ct > 52.4 for M in the stand II, 71.1 for M > 48.5 for Ct > 46.1 for H in the stand III, 67.1 for H > 59.9 for M > 57.1 for Ct in the stand IV. These results suggest that the thinning plays an important role to influence C storage for the *P. densiflora* forests.

A-09 Dendrochronology: a useful tool in climate change research

Organizer: Margaret Devall, *U.S. Forest Service, USA, mdevall@fs.fed.us.*

Extracting climate information from tree-rings via ensemble empirical mode of decomposition. Guan, B.T., Wright, W.E., Chiang, L.S. (*National Taiwan University, China-Taipei; btguan@ntu.edu.tw; wwright@ntu.edu.tw; r97625032@ntu.edu.tw*), Cook, E.R. (*Columbia University, USA; drdendro@ldeo.columbia.edu*).

As a natural archive of paleoinformation, tree rings have been used extensively and successfully in understanding paleoclimate dynamics. In this study, by assuming that the climatic signals are composed of quasi-cycles of various periods, we propose the use of ensemble empirical mode of decomposition (EEMD) as an alternative to extract climate signals. As an example, we applied the method to a set of tree-ring time series of *Pseudotsuga wilsoniana* with ages ranging from 92 to 210 years. Five intrinsic mode functions (IMFs) were extracted from the data. The periods of the IMFs are consistent with the quasi-periods of many well-known climate indices. The first two IMFs, which contain the highest frequency signals, correlate with El Niño-Southern Oscillation (Niño 3.4). The third and fourth IMFs combined correlates with the Pacific Decadal Oscillation. The fifth IMF, which has a dominant frequency at 76 years, correlates strongly with the Atlantic Multidecadal Oscillation and moderately with the Jan–Feb average of the Antarctic Oscillation. Although the mechanisms linking the climate dynamics to Taiwan are not yet clear in some cases, our results demonstrated the potentials of the EEMD approach in dendroclimatology.

An ensemble empirical mode decomposition approach for detecting climate signals in tree rings. Lo, Y.H., Guan, B.T. (*National Taiwan University, China-Taipei; yhlo@seed.net.tw; btguan@ntu.edu.tw*).

An important topic in dendroclimatology is to establish the relationship between tree-ring and global climate dynamics. By assuming climate signals are quasi-periodic in nature, in this study we explore the use of ensemble empirical mode decomposition (EEMD) to extract climate signals at different frequencies from tree-ring widths. Tree-ring widths for *Pseudotsuga menziesii* and *Picea glauca* × *engelmannii* were examined along an 800-meter elevation gradient in southern interior British Columbia, Canada. Ring-width data for each species at each site were decomposed into several levels of intrinsic mode functions (IMFs). Simple correlations were used to explore the relationships between the extracted IMFs and certain well-known climate indices. The IMF 1 and 2 of both species significantly correlated with high-frequency sea surface temperature indices, including NINO1+2, NINO3.4, and the Multivariate ENSO Index. The IMF 3 and 4 correlated significantly with low frequency signals including Pacific Decadal Oscillation and North Pacific Gyre Oscillation, relationships that the tree-ring chronologies based on the traditional dendrochronological approach failed to detect. Our results suggest that EEMD offers an alternative for establishing tree growth-climate relationships.

Species modeling as a useful tool for dendroclimatology studies with tropical trees. Mattos, P.P., Garrastazu, M.C. (*Embrapa Florestas, Brazil; povoa@cnpf.embrapa.br; marilice@cnpf.embrapa.br*), Siqueira, M.F. (*Jardim Botânico do Rio de Janeiro, Brazil; marinez@jbrj.gov.br*), Oliveira, M.F. (*Universidade Federal do Parana, Brazil; mari_ferraz17@hotmail.com*), Salis, S.M. (*Embrapa Pantanal, Brazil; smsalis@cpap.embrapa.br*), Braz, E.M. (*Embrapa Florestas, Brazil; evaldo@cnpf.embrapa.br.*).

Dendrochronological studies of tropical trees are becoming more frequent. The confirmation of annual ring formation and the determination of annual growth rate are the most common results, but correlation with climate, identification of key years and the construction of master chronologies are not so common. The greatest challenge is the recommendation that samples should be collected near the limit of their growth range. The aim of this work was to test species modeling as a tool to identify potential areas for dendroclimatological sample collection. Specieslink-CRIA (Reference Center on Environmental Information) databases, and experimental data from 5 tree species, were processed in OpenModeller software, testing different algorithms. Two species were from the South (cold) and three from Southwest Brazil (warm). They were compared with results where ring sensitivity was recorded of different sites from previous work developed with *Araucaria angustifolia* from southern Brazil. The best results were obtained with Bioclim and Climate Space Model algorithms. The sites were classified from very sensitive to almost insensitive. *Araucaria angustifolia* samples from Caçador, Colombo, Passo Fundo and Três Barras Counties, from South Brazil, and *Tabebuia heptaphylla* from the Pantanal region in Southwest Brazil, can be considered for dendroclimatological studies.

High-resolution radiocarbon measurements for detecting solar activity using tree rings from Korea. Park, W.K., Kim, S.K., Nam, T.K. (*Chungbuk National University, Korea; wood1957@hanmail.net; kskksk8181@hanmail.net; tour9317@naver.com*), Park, J.H., Hong, W. (*Korea Institute of Geoscience and Mineral Resources, Korea; junghun@rock25t.kigam.re.kr; whong@kigam.re.kr*).

The objectives of this 3-year study were to establish a regional radiocarbon (^{14}C) calibration curve by single-year ^{14}C measurements in tree-ring samples and to analyze the relationship between delta-^{14}C and solar activity in East Asia. In the first year, a total of 130-year measurements of AMS radiocarbon (A.D. 1249–1378) were analyzed. Cellulose extraction was performed to avoid any contaminations. Substantial differences were found between Korean yearly ^{14}C data and IntCal04 decadal data in the entire span. However, no significant differences were found in 10 year average data except for one period (AD 1285–1294). There was about 5 per mil difference between Korean delta-^{14}C and IntCal04 delta-^{14}C. We found indirect relationships between Korean delta-^{14}C and solar activity or sunspot number data. The relationship between auroral records in Korean and Chinese historical documents and Korea delta-^{14}C data appeared to be indirect. The high auroral records and low delta-^{14}C data in the 13th century indicated a medieval warm period in East Asia. The relationship between Northern Hemisphere temperature and Korea delta-^{14}C data was not significant. In the next two years we plan to measure radiocarbon for AD 1379 to AD 1748 to complete the 500-year calibration.

Potential carbon sequestration in savanna estimated from growth rings. Salis, S.M. (*Embrapa Pantanal, Brazil; smsalis@cpap.embrapa.br*), Mattos, P.P. (*Embrapa Florestas, Brazil; povoa@cnpf.embrapa.br*), Fernandes, A.H.B.M. (*Embrapa Pantanal, Brazil; amarozzi@cpap.embrapa.br*), Mausbach, M.M. (*UFPR, Brazil; mariana_mausbach@hotmail.com*), Bergier, I., Fernandes, F.A. (*Embrapa Pantanal, Brazil; ivan@cpap.embrapa.br; fafernan@cpap.embrapa.br*).

The biomass and potential of annual carbon sequestration of a savanna (Cerrado) was estimated in a Pantanal wetland. This tropical type of vegetation is not well studied yet, although it occupies large areas in Brazil. The main woody species with diameter at ground level > 6 cm occurring in the savanna were sampled by the quarter wandering method. For biomass estimation a destructive collection was carried out, and allometric equations were developed with non-linear determination coefficient adjusted > 0.85 for the main species (*Curatella americana* and *Mouriri elliptica*) and a generic equation for the other species. The growth rings of the disks were counted and measured at ground level for all cut trees to obtain the average annual increment in diameter for the two main species and a third annual average for the other species. Total biomass was calculated twice applying equations using the diameters measured and adding the respective mean annual increment. The annual biomass increment was considered as the difference between the two biomass values. The annual biomass increment was estimate at 11.12 Mg/ha/year, representing potential carbon sequestration of 5.56 Mg/ha/year, if carbon sequestration is considered 50% of carbon.

Tree-ring dating of Korean Buddhist statues and extension of chronologies for climate reconstruction. Son, B.H., Kim, S.K., Kim, Y.J., Lee, K.H. (*Chungbuk National University, Republic of Korea; bhson81@hanmail.net; kskksk8181@hanmail.net; fairy@cbnu.ac.kr; bluesea044@hanmail.net*), Choi, S.I. (*Incheon International Airport, Republic of Korea; csi34@naver.com*), Park, G.J. (*Korea Basic Science Institute Research and Lab, Republic of Korea; gpark0403@kbsi.re.kr*), Park, W.K. (*Chungbuk National University, Republic of Korea; wood1957@hanmail.net*).

We analyzed wood species and tree-ring dates of 70 Buddhist statues in South Korea. Most Buddhist statues were made from *Ginkgo biloba*, and some minors from *Alnus* and *Pinus* spp. The ginkgo tree was known to be introduced to Korea from China with Buddhism. Its wood has low shrinkage and fine texture. We tried to obtain both tree-ring dates and radiocarbon dates of the statues. Tree-ring dating could not be applied to some statues with insufficient rings. Wiggle matching of radiocarbon dates, which provides precise dates in some cases, was very useful to date the objects which could not be dated dendrochronologically. The earliest date was in the 11th century. Most statues belong to the 17th and 18th centuries. The tree-ring dates of some statues and their historical construction records indicated that they were made within 3 to 8 months after logging. This is a rather short time if we consider the period required for natural drying to avoid cracking and crooking. As a result of this study, we could extend Korean master chronologies to the 11th century. We will include preliminary results about precipitation reconstruction using tree-ring chronologies of old wood (statues and buildings) and living trees.

Tropical dendrochronology: a review of results in Latin American countries. Tomazello Filho, M. (*University of São Paulo, Brazil; mtomazel@esalq.usp.br*).

Large regions of the American continent are covered by tropical forests, recognized by the diversity and complex interaction of plant and animal species. In this highly complex ecosystem, the application of dendrochronology as a science constitutes a huge challenge for researchers from different countries. Moreover, there is a growing interest in the implementation of this important tool in forestry, ecology and climate studies. Estimates of tree ages, growth rates, sustainable exploitation levels and tree growth recovery, forest restoration techniques, and wood quality analyses are among the types of information demanded by the forest managers. On the other hand, the tree ring chronologies can be used in the reconstruction of past environments, flooding frequency, El Niño events and to assess the effect of climate change. With this aim, this paper presents the actual scientific knowledge on dendrochronology acquired in different countries of Latin America Neotropics, particularly in the areas of Amazon forests. The tree species suitable for dendrochronological studies, the anatomical characterization of the tree-rings, the main methodologies and results, the relationship between tree-rings and climate, forest management, flooding events, etc. are also presented.

Posters

Growth pattern analysis by tree ring growth of Korean pine (*Pinus koraiensis*) natural forest according to elevation in Mt. Odae and Seorak, Korea. Bae, S.W., Kim, H.S., Jang, S.C. (*Forest Practice Research Center, Korea Forest Research Institute, Republic of Korea; bae1144@forest.go.kr; firekim98@hanmail.net; blackdog@forest.go.kr*).

We investigated tree ring growth (TRG) of natural *Pinus koraiensis* by elevation in Mt. Odae (N 37° 48′ – E 128° 34′) and Seorak (N 38° 08′ – E 128° 24′), Korea. Study sites were located at elevation 1,300 m in Mt. Odae (site 1), 900 m (site 2), and 600 m (site 3) in Mt. Seorak. We measured TRG by core, using an increment borer. A 401-year-old tree (DBH 59.5 cm) in site 1 was 2.10 mm/yr (at 6 years) maximum TRG, 0.52 mm/yr mean TRG, and 0.21 mm/yr mean TRG of late 5 years. A 207-year-old

tree (DBH 39.8 cm) in site 2 was 3.12 mm/yr (at 140 years) maximum TRG, 0.77 mm/yr mean TRG, and 0.54 mm/yr mean TRG of late 5 years. A 359-year-old tree (DBH 65.1 cm) in site 3 was 3.69 mm/yr (at 279 years) maximum TRG, 0.92 mm/yr mean TRG, and 0.98 mm/yr mean TRG of late 5 years. Mean TRG and mean TRG of late 5 years in lower elevation sites was greater than that of higher elevation sites. The maximum TRG of site 2 and site 3 appeared in mid or late growth. These results indicated that very old natural *P. koraiensis* actively responds to various environmental changes.

Dendroclimatic potential of five tree species of the dry tropical ecosystem of Armero–Tolima. Briceño, A.M., Arévalo, R.L. (*Universidad del Tolima, Colombia; bricenoan@gmail.com; rlareval@ut.edu.co*).

Tree growth rings have revealed environmental conditions of ecosystems and helped us to learn about past climatic events and estimate future events. In the tropics, research work is taking place that relates the activity of the cambium to environmental conditions and growth periodicity. In the dry tropical ecosystem of Armero-Tolima, the following species were studied: *Gmelina arborea* Roxb, *Cordia alliodora* (R&P)Oken, *Pseudosamanea guchapele*(Kunth) Harms, *Enterolobium cyclocarpum* (Jacq)Griseb, and *Samanea saman* (Jacq)Merrill. With the purpose of studying the dendroclimatic potential of these species, the following variables were analyzed: tree ring width, changes in density, and wood anatomy under the climatic conditions of the area. Dating was done with the COFECHA software, and the correlation of the variables was estimated on the basis of principal components. The variable of ring width was correlated with the variable of precipitation; temperature as a variable has little significance for the growth of the species. The species show great variety concerning the formation of growth rings over time and thus have a potential for reconstructing climatic conditions.

Carbon and oxygen stable isotopes as a signal from tree-rings to estimate physiological changes in Norway spruce infected by *Heterobasidion parviporum.* Gori, Y., Camin, F. (*FEM-IASMA, Italy; yuri.gori@iasma.it; federica.camin@iasma.it*), Cherubini, P. (*WSL, Switzerland; paolo.cherubini@wsl.ch*), La Porta, N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*).

In this study we combined a treering-proxy analysis with an isotopic-proxy analysis to determine the impact of the fungus *Heterobasidion parviporum*, the causal agent of root and butt rots of conifers. This fungal pathogen causes serious economic damage to the conifer forests of the boreal hemisphere and is particularly dangerous in weakening conifer root systems and in predisposing them to windfall. The hypothesis we tested with this multi-proxy approach was that with the progression of fungal attack the trees show a constant reduction of water potential and a decrease in stomatal conductance. The aim of this study was to test the potential of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopes as indicators of *H. parviporum* impact on *Picea abies*. The relationship between infected and non-infected trees was assessed by multi-isotope signatures from tree-ring cellulose. We assume that extensive root decay would trigger ^{13}C and ^{18}Oenrichment of tree-ring α-cellulose through higher net photosynthetic rate and reduced stomatal conductance. For this reason, 10 healthy and 10 infected trees of *P. abies* at three different elevation sites were compared by annual resolution of tree-ringwidth and by $\delta^{13}C$ and δO ^{18}Ochronologies.

Climate-growth relationships of *Pinus massoniana* in the Three-Gorge Reservoir region, China. Lei, J.P., Xiao, W.F., Jiang, Z.P. (*Chinese Academy of forestry, China; leijp@caf.ac.cn; xiaowenf@caf.ac.cn*).

The climate-growth relationships of *Pinus massoniana* in the Three-Gorge Reservoir region, China, were assessed by dendrochronological techniques including correlation functions and single-year analyses, to understand and predict the effects of global climate change on local *Pinus* populations. Fifty-two and 44 increment cores were collected respectively at around 300 m and 1,000 m elevations. The correlation model of tree-ring width index and climatic factors was simulated by multi-factor regression at different elevations. Radial growth responses of *P. massoniana* were found to respond to temperature and precipitation significantly differently. At 300 m elevation, growth was significantly positively correlated with the mean precipitation and the humidity indices of May and June. At 1,000 m elevation, tree growth was found to be significantly positively correlated with the mean temperature of May and the humidity index of the previous November, and negatively correlated with the mean temperature of June. Our findings suggests that global warming will influence highland *Pinus* populations rather than lowland populations, but changes in precipitation patterns will affect the lowland populations most. This study, though preliminary, might provide useful information for ecological forecasting of future climate change affects on *Pinus* populations in south-central China.

Analysis of declining Norway spruce forests (*Picea abies* L. Karst.) in the western Carpathians using dendroclimatological methods. Marušák, R., Kulla, L. (*Czech University of Life Sciences Prague, Czech Republic; marusak@fld.czu.cz; kulla@fld.czu.cz*), Baláž, P. (*National Forest Centre, Slovakia; balaz@nlcsk.org*).

Dendroclimatological analysis of 336 Norway spruce trees was performed in order to contribute to the explanation of the current massive spruce dieback in the Orava region (Northern Slovakia). Sample trees were selected as pairs including one vital and one declining dominant spruce tree along transects extending across the territory of interest. Increment cores from all trees were sampled at breast height (1.3 m) in 2008 and classical tree-ring analyses were carried out (measurements with digital positiometer to the nearest 0.01 mm and synchronisation of the tree-ring diagrams). For each pair of trees, climatic data were derived from the seven nearest weather stations by interpolation and regression with altitude. Results indicate that the radial increment increased continually during the period 1972–2002 in accordance with general growth trends observed in Central Europe. The largest increase was observed in the youngest trees, with rising age the increase significantly ldecreased. There is no evidence for long-term predisposition of spruce trees to dieback due to climatic factors. In 2002, just when the massive dieback started, a breakpoint in radial increment trends appeared, when increase changed to stagnation or decrease in average.

Will the outbreak areas and fluctuation pattern of gypsy moth in central Europe be influenced by climate change? Turčáni, M., Hlásny, T. (*Czech University of Life Sciences, Czech Republic; turcani@fld.czu.cz; hlasny@fld.czu.cz*), Csoka, C. (*Forest Research Institute, Hungary; csokagy@erti.hu*), Milanovic, S. (*Institute of Forestry, Serbia; slobodan.milanovic@gmail.com*), Soukovata, L. (*Forest Research Institute, Poland; L.Soukovata@ibles.waw.pl*), Nakládal, O. (*Czech University of Life Sciences, Czech Republic; nakladal@fld.czu.cz*).

We present the results of our study on the use of dendrochronology for the reconstruction of fluctuation patterns of nun moth (*Lymantra monacha*) and gypsy moth (*Lymantra dispar*) in Central Europe (CE). The project focused on expected changes of spatial distribution of gypsy moth outbreak areas as well as of fluctuation pattern of this species under climate change in CE. The analysis was based on historical data on size and frequency of gypsy moth outbreaks in CE and on the recent generation of climate change scenarios developed within the frame of 6FP project CECILIA (Central and Eastern Europe Climate Change Impacts and Vulnerability Assessment).This knowledge allowed for the identification of regions in the Slovak and Czech Republics (as model areas), where this species may play a more important role in the future than now, and severe impacts on forest health and integrity may occur. Such tendencies have already been observed in recent years, for example in Hungary. The project identified the regions where an increase in outbreak areas of *L. dispar* and changes in outbreak frequency may be expected during years 2020–2025, 2045–2050, and 2075–2080. Finally, optimal control measures and forest management strategies were proposed for all of these regions in order to minimize the expected losses.

A-10 Adapting to future wildland fire regimes

Organizers: W.J. de Groot, *Natural Resources Canada, Canada, Bill.deGroot@nrcan.gc.ca;* Ahmad Ainuddin Nuruddin, *Universiti Putra Malaysia, Malaysia, ainuddin@forr.upm.edu.my;* Douglas McRae, *Natural Resources Canada, Canada, Doug.McRae@nrcan.gc.ca.*

Spatial assessment of wildland fire vulnerability. Chuvieco, E. (*University of Alcalá, Spain; emilio.chuvieco@uah.es*), De la Riva, J. (*University of Zaragoza, Spain; delariva@unizar.es*).

Fire risk assessment requires considering the potential damages should a fire occur, which should be related to the socio-economic and ecological values of the areas at stake. This concept is traditionally named "vulnerability" in most natural hazards, but it has little development in fire risk assessment systems. This paper presents some thoughts to assess the spatial diversity of fire vulnerability, which should be very valuable to improve pre-fire strategic management. Results will be presented at two different spatial scales: national and global. The model is part of an integrated fire risk assessment system currently being developed in Spain. The assessment of vulnerability at national scale includes a socio-economic module and an ecological module. The former considers the values of houses and infrastructures, tourist resources, and economic activities in the forested areas as well as ecosystem services values. The ecological component is based on the soil erosion potential, vegetation resistance, and resilience as a result of fire. Two temporal horizons have been considered: short-term (1–2 years after fire) and long-term (25 years). A similar scheme was applied to the global scale, but with simplified inputs depending on data availability.

Global wildland fire and climate change. Flannigan, M.D. (*Natural Resources Canada, Canada; mike.flannigan@nrcan.gc.ca*), Krawchuk, M.A. (*University of California/Berkeley, USA; megk@berkeley.edu*), De Groot, W.J., Wotton, B.M., Gowman, L.M. (*Natural Resources Canada, Canada; bill.degroot@nrcan.gc.ca; mike.wotton@nrcan.gc.ca; lynn.gowman@nrcan.gc.ca*).

Wildland fire is a global feature resulting from interactions among climate/weather, fuels, and people. Our climate is changing rapidly due to human activities that may have dramatic and unexpected impacts on global fire activity. This presentation reviews the current understanding of what the future may bring with respect to wildland fire and presents future options for research and management. Existing studies suggest a general increase in area burned and fire occurrence but there is a lot of spatial variability, with some areas of no change or even decreases in area burned and occurrence. Fire seasons are lengthening for temperate and boreal regions, and this trend should continue in a warmer world. Future trends of fire severity and intensity are difficult to determine because of the complex and non-linear interactions among weather, vegetation, and people. Improved fire data are required along with continued global studies that dynamically include weather, vegetation, people, and other disturbances. Lastly, we need more research on the roles of policy, practices, and human behaviour because most global fire activity is directly attributable to people.

The role of air pollution in increasing forest susceptibility to wildfire. Grulke, N. (*U.S. Forest Service, USA; ngrulke@fs.fed.us*).

Air pollution is an underestimated agent of change in ecosystems. Few studies have shown how ozone interacts with other abiotic and biotic stressors to effect ecosystem change. In one of North America's most polluted forests, phenomenological and experimental evidence is presented for how air pollution (elevated ozone and nitrogen deposition) has increased ponderosa pine susceptibility to drought stress, successful bark beetle attack, tree mortality, and stand susceptibility to wildfire. In areas of high air pollution, mature trees have lower root mass, higher leaf turnover rates, loss of stomatal control under unfavorable conditions, and increased carbohydrate allocation to bole tissue. Loss of stomatal control combined with decreased root mass increased tree susceptibility to drought stress. Bark beetle attacks were likely more successful due to change in both increased tree drought stress and increased carbohydrate allocation to bole tissue. Increased litter production, decreased litter decomposition, and increased tree mortality due to bark beetle all contributed to increased forest susceptibility to wildfire. Integrative interpretations of effects of concurrent multiple stressors are needed to guide land management practices likely to experience environmental change.

Implications of climate change for fire management in Mediterranean ecosystems in the south-west of Western Australia. McCaw, L. (*Department of Environment and Conservation, Australia; lachie.mccaw@dec.wa.gov.au*).

The south-west of Western Australia is characterized by extensive areas of fire-prone sclerophyll eucalypt forest, woodland, and shrubland that support a rich biodiversity with high levels of endemism. Effective fire management is an essential prerequisite for achieving sustainable forest management objectives for biodiversity conservation, forest production, soil and water values, and community protection. Over recent decades the Mediterranean-type climate of south-west Western Australia has become warmer and drier, with a decline in annual rainfall of up to 14% since 1970. Declining rainfall has resulted in significant lowering of groundwater levels, changes to fuel moisture regimes, and a general extension of the fire season later into the autumn. Prescribed

fire is used extensively to manage fuel accumulation and achieve forest management objectives, and its effectiveness in reducing the extent and impacts of unplanned fires has been clearly demonstrated. Faced with future climate change, fire management will need to minimize the impact of extreme fire events, protect fire-sensitive ecosystems subject to increasing levels of moisture stress, and implement fire regimes that limit the emission of greenhouse gases from planned and unplanned fires.

Effects of fire on tropical forests biodiversity. Nuruddin, A.A. (*Universiti Putra Malaysia, Malaysia; ainuddin@forr.upm.edu.my*), Syaufina, L. (*Bogor Agriculture University, Indonesia; lailan@yahoo.com*).

Forest fires have affected millions of hectares of tropical forests and other vegetation types annually. Over past decades, increased occurrences of fires have caused degradation of tropical forest ecosystems and affected the environment. The objective of this paper is to briefly review impacts of fires on the tropical forest ecosystem and to suggest mitigating factors to reduce impacts. Fire alters tropical ecosystems by opening the forest canopy, increasing soil temperature, and changing hydrological regimes. Fires in tropical peat swamp forests release carbon into the atmosphere, contributing to global climate change. Vegetation responses to burning vary with the severity of burning and adaptability of individual plant species to fire. Forest fires affect vegetation by suppressing certain species and promoting other species, causing changes in vegetation structure and altering successional patterns. In severe burnt areas of tropical forest, fast-growing grasses may dominate, making these areas more prone to fire. This is known as positive feedback, in which successive cycles of fire occurrences increase the amount of area under grasses, which further increases the risk of forest fire occurrences. Mitigating factors in reducing the impact include forest restoration and sound forest fire management, which includes effective forest fire prevention, control, and suppression.

Future impacts of climate change on forest fire danger in southwestern China. Tian, X.R., Shu L.F., Wang, M.Y., Zhao, F.J. (*Chinese Academy of Forestry, China; tianxr@caf.ac.cn; shulf@caf.ac.cn; fire@caf.ac.cn; zhaofj@caf.ac.cn*).

Climate warming has a rapid and far-reaching impact on fire activities in forests. This study used a regional climate model output and the calculated Canadian Forest Fire Weather Index to analyze changes in fire danger and fire season for future periods under SRES A2 and B2 scenarios. China's regional climate for the period (1991–2100) was modeled from a regional climate model system (PRECIS) and baseline period used as our validation data. Meteorological data and fire weather index were interpolated to 1 km × 1 km scale by using ANUSPLIN software. Results show the PRECIS model had a good ability to simulate temperature and precipitation of the study area during the validation period. The average FWI for future fire seasons will increase 0.92, 1.44, and 2.39 under scenario A2 and 1.45, 2.12, and 0.77 under scenario B2 for periods of 2020s, 2050s, and 2080s respectively. Days in the high, very high, and extreme fire danger categories will increase 9,18, and 32 days under scenarios A2 and 13, 22, and 31 days under scenario B2 for the periods of 2020s, 2050s, and 2080s respectively. Regions with the most obvious extended fire season are located in the central Sichuan and western Guangxi.

A-11 Fire and sustainable management of future forests

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Wildland fires in the late Anthropocene: the role of fire management in future global environmental engineering. Goldammer, J.G. (*Global Fire Monitoring Center* (*GFMC*)*, Germany; johann.goldammer@fire.uni-freiburg.de*), De Groot, B. (*Natural Resources Canada, Canada; BDeGroot@NRCan.gc.ca*).

The increasing incidence, extent, and severity of excessive burning globally, together with its many adverse consequences, has brought fire into the international environmental policy arena, with growing calls for international action leading to greater control. Despite this concern, there is still a paucity of accurate and timely information on the occurrence and impacts of vegetation fires, including atmospheric and climatic consequences; and on the social, economic, and environmental costs. Given that fire is also an important natural process in many ecosystems, and that people have traditionally used fire for millennia as a land-management tool, the challenge is to develop informed policies and implementation practices that recognize both the beneficial and destructive roles of fire. The importance of global vegetation cover for human well-being, sustainable development, and terrestrial carbon storage has brought the concept of forest protection against destruction or degradation into the global policy arena, notably in the frame of the UNFCCC COPs 13 and 15 and the UN International Strategy for Disaster Reduction. Internationally concerted initiatives have been created to address the escalating global fire problems. The paper will present the state of development in international cooperation in enhancing fire management capacity globally.

Risk and potential implications of forest and grassland fires in the Chernobyl exclusion zone. Hohl, A. (*Humboldt State University, USA; amhohl@yahoo.com*), Sibtsev, S. (*National University of Life and Environmental Sciences of Ukraine, Ukraine; sergiy.zibtsev@nauu.kiev.ua*), Goldammer, J. (*Global Fire Monitoring Center, Germany; johann.goldammer@fire.uni-freiburg.de*), McCarter, J. (*University of Washington, USA; jmac@u.washington.edu*), Niccolai, A. (*U.S. Coast Guard Research and Development Center, USA; aniccolai@yahoo.com*), Oliver, C. (*Yale University, USA; chad.oliver@yale.edu*), Petrenko, M. (*National University of Life and Environmental Sciences of Ukraine, Ukraine; mykhaylo_petrenko@ukr.net*).

A fire risk classification system based on stand structure and fuel loading was used in conjunction with a stand inventory to assess the wildfire risk in the Ukrainian portion of the Chernobyl Exclusion Zone (CEZ). The majority of the inventoried forest consisted of stands with a high risk of sustaining a crown fire**.** Subsequently, we assessed the potential implications of a wildfire burning under extreme conditions on populations living and working near the CEZ. We modeled a worst-case scenario in which it was assumed that a fire would consume the all available fuels and release deposited radionuclides into the atmosphere. The model was designed to be extremely conservative and to over-estimate potential exposure. The estimated exposure of populations 25 or more kilometers from the source of the fire is below the critical thresholds that would require evacuation under Ukrainian law.

However, the response to the fire might require limiting ingestion of certain foodstuffs to avoid exposure via ingestion. Thus, although the risk of a high-intensity fire in the CEZ is high, the effects on human populations living adjacent to the zone can be readily mitigated.

Forest fire risk assessment for conservation and management: a geospatial approach. Jung, J.H., Heo, J. (*Yonsei University, Republic of Korea; lionheart_kr@yonsei.ac.kr; jheo@yonsei.ac.kr*).

Forests are living treasures of the earth that should be protected from the influences responsible for their degradation. Forest fire causes serious damage to forest areas. As a consequence, partial or complete destruction of vegetation occurs, which leads to many cascading problems. In this study, an attempt has been made to identify the forest areas, which are under fire risk in part of Eastern Ghats of Tamil Nadu. Relevant thematic maps were generated from satellite data, topographical maps, primary and secondary data, and weightings to each map were assigned following Analytic Hierarchy Process (AHP). Weighted overlay analysis was carried out to identify the fire prone forest areas. The medium fire prone category occupied majority of the forest area (46%) followed by low fire-prone category, occupying 45% of forest area. The high and very low fire-prone categories occupied 2% and 3% of the forest area respectively. About 75% of burned areas belonged to high fire-prone category. The results of spatial modeling would be useful to forest officials and conservationist to plan for effective conservation.

Integration and institutionalization of community-based forest fire management in community forests of the Terai region of Nepal. Lamsal, R.P. (*Ministry of Forest and Soil Conservation, Nepal; ramplamsal@gmail.com*).

The participatory approach is the backbone of forest fire management, and Nepal has integrated the concept it its Community Forestry Programme. The objectives of this study were to assess the conceptual and institutional aspects including roles, responsibilities, and capacities of different stakeholders for prediction, preparedness, prevention, mitigation, and restoration in community-based forest fire management in Nepal and to propose methods for better integration of forest fire management in community forestry. Apart from undertaking primary surveys in 32 community forests of the Chitawan District, experiences, literature, and documents from the Terai Arc Landscape Program were extensively used. The findings reveal that traditional methods developed by communities need backup of scientific knowledge and technology. Co-ordination and networking are essential to synergize the efforts of stakeholders and reduce the gaps in technology and resources. The focus must be on prevention because mitigations are highly expensive and unpractical in remote areas. The Community Forest Operational Plan can integrate and institutionalize forest fire management; provide guidance to improve forest management, and provide a framework for participation of women, the poor, and disadvantaged groups to greatly reduce fire vulnerability. Based on these findings, a national strategy is being prepared for enhancing collaboration at different levels.

Future trends in wildfire potential in North America. Liu, Y.Q., Stanturf, J.A., Goodrick, S.L. (*U.S. Forest Service, USA; yliu@fs.fed.us, jstanturf@fs.fed.us; sgoodrick@fs.fed.us*).

Global climate models have projected overall warming and drying trends in many mid-latitude regions by the end of this century due to the greenhouse effect. Climate is a major driver for wildfires along with vegetation (fuel) and topography, with both natural and anthropogenic ignition sources. Fire shapes forest vegetation composition and structure. Our recent study identified a number of regions globally, including North America, where wildfires are expected to increase as a result of projected climate change. This study builds on that work; we conducted a more detailed analysis of spatial patterns of future wildfire potential in North America by examining several wildfire potential indices including the Keetch-Byram Drought Index (KBDI) and the National Fire Danger Rating System (NFDRS). These and other indices were calculated and compared for current and projected future climates, using climate conditions obtained from the North American Regional Climate Change Assessment Program. The results indicate that climate change will lead to significant change in fire intensity (longer periods of high intensity fire behavior) and extensions of fire seasons in North America.

Weather and fire behaviour during the Victorian bushfires of 7 February 2009. McCaw, L. (*Department of Environment and Conservation, Australia; lachie.mccaw@dec.wa.gov.au*), Bannister, T. (*Bureau of Meteorology, Melbourne, Australia; t.bannister@bom.gov.au*), Sullivan, A. (*CSIRO Sustainable Ecosystems, Australia; andrew.Sullivan@csiro.au*), Tolhurst, K. (*University of Melbourne, Australia; kgt@unimelb.edu.au*).

A defining Australian natural disaster occurred in Victoria on Saturday, 7 February 2009. On a day of unprecedented heat in Victoria, bushfires in central and southeast parts of the state caused a level of death and destruction that surpassed previous fire events in the recorded history of Australia. Record high temperatures were set over most of Victoria, exceeding 45 °C in many places, with the depth of atmospheric mixing exceeding 5,000 m. Wind gusts to 115 km/h were reported at higher elevations prior to the change. More than 500 grass and forest fires were reported across Victoria, of which 14 developed into major fires, with the most extensive damage and loss of life resulting from four of these fires. Fire behaviour was extreme with very widespread crown fire activity and extensive propagation of spot fires over distances of 30 km or more. These bushfires exhibited characteristics observed during previous major bushfire events, albeit of a scale and intensity exceeding most previous events. Extreme dryness of the landscape and the protracted heat wave leading up to the fires played a critical role in determining the severity and extent of the fires and the resultant impacts on the Victorian community.

Repeated droughts and fires mutually increase their impact on forest ecosystems. Vennetier, M. (*CEMAGREF, France; mvennetier@cemagref.fr*), and 50 co-authors.

In a recent research project performed in South-Eastern France on the impact of repeated fires on forest environment components (vegetation, fauna, microbiology, soil physics, chemical properties, organic matter, nutrients), we showed a strong interaction between repeated droughts and repeated fires. Each disturbance significantly increases the impact of the other one. Repeated droughts can stop and even reverse the recovery process after fire, and delay this recovery when they occurred before fire. Repeated fires lessen the resistance and resilience of the ecosystem to drought. Forest regeneration processes are threatened even in typically fire-prone environments that usually are resilient. Soil biological activity is severely affected, particularly some key

groups such as earthworms and bacteria that contribute to the nitrogen cycle. Soil physics and chemical properties appear to be degraded, and indirectly the reduction of biological activity limits their recovery, including a negative carbon balance. Four successive years appears to be the critical threshold for drought, and four times in 50 years the critical threshold for fires. Because climate change may lead to higher drought frequency and because fire occurrence is tied to drought, the drought/fire interaction may degrade forest ecosystems more rapidly than expected from separate assessments of drought and fire impacts.

Forest fire danger rating and human-caused fire in South Korea. Won, M.S., Koo, K.S., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; mswon@forest.go.kr; kyosang@forest.go.kr; mblee@forest.go.kr*).

On average, from 1999 to 2008, 497 fires burned 3,637 ha of forest lands each year in South Korea. Most of the fires were brought about by man-made activity, especially burning by people in areas adjacent to rural forests. Only 6 fires were caused by lightning; the main causes of forest fire include carelessness, weed burning, fireworks, and ceremonies honoring the dead. This study aims to develop a Korean Forest Fire Danger Rating System (KFFDRS) to support forest fire prevention efforts in South Korea. The KFFDRS consists of three, 10-scale indices: daily weather index (DWI), fuel model index (FMI), and topography model index (TMI). DWI represents the meteorological characteristics, such as effective humidity, temperature, and wind speed, and is adapted to local conditions through the use of one of eight logistic regression models. Both FMI and TMI were derived by analyzing the forest types and ignition points of 126 forest fires. Various factors affecting forest fire occurrence were analyzed with a thematic map, on the basis of forest type, topography, administrative units, and meteorological data. The forest fire danger rating index (FFDRI) is used to produce indices for fire hazards on the web in real-time.

Posters

Behaviour of fire during experimental burning in a bed of *Pinus taeda* needles under laboratory conditions. Batista, A.C., de Oliveira, E.C., Ferreira, J. (*Universidade Federal do Paraná, Brazil; batistaufpr@ufpr.br*).

This research was carried out in the forest fire laboratory of the Universidade Federal do Paraná, Curitiba, Brazil, with the aim to obtain estimates about the behaviour of fire in controlled burnings. To this end, a series of burning experiments under controlled laboratory conditions was carried out. Each burning lot consisted of a bed of *Pinus taeda* needles evenly distributed over an area of 1 m^2, with the quantity of fuel ranging from 100 to 500 $g.m^2$. All meteorological conditions were monitored during the burnings. The following fire variables were measured during the burnings: propagation speed of the fire, height of flames, and fuel consumption. The following results regarding the behaviour of fire were obtained:median propagation speed of 0.2607 m. min^{-1}, median height of flames of 0.188 m, and median consumption of fuel of 125 $g.m^{-2}$. These results indicate a strong relationship between the variables of the fire and the fuel available for burning and, as a consequence, good estimates of the studied fire variables were achieved (fire intensity – R^2 = 75,3554; Syx = 0,722742; fuel consumption – R^2= 66,7103; Syx = 0,0736297; and flame height – R^2 = 76,059; Syx = 0,335771).

A global early warning system for wildland fire. De Groot, W.J. (*Natural Resources Canada, Canada; bill.degroot@nrcan.gc.ca*), Goldammer, J. (*The Global Fire Monitoring Center, Max Planck Institute for Chemistry, Germany; johann.goldammer@fire.uni-freiburg.de*), Justice, C. (*University of Maryland, USA; justice@hermes.geog.umd.edu*), Lynham, T. (*Natural Resources Canada, Canada; tim.lynham@nrcan.gc.ca*), Csiszar, I. (*NOAA/NESDIS Center for Satellite Applications and Research, USA; Ivan.Csiszar@noaa.gov*), San-Miguel-Ayanz, J. (*European Commission – DG Joint Research Centre, Italy; jesus.san-miguel@jrc.ec.europa.eu*).

Wildland fires burn several hundred million hectares of vegetation every year, and increased fire activity has been reported in many global regions. Many of these fires have had serious negative impacts on human safety, health, regional economies, global climate change, and ecosystems in non fire-prone biomes. Worldwide fire suppression expenditures are rapidly increasing in an attempt to limit the impact of wildland fires. To mitigate fire-related problems and costs, forest and land management agencies, as well as land owners and communities, require an early warning system to identify critical periods of extreme fire danger in advance of their potential occurrence. Early warning of these conditions allows fire managers to implement fire prevention, detection, and pre-suppression plans before fire problems begin. This paper presents a global early warning system for wildland fire that was developed through an international collaboration of fire, weather, and remote sensing agencies. The system provides advanced early warning capabilities at local to global levels with outputs for numerous commonly used national fire danger rating systems, and it provides a fire danger rating system for the many countries that do not have a national system in place.

Anthropogenic influence on forest fire in Beaufort, Sabah, using GIS and socio-economic survey techniques. Kamlun, K.U., Phua, M.H. (*Universiti Malaysia Sabah, Malaysia; kamlisa@ums.edu.my; pmh@ums.edu.my*).

Fire has severely and repeatedly damaged forest as well as wetland vegetation. Beaufort is a large lowland coastal plain located in the southwestern coast of Sabah. This lowland plain is often referred to Klias Peninsula, which lies at the foothills of the Crocker Range. The Klias Peninsula was home to an extensive wetland ecosystem, which was unfortunately destroyed by fires especially in 1998 and 2003. The unique transport of flammable vegetation overlain with human impacts on the fire regime demand a new level of understanding for the coexistence with fire occurrences. We aimed at examining the anthropogenic influences on the forest fire using GIS and socio-economic survey techniques. Buffering analysis with 1,000-m-interval was used to generate of three different distance factors (settlement, agriculture, and roads). Overlay analysis showed that agriculture was the main factor contributing to the fire ignition and deforestation in this area. Field interviews also reached the same conclusion, that slash-and-burn for plantations was the major cause of the fires in 1998 and 2003. In short, anthropogenic activities, especially agricultural practices, contribute to fire ignition and hence the destruction of the wetland vegetation.

Influence of vegetation recovery on runoff and sediment yield following a forest fire in Samcheok, Korea. Kim, Y.M., Shin, Y., Seo, H.S. (*Kangwon National University, Republic of Korea; yoonmi@korea.kr; shinyoungseob@empal.com; hyungsoonim@hanmail.net*), Kim, C.G. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; changgikim@empal.com*), Joo, K.Y., Choung, Y. (*Kangwon National University, Republic of Korea; ecowald@hanmail.net; yschoung@kangwon.ac.kr*).

Most forest fires occur in spring in Korea. Following fires, monsoon in summer damages soil surface severely. Thus, we aimed to examine the relative influence of rainfall events and vegetation on runoff and sediment yields with time. From 21 runoff plots, runoff and sediment yields were measured for 7 years, from the 4th year to the 9th year, in *Pinus densiflora* forest severely burnt by the East Coast fire in Samcheok, Korea in 2000. Vegetation recovery has mitigated the influence of rainfall events on the runoff and sediment yields from the 7th year following the forest fire. Nevertheless, significant differences of runoff yields between vegetation classes have been maintained for 7 years. To lower the losses from the 'intermediate 'and the 'low ' plots to the level of the 'high regeneration' plots, at least several years would be needed. For 7 years total, sediments totalling 12.3 and 15.0 ton ha^{-1} have been produced from the 'intermediate' and 'low' plots, respectively, 2.5 and 3.0 times the 'high' plots (4.9 ton ha^{-1}). This strongly implies that proper hill treatment such as mulching should be applied immediately after fires to reduce soil erosion and to restore burnt forests faster.

Case study on establishment of a firebreak forest for reduction of fire damage. Koo, K.S., Won, M.S., Jung, S.C., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; kyosang@forest.go.kr; mswon@forest.go.kr*; *scjung20@msn.com; mblee@forest.go.kr*).

To analyze the effect of improving pure pine stand structure for reducing fire-affected areas, the research district was composed of 300, 200, and 100 trees/ha, which treated and monitored areas with higher density than the optimum stand density. Also, the combustive heat flux of pine forest and mixed forest was analyzed to assay the effect of a firebreak forest. As a result of analysis, 100 trees/ha was profitable, and the importance of *Q. mongolica* was the highest in the stand where the upper layer was removed and lower layer remained, because the sprouting of *Q. mongolica* was prosperous. Seedlings of the pine trees rarely emerged, and there was no significant difference with the stand where the upper and lower layers were eliminated. Thus, it is suitable to improve the stand structure of the pure pine forest. As a result of analyzing the combustive heat flux, the pure pine forest showed 4,852.5 cal/g, and the mixed forest showed 4,148.6cal/g. The pure pine forest needs to have the burning materials removed through forest management work since it has a high combustion amount for potential forest fire compared to the mixed forest.

Analysis of fuel moisture content changes after precipitation in the deciduous forest during forest fire periods in the east sea region in Korea. Lee, S.Y., Kwon, C.G., Lee, H.P. (*Kangwon National University, Republic of Korea; lsy925@kangwon.ac.kr; kcg3338@kangwon.ac.kr; crelab@kangwon.ac.kr*), Park, H.S. (*Dongguk University, Republic of Korea; parkhs08@naver.com*).

This study examined the relationship between variation in fuel moisture and the risk of forest fire by measuring changes in the moisture-containing ratio on-site and the average moisture in the fallen leaves layer, humus layer, and soil layer in the forest. The measurements were performed on 6 days from the day after a rainfall. The fuel moisture on-site was measured on the day when the accumulated rainfall was above 5.0 mm, and the measurements were taken two times in autumn. From the deciduous forests that are distributed around Samcheok in Kangwondo, three regions were selected by loose, medium, and dense forest density, and the fuel moisture was measured on the fallen leaves layer, humus layer, and soil layer in the forest for 6 days from the day after a rainfall. The study showed that the moisture-containing ratio converged on 3 to 4 days in autumn and for the fallen leaves layer, and the convergence was made more than 6 days in autumn for the humus layer. In the other case of soil layer, the variation of moisture-containing ratio after rainfall was not distinguishable regardless of forest density.

Application of Canadian forest fire weather index (FWI) and prediction of human caused forest fire ignition under future climate change condition in Kyeongsangbuk-Do and Cheolanam-Do, Korea. Lee, S.Y. (*Kangwon National University, Republic of Korea; lsy925@kangwon.ac.kr*), Park, H.S., Yun, H.Y. (*Dongguk University, Republic of Korea; parkhs08@naver.com; yunhy@dongguk.edu*), Lee, H.P. (*Kangwon National University, Republic of Korea; crelab@kangwon.ac.kr*).

Forest fire ignition in Korea has been caused by human activities such as ground burning for cultivation, camp fire, the spark of cigarettes, etc. The ignition of forest fire by human activities was affected by ground fuel moisture contents and climate condition such as wind. The Canadian Forest Fire Weather Index (FWI) was an indicator of ground fuel moisture contents for forecasting forest fire ignition. In this study, for examination of FWI (FFMC, DMC, DC) application and prediction of future forest fire ignition, we analyzed records of human-caused forest fires during 10 years in Kyeongsangbuk-Do and Cheolanam-Do and calculated FWI from weather data at that time. We found that human-caused fire occurred under high FFMC condition; therefore, FFMC could be applied for predicting future forest fire ignitions. Other indices (DMC, DC, FWI) had less relationship with human-caused fire ignition. Further, the human-caused forest fire ignition model in Canada developed by B.M. Wotton et al. would need more improvements through more surveys in other places in Korea for forecasting of future forest fire ignitions.

The spatial allocation of suppression resources to improve the effectiveness of initial attack on wildland fires. Lee, Y. (*Oregon State University, USA; Yohan.lee@oregonstate.edu*), Fried, J.S., Haight, R.G. (*U.S. Forest Service, USA; Jeremy.fried@fs.fed.us; rhaight@fs.fed.us*), Albers, H.J. (*Oregon State University, USA; Heidi.albers@oregonstate.edu*).

This study develops a synergistic, stochastic simulation and an optimization framework to improve the efficiency of allocation and configuration of resources for initial attack on wildland fires. A standard response model is formulated with two objective functions: number of suppression resources deployed, and daily expected number of fires that do not receive a standard response. Standard response is defined as a required number of resources that can reach the fire within a maximum response time. To determine how budget levels affect the standard response objective, a weighted sum of objective functions is minimized subject to budget constraints, which are varied to generate tradeoffs. We use the model to deploy engines, dozers, hand-crews, and aircrafts among stations in the Amador-El-Dorado, Nevada-Yuba, and Tuolumne-Calaveras units of the California Department of Forestry and Fire Protection. Each deployment is further compared with the spatial allocation of the joint model. Results show that many required resources are saved when they are shared widely with adjacent units. This study has broadened both optimization and fire simulation models to look at several adjacent management units and interactions among these units; we found significant gains from coordinating the spatial allocation of limited initial attack resources across management units.

Forest fire risk zone mapping using GIS/RS in Selenge, Mongolia. Ochirsukh, B.A., Lee, W.K. (*Korea University, Republic of Korea; ochirsukhmb@yahoo.co.uk; leewk@korea.ac.kr*).

In Mongolia, fire is a major factor which determines spatial and temporal dynamics of forest ecosystems. Fire occurrence and extent are controlled by several factors, such as geographic location, climate, vegetation patterns, and human activities. It is difficult to control nature, but it is possible to map forest fire risk zones to help forecast the frequency of fire and focus management attention to decrease damage by fire. Forest fire risk zones are locations where fire is likely to start, and from where it can spread to other areas. Fire management including its prevention would be satisfactory when a fire risk zone map is available. Selenge province in the northern region of Mongolia was selected for this study since it continually faces a forest fire problem. All maps have been produced using GIS/RS tools. Low resolution satellite (NOAA and MODIS) data was used for vegetation mapping. Slope data and other infromation (roads, settlements) were derived from topographic maps and field information. Four categories of forest fire risk ranging from very high to low were derived automatically. There were four fire risk zone identified that would be useful for fire management in Mongolia.

A study on combustibility of living leaves of *Quercus variabilis* by climatic zones. Oh, J.Y., Lee, H.P., Lee, S.Y., Park, Y.J. (*Kangwon National University, Republic of Korea; sman5009@kangwon.ac.kr; crelab@kangwon.ac.kr; lsy925@kangwon.ac.kr; yjpolymer@kangwon.ac.kr*).

In this study, we conducted a comparative study of combustibility for same species by climatic zones using living leaves of *Quercus variabilis* collected in the eight regions. This study was fulfilled to investigate the forest fire risk of forest fuels based on the combustion characteristics of living leaves of broadleaf trees. We inspected the combustibility of forest fuel using the ignition temperature tester, cone calorimeter, and smoke density chamber, and we also measured the moisture content. According to the results, combustibility such as total smoke release, total heat release, ignitibility and moisture content slightly varied depending on the climatic zones. The samples collected in coastal temperate, middle temperate, and subtropical zones showed a relatively low moisture contents and rapid ignitibility. Also, the samples of coastal temperate and subtropical zones showed the highest levels of smoke release and heat release. We concluded that moisture content is one of the critical factors that would affect the combustibility of living leaves of *Q. variabilis*.

Spatial and temporal distribution of fires in Ghana. Owusu-Afriyie, K. (*Forestry Research Institute of Ghana, Ghana; ko.afriyie@yahoo.com*), Swaine, M.D. (*University of Aberdeen, UK; m.swaine@abdn.ac.uk*), Agyeman, V.K. (*Forestry Research Institute of Ghana, Ghana; vagyeman@csir-forig.org.gh*), Boateng, K. (*Kwame Nkrumah University of Science & Technology, Ghana; kyerehb@yahoo.com*), Orgle, T.K. (*Resource Management Support Centre, Ghana; tkorgle@yahoo.com*), Lopez, L.A.T (*University of Aberdeen, UK; leonellopeztoledo@yahoo.co.uk*).

Fire incidence has become rampant in Ghana in recent times, probably due to climate change, and consequently is giving cause for concern due to its negative impacts on the savanna and forest vegetation types. It is certain that the national wildfire policy would benefit from the availability of empirical data by providing implementation benchmarks. However, whilst fires are more rampant in savanna and on farmlands, recent research on aspects of fire in Ghana has focused on forest reserves. Satellite record of fire incidence for the entire country over 11 years (1997 to 2007) in 1-km pixels covering all the vegetation types obtained from the European Space Agency was modelled via binary logistic regression analysis, and correlations between fire incidence and the correlates of fire used to explain the observed trends. Fire incidence was found to be correlated with multiple variables which probably co-vary. Rainfall, vegetation type and geology showed the strongest correlations with fire incidence. Implications for fire policy in relation to sustainable forest management are discussed.

A study on combustibility of living leaves of *Pinus densiflora* by climatic zones. Park, Y.J., Lee, H.P., Lee, S.Y., Oh, J.Y. (*Kangwon National University, Republic of Korea; yjpolymer@kangwon.ac.kr; crelab@kangwon.ac.kr; lsy925@kangwon.ac.kr; sman5009@kangwon.ac.kr*).

In this study, we conducted a comparative study of combustibility for same species by climatic zones using living leaves of *Pinus densiflora* collected in the eight regions. This study was fulfilled to investigate the forest fire risk of forest fuels based on the combustion characteristics of living leaves of coniferous trees. We inspected the combustibility of forest fuel using the ignition temperature tester, cone calorimeter, and smoke density chamber, and we also measured the moisture content. According to the results, combustibility such as total smoke release, total heat release, ignitibility, and moisture content slightly varied depending on the climatic zones. The sample from the subtropical zone showed the lowest level of moisture content and rapid ignitibility, whereas the sample from the northern temperate zone recorded a relatively high heat release and the sample from the southwestern temperate zone showed a high smoke release. We concluded that moisture content is one of the critical factors that would affect the combustibility of living leaves of *Pinus densiflora*.

Fire risk mapping using GIS-based probability modeling for operational fire monitoring in the tropics. Phua, M.H. (*Universiti Malaysia Sabah, Malaysia; pmh@ums.edu.my*), Lee, J.S. (*Kangwon National University, Republic of Korea; jslee72@kangwon.ac.kr*), Tsuyuki, S. (*University of Tokyo, Japan; tsuyuki@fr.a.u-tokyo.ac.jp*).

Repetitive fire occurrences have been devastating to peat swamp forests in the topics. Anthropogenic fires during the recent El Niño have been particularly damaging and threatening to the shrinking peat swamp forest in the tropics, and the peat swamp forests in the Klias Peninsula were destroyed by fires during the El Niño events of 1998 and 2003. An operational fire risk map is imperative because of limited monitoring resources in developing countries. The fire occurrences in 1998 and 2003 were detected using a multisensor remote sensing approach. This research discuss the assessment and prediction of fire occurrences using a fire risk map produced with GIS-based probability modeling based on anthropogenic factors. The 1998 fire occurrence was assessed as a conditional probability based on distance classes from settlements, roads, rubber plantations, and oil palm plantations. Comparison of the assessment rates of different distance settings was carried out for producing the best fire risk map. The usefulness of this approach is demonstrated in the production of a fire risk map that has successfully assessed the 1998 fire occurrence and predicted the 2003 fire occurrence.

Fire vulnerability of *Pinus densiflora* and *Quercus variabilis* forests in Korea. Seo, H.S., Choung, Y.S. (*Kangwon National University, Republic of Korea; hyungsoonim@hanmail.net; yschoung@kangwon.ac.kr*).

In Korea, most human-caused forest fires originate in pine (*Pinus densiflora*) forests and damage them severely compared to other forests. Frequent fires from pine stands might be related to the lowland distribution of pine stands due to easy access. However, we hypothesized that the vulnerability is mainly caused by the fuel types, morphology, and stand structure of the pine. We conducted ignition experiments and investigated the stand structure compared with oak (*Quercus variabilis*) forests that are also common in lowland regions. In cigarette experiments, dry pine leaves caught on fire and ignited significantly faster, while oak leaves only got charred but did not ignite. In the combustion experiment using dry leaves with different moisture contents and fuel loads, the maximum flame temperature of pine was significantly higher and maintained the combustion longer. Morphologically, pine was found to have thinner bark with lower dead branches. In addition, pine stands showed dense understory with high canopy tree density. The combination of the above characteristics explains why pine stands are more vulnerable to fires during the serious fire season in spring even though deciduous oak stands accumulate more fine fuel.

Forest fire monitoring using satellite imageries in Nepal. Shrestha, H.L. (*Kathmandu Forestry College, Nepal; hlshrestha@gmail.com*) Bastakoti, R.R. (*Resource Identification and Management Society, Nepal; rishibasatakoti@hotmail.com*).

Nepal is a mountainous and sub-tropical country and we face forest fire each year during March and April. However, Nepal is not adequately equipped to combat forest fire if it spreads in huge quantity. Because of this anomaly, last year during the same season, several human lives were lost due to forest fire. Forest fire also has impacts in the context of forest depletion and greenery of the forest, and obviously it has a crucial impact in the context of climate change as it enhances carbon emissions. There is strong need for a forest fire monitoring mechanism in Nepal. The study tried to use satellite imageries provided from the MODIS rapid response team to monitor forest fires at the national level. This study will show the daily forest fire incidence in peak season and the impacts on the forest, comparison with previous years' data, and the contribution of forest fire in carbon emission each year. This study shows an example of application of geospatial technologies for forest fire monitoring. It can be suggested and recommended that nations should develop some rapid response mechanism for forest fire using geospatial technologies to reduce the losses of forest and human lives.

Estimation of temporal and spatial fluctuations of forest fire hazard index: the case of a forested public area in Japan. Tamai, K., Goto, G. (*Forestry and Forest Products Research Institute, Japan; a123@ffpri.affrc.go.jp*).

Mapped estimates of the risk of forest fire would benefit forest management, and could be used to decide restrictions on public use of forest areas. In this study, litter moisture content ratios were predicted with this model and forest fire hazard was estimated for a forested park in Japan. The model was adapted to around a 40-ha area in this park, classified into 9 stands based on tree height, tree species, and slope direction. Fuel moisture decreased with each speed for each forest stand among simulated days depending the solar radiation on the each forest floor. Litter moisture was less than 0.2 g g^{-1} and fire risk was judged to be highest in 7 forest stands among the 9 stands on the day after a long drought period. On the other hand, spatial variation of litter moisture was widest, at 0.198 – 0.811 g g^{-1}, on the day during the drying process. This means that litter drying speed and fire risk are different between forest stands. Thus, it is significant to construct a forest fire warning system for each forest stand to manage people's activities in public forested areas to prevent the forest fire.

Evaluation of the production of *Ilex paraguariensis* and *Camellia sinensis* in the state of Paraná, Brazil, to support the establishment of green forest fire breaks. Tetto, A.F. (*Secretaria da Agricultura e do Abastecimento do Estado do Paraná, Brasil; alexandretetto@seab.pr.gov.br*), Batista, A.C., Soares, R.V., Muñiz, G.I.B. (*Universidade Federal do Paraná, Brazil; batistaufpr@ufpr.br; rvsoares@ufpr.br; gbmuniz@ufpr.br*).

The lack of silvicultural treatment in forest cultivations results in an increased risk of forest fires. One way of preventing this is the establishment of green fire breaks. For this purpose it is important to know about silvicultural and economic aspects of the species used for the fire breaks in order to make the objects of the forestry activity compatible with the products gained from managing the green shelterbelts, as well as with forest fire prevention. This study aimed at identifying sites and production of *Ilex paraguariensis*, and *Camellia sinensis*, for their optimum use in fire breaks and the production of tea. For this purpose, the data of 20 core areas of the Agricultural Ministry of Paraná were used. The results indicate that the production of *I. paraguariensis* in 2008 amounted to 287,252 tons, cultivated in 147 municipalities mainly in the south of the state. With regard to *C. sinensis*, the production amounted to 1,245 tons, concentrated in 2 municipalities in the southeastern region. These results will serve as a basis for our research that aims at maximising the use of land, minimizing erosion and, reducing the costs of maintaining fire breaks.

A study of forest fire occurrence in the north of Iran (Mazandaran Province) from 1994 to 2007. Yousefi, A., Jalilvand, H. (*University of Agriculture and Natural Resources of Sari, Iran; Majidforestry@gmail.com; hj_458_hj@yahoo.com*).

Forest fire is one of the destructive factors—such as illegal and indiscriminate cutting of trees, excessive livestock grazing, pests, and disease—that have led to destruction of forests in several past decades. The paper looks at the occurrences of forest fire in the north of Iran from 1994 to 2007. Statistics show that about 490 forest fires took place within this period. The main causes of fire occurrences in forests and range lands include the high temperature in hot seasons of year and the dry conditions along with available fuel materials in forest areas and fire ignitions caused by negligence and carelessness of humans. In 1998, dry weather and reduction of annual precipitation were natural factors that provided favorable conditions for the creation of widespread fires. In these years the average expansion of fire in range areas was more than in forest areas. Fire as an ecological factor always causes changes to vegetation structure in ecosystems, so forest fire prevention and control are key factors in our ecological plans. The precise causes of the majority of the fires are human; however, education and extension programs can be used as suitable tools for forest protection and maintenance against fires.

A-12 Adaptation of temperate and boreal forests to climate change: what experimental trial system is needed?

Organizers: Andreas Bolte, *Johann Heinrich von Thuenen-Institute, Germany, andreas.bolte@vti.bund.de;* Mirko Liesebach, *VTI-Institute of Forest Genetics, Germany, mirko.liesebach@vti.bund.de;* Palle Madsen, *University of Copenhagen, Denmark, pam@life.ku.dk.*

Functional forests: addressing climate change and demands for forest products and environmental services and benefits. Clinton, P.W., Paul, T.S.H., Palmer, D., Payn, T.W. (SCION/*New Zealand Forest Research Ltd* (*Scion*)*, New Zealand; Peter.Clinton@scionresearch.com; Thomas.Paul@scionresearch.com; David.Palmer@scionresearch.com; Tim.Payn@scionresearch.com*); Tait, A. (*NIWA, New Zealand; TaitA@NIWA.co.nz*).

Few trials specifically test potential climate change adaptations for forests and forestry. We are now addressing this critical issue for New Zealand, where forestry is the third largest export earner but is threatened by climate change. Also at risk is the potential for non-timber benefits and environmental services to improve sector profitability while maintaining and enhancing environmental integrity and sustainability. Previous trials have examined the comparative performance of a number of species and provenances under recent climates. We are proposing new multi-species trials (including indigenous species) across major edaphic and climate gradients that represent potential shifts in climate and land use change. These long-term trials and associated research will study tree performance and the provision of important environmental services and benefits. This is because future forests may not necessarily be valued just for their productivity or high quality wood but also for their ability to deliver a range of functions, including erosion management, flood management, water quality enhancement, biodiversity, and carbon sequestration. We held a series of workshops with stakeholders to identify design requirements of future forests in terms of composition, structure, and function and now propose a new trial design.

Strategies in forest adaptation to climate change in different European regions: identifying suitable species and provenances and other response options. Lindner, M., Kolström, M., Vilén, T. (*European Forest Institute* (*EFI*)*, Finland; marcus.lindner@efi.int; marja.kolstrom@efi.int; terhi.vilen@efi.int*), Lexer, M.J. (*University of Natural Resources and Applied Life Sciences, Austria; mj.lexer@boku.ac.at*).

Climate change is expected to have significant impacts in European forests. Because of the long life-span of trees, forest adaptation measures are already now urgently needed. A comprehensive review of potential adaptation options for forestry in Europe was conducted for the European Commission in 2008. Building on that, the COST Action 0703 ECHOES (Expected Climate Change and Options for European Silviculture) is now expanding the knowledge base about on-going and planned forest adaptation measures in European countries. The selection of suitable species and provenances is important, but also many other measures have been identified. Most on-going and planned measures are focusing on reducing disturbance risks. Increasing diversity at different scales is another very important strategy that especially supports the inherent adaptation of forest ecosystems to climate change. While certain measures can be combined, others are mutually exclusive. Important questions include when to implement specific adaptation measures and how to choose suitable species and provenances. Should the current or the projected future climate be the main reference for the selection? Combining different strategies at the landscape scale is also a relevant option. We discuss these issues and present suitable adaptation measures for different bioclimatic regions in Europe.

The genetic diversity of refugial populations: perhaps the most valuable genetic resource to support forest adaptation? Madsen, P. (*University of Copenhagen, Denmark; pam@life.ku.dk*), Stanturf, J.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us*), Terazawa, K. (*Hokkaido Forestry Research Institute, Japan; terazawa.kazuhiko@pref.hokkaido.lg.jp*), Sagheb-Talebi, K. (*Research Institute of Forests and Rangelands, Iran;* saghebtalebi@rifr-ac.ir), Larsen, J.B., Hansen, O.K., Nielsen, U.B. (*University of Copenhagen, Denmark; jbl@life.ku.dk; okh@life.ku.dk; ubn@life.ku.dk*).

It is hypothesized that the retreats and advances of the glaciers during the Pleistocene ice ages and interglacials induced a relatively strong selection pressure on tree species populations that depended on the environmental conditions of the refugial areas. Further, it is hypothesized that the ice ages thus considerably reduced the genetic diversity of many European forest tree populations, leaving the refugial populations with the largest genetic diversity. The importance of a large genetic diversity for the adaptability to various environmental conditions has been documented for the European silver fir (*Abies alba*). The Calabrian provenance is a refugial population from southern Italy, and it has shown superior health and growth in provenance trials across Europe. There is little doubt that challenges of climate change as well as novel pest and disease scenarios will increase the need for adaptation by forest tree species, and refugial populations may qualify to play a key role in efforts and strategies to maximize the adaptation potential for our forests by increasing the genetic diversity of our tree species. We will present a review on the refugial populations of important deciduous tree species and their potential role in forest adaptation.

Can oak bio-groups produce high quality trees? Saha, S., Bauhus, J. (*University of Freiburg, Germany; somidh.saha@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de*), Kohnle, U. (*Forest Research Institute of Baden Württemberg-FVA, Germany; Ulrich.Kohnle@forst.bwl.de*), Kühne, C. (*University of Freiburg, Germany; christian.kuehne@waldbau.uni-freiburg.de*).

Oaks are likely to gain in importance in a warmer climate. However, the expansion of oak is slow owing to the high costs of artificial regeneration. A cost-effective alternative regeneration technique is the so called "oak bio-group" planting, which became popular in central Europe for re-afforestations from 1970s onwards. Bio-groups are either so-called nests, where 20–30 oaks/m^2 were sown or planted, or groups with 25–26 trees at 1 m spacing, and where the bio-groups at spaced out at the distance of future crop trees. Although many experimental trials have been established to analyse this approach, and some have been evaluated individually, so far there has been no comprehensive analysis of all experiments. Here we will present a comparative assessment of tree quality development between bio-groups and row plantings through a mixed effect meta-analysis with

hierarchical linear modelling. The main parameters analysed were stem form, crown type, slenderness, and branch free bole length. At the stand level, the two treatments were compared on the basis of the number of future crop trees. This first silvicultural meta-analysis of a regeneration method will provide an important basis for future decisions about establishment of oak-dominated stands in Central Europe.

Adaptive forest management for climate change: strategies and specific options for central Europe. Spathelf, P. (*University of Applied Sciences Eberswalde, Germany, pspathelf@fh-eberswalde.de*).

Climate change is likely to increase the vulnerability of forests in Central Europe. Adaptive forest management can help forest ecosystems adapt to these new conditions to achieve management goals, maintain desired forest ecosystem services, and reduce the risks of forest degradation. With a focus on Central Europe, the following management strategies are presented: (1) perpetuation of forest structures, (2) active adaptation, and (3) passive adaptation. The feasibility and criteria for the application of the different strategies are discussed. Furthermore, silvicultural adaptation options at the stand level are outlined. Forest adaptation may entail the establishment of 'neo-native' forests, including the use and intermixing of native and non-native tree species as well as non-local tree provenances assumed to be less sensitive to climate change. An integrative adaptive management concept is proposed that combines: (i) species suitability tests and modelling activities at the international scale, (ii) priority mapping of adaptation strategies at the national to regional scale, and (iii) implementation at the local scale. An international experimental trial system is recommended to test suitable adaptive measures throughout Europe and worldwide.

Restoration for the future: adaptation to global change. Stanturf, J.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us*), Madsen, P. (*University of Copenhagen, Denmark; pam@life.ku.de*), Lamb, D. (*Queensland University, Australia; d.lamb@uq.edu.au*).

Restoration is generally regarded as a process of returning an ecosystem to conditions that existed before degradation, traditionally looking to past conditions for soft or hard targets. The prospect of global change, however, suggests that backwards is the wrong way to look, and restorationists should look forward to future climate conditions and construct resilient ecosystems. Anticipating future conditions is more complex than simulating increases in temperatures and decreases in precipitation. Global change is composed of the legacy effects of past alterations of natural systems; future drivers of change (increased population, larger environmental footprint, and globalization of impacts); climate change; ecosystem responses; human responses to climate change; and interactions with secondary effects. Critical changes will affect limiting conditions for regeneration, pest, and disturbance dynamics. Native and non-native species will invade new habitats or change competitive relations. Changed conditions will cause effects at variable rates and over a range of scales, complicating strategies for responding. Managers need strategic but adaptive approaches that focus on restoring resistance and resilience, or that facilitate adaptation for further change. By emphasizing function, restoration for future conditions will result in novel ecosystems and translocation of high-value current plant communities in novel locations.

Assessing drought risk in central Europe, based on forest monitoring data. Von Wilpert, K., Puhlmann, H. (*Forest Research Institute Baden-Wuerttemberg, Germany; Klaus.wilpert@forst.bwl.de; heike.puhlmann@forst.bwl.de*).

Climate change scenarios state an increasing probability for drought in Central Europe that may lead to severe disturbance of tree health and forest growth as well as damage to the filtering functions of soils. Hence adequate assessment of drought stress risk will be a precondition for silvicultural planning in the future. Forest monitoring data and a few additional measurements and/or evaluations allow for differentiated examination on the ecological effects of climate change scenarios. The aim of this talk is to demonstrate how routine monitoring data contribute to assessment of drought risk and to what extent further data and evaluations are needed. Matrix potential is a suitable tool to predict the intensity of drought stress limiting tree growth. To assess drought stress risk for whole landscapes, model results on parameters of water balance have to be related to the landscape scale. For this, we assessed soil hydraulic properties (water retention, water conductivity, and derived pedo-transfer functions (PTFs)) based on soil monitoring information. Soil hydraulic properties will be transferred from monitoring points, where their soil physical input parameters are measured, to the landscape scale by using upscaling methods. We show example results for soil texture, rooting depth, and soil skeleton.

Posters

Interactions between under- and over-storeys, consequences for designing silvicultural systems adapted to climate change. Balandier, P. (*CEMAGREF / INRA Clermont-Ferrand, France; philippe.balandier@cemagref.fr*), Ginisty, C. (*CEMAGREF Nogent-sur-Vernisson, France; christian.ginisty@cemagref.fr*).

Forests comprise several interacting strata of vegetation; overstorey trees are most obvious but sub-canopy strata, collectively termed understorey or undergrowth, are typically present including herbaceous plants, shrubs, seedlings and saplings, and suppressed under- and midstorey trees. For decades only adult trees have been considered in forests and most often, only crop trees. However the understorey also plays a fundamental role in ecosystem functioning and health. Various silvicultural systems are currently designed or experimented in relation with climate changes, and in particular a reduction of soil water availability together with an increase of scorching temperatures in many regions of the temperate area. Modifying tree species composition and density of the forest ecosystem will have consequences on the understorey composition and functioning, which in turn will interact with the overstorey. These interactions will modify the whole ecosystem functioning in terms of biodiversity, tree regeneration, wild fauna habitats, pest and diseases, etc. Therefore it is compulsory to account for the interplays between the different strata in forest to better design silvicultural operations relative to climate changes. Examples of such interactions will be given and consequences for designing experimental systems and new silvicultures will be discussed.

Changes of ecological niche of *Quercus acutissima* due to global warming. Cho, K.T., You, Y.H. (*Kongju National University, Republic of Korea; rbxo38@kongju.ac.kr; youeco21@kongju.ac.kr*).

Quercus acutissima is the dominant tree species on soils with high moisture status in open lowland habitats of South Korea. To investigate the ecological niche change of *Q. acutissima* due to warming, we cultivated saplings of *Q. acutissima* under elevated

temperature (approximately 3 °C above the control) and atmospheric CO_2 conditions (700–800 ppm) from May to October, and varied the soil moisture levels (low level: 1 to high level: 4). Then we measured the growth status and evaluated shifts of the ecological niche of *Q. acutissima*. Growth parameters included leaf weight, shoot weight, root weight, and plant weight. For several growth parameters, we found no difference between global warming treatment and control, but leaf-related parameters showed lower values under global warming than in the control. Treated *Q. acutissima* saplings increased 16 measured parameter compared to control saplings, but root/shoot ratio, root weight, root length, photosynthetic investment, and leaf number decreased with exposure to warming / elevated CO_2 conditions. Thus, the growth status of *Q. acutissima* was not affected by global warming, but the ecological niche width of the oaks seems to be enlarged.

Growth performances and physiological characteristics of containerized seedlings of *Liriodendron tulipifera* and *Zelkova serrata* growing under three different temperature regimes. Cho, M.S., Lee, S.W., Kim, J.W. (*Korea Forest Research Institute, Republic of Korea; gungdong@hanmail.net*; *lsw361@forest.go.kr*; *jaewkim@forest.go.kr*).

The present study investigated growth performances, photosynthetic responses, chlorophyll fluorescence, and chlorophyll contents of containerized seedlings of *Liriodendron tulipifera* and *Zelkova serrata* growing under three different temperature regimes (25 ºC, 30 ºC, and 35 °C). The root collar diameter and height of *L. tulipifera* attained highest values at 25 °C and those of *Z. serrata* at 35 °C. With temperature rise both root collar diameter and height of *L. tulipifera* decreased, while those of *Z. serrata* increased. Leaf, shoot, root, and total biomass showed the same trends as growth of root collar diameter and height. Warming descreased photosynthetic capacity of *L. tulipifera*: we found the highest photosynthetic capacity at 25 ºC and the lowest at 35 °C. For *Z. serrata*, however, photosynthetic capacity was highest at 35 ºC showing the contrary trends compared to *L. tulipifera*. *L. tulipifera* showed the highest photochemical efficiency (apparent quantum yield) at 25 ºC, while *Z. serrata* showed the highest photochemical efficiency at 35 ºC. As the temperature increased, total chlorophyll contents of *L. tulipifera* significantly decreased and *Z. serrata* increased. These results point to a higher adaptive potential of *Z. serrata* relative to *L. tulipifera* regarding warming effects.

Predicting the changes in forest distribution using the thermal and hydrological indices. Choi, S.H., Lee, W.K. (*Korea University, Republic of Korea; gkattack@korea.ac.kr; leewk@korea.ac.kr*), Lim, J.H. (*Korea Forest Research Institute, Republic of Korea; limjh@forest.go.kr*).

Changes in thermal and hydrological conditions can affect the vegetation spatial patterns. This study was aimed at assessing the effect of climate change on forest vegetation distribution in Korea. For this, we used climatic data for the past 30 years (1971–2000) provided by the Korea Meteorological Administration (KMA) and future climatic data under the A1B scenario of the Intergovernmental Panel on Climate Change (IPCC) provided by the National Institute of Meteorological Research (NIMR). As thermal gradient indices, we applied the Warmth Index (WI) and the mean minimum temperature index of the coldest month (MTCI). As hydrological indices, we employed water supply index of the growing season precipitation, moisture input index, and wetness index. Then, we defined a new Plant Functional Types (PFTs) according to optimal habitat ranges of thermal and hydrological indices for each tree species, so called the 'Thermal Analogy Groups (TAG)' and 'Hydrological Analogy Groups (HAG)'. As a result, we could predict the detailed potential forest distribution of Korea from the past (1971–2000), the near future (2021–2050), and the far future (2071–2100).

Effects of global warming on growth response of *Quercus acutissima* and *Quercus variabilis.* Jeong, J.K., You, Y.H. (*Kongju National University, Republic of Korea; sksky82@kongju.ac.kr; youeco21@kongju.ac.kr*).

Global warming brings changes to natural ecosystems and effects on plant growth response. *Quercus acutissima* and *Q. variabilis* are taxonomically similar and dominant endemic species in deciduous forests in South Korea. To understand the ecological response of *Q. acutissima* and *Q. variabilis* to global warming conditions, we cultivated seedlings of the two oak species in ambient conditions (control) and treatment with elevated CO_2 (700–800 ppm) and increased temperature (approximately 3 ºC above than control). Then we measured the growth characteristics among them and analyzed the relationship of two species using PCA ordination. Stem length and total plant weight of *Q. acutissima* were significantly affected by elevated atmospheric CO_2 concentration and increased temperature. Stem diameter and weight of *Q. variabilis* were significantly affected by elevated CO_2 concentration and increased temperature ($p < 0.05$). On the percentage of variation, characteristics of *Q. acutissima* were changed more than *Q. variabilis* by elevated atmospheric CO_2 concentration and increased temperature. These results mean that *Q. acutissima* is more sensitive to global warming than *Q. variabilis*. PCA ordination showed that two species were arranged by two distinct groups based on 10 characters by elevated atmospheric CO_2 and increased temperature.

Effects of elevated CO_2 and temperature on photosynthetic characteristics and C/N ratio of *Quercus gilva* (an endangered species) and *Quercus glauca.* Kim, H.R., Lee, H.J., You, Y.H. (*Kongju National University of Korea, Republic of Korea; khr0727@kongju.ac.kr; eross0528@hanmail.net; youeco21@kongju.ac.kr*).

Over this century, a doubling of present atmospheric CO_2 concentrations is predicted, accompanied by rising global air temperatures. Both factors affect plant growth and physiology. Seedlings of the two oak species *Quercus gilva* and *Q. glauca* were studied to understand the photosynthetic responses and C/N ratio to global warming. In a global warming treatment, the treated seedlings were exposed to elevated atmospheric CO_2 concentration and temperature whereas the control seedlings grew under ambient conditions. Leaf temperature and transpiration rate of both species were high but stomatal conductance was low for the treated seedlings. Photosynthesis rate of *Q. gilva* was not significantly affected by elevated CO_2 and temperature, whereas treated *Q. glauca* seedlings attained higher values than the control seedlings. Nitrogen content of both oak species was higher in control than in treatment plants, and the C/N ratio of the two species was positively affected by the treatment. These results indicate that *Q. glauca* is more sensitive than *Q. gilva* to global warming.

Cold tolerance assessment of *Quercus* spp. as evergreens for the central region in South Korea. Shin, H.C., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; shinhc99@forest.go.kr; pnch@forest.go.kr*), Huh, K.Y., Kim, I.H. (*Jinju National University, Republic of Korea; sumoto@jinju.ac.kr; inhyekim@hanmail.net*).

This study was carried out to explore the potential use of *Quercus* spp. from southern regions of South Korea for urban greening of the central region by evaluating their cold tolerance. Electrolyte leakages from *Quercus myrsinaefoilia, Q.s salicina, Q. glauca*, and *Q.s acuta* were measured and the regrowth of intact plants was investigated. In a winter experiment *Q. salicina* and *Q. myrsinaefoilia* were more tolerant due to cold acclimation, with survival rates of more than 75% when exposed to −10 °C, compared to *Q. glauca* and *Q.s acuta*, which did not survive. In a summer experiment, the electrolyte leakage values from all tested *Quercus* species were higher than those in winter experiment, indicating the effects of cold acclimation. All tested plants did not survive when exposed to −5 °C. As the differences in cold tolerance between the four *Quercus* species were obscure in summer, a cold tolerance assessment model using both electrolyte leakage method and regrowth test is expected to be more effective in winter season when cold acclimated plant materials are available.

REINFFORCE: A project of the Atlantic arc for the evaluation of the effects of climate change on Atlantic forests. Silva-Pando, F.J. (*CIF-Lourizán, Spain; jsilva.cifal@siam-cma.org*).

The effects of climate change on forest species are of high interest for assessing species' adaptive potential to climate change. For this purpose, a working group consisting of 11 research centres in 4 countries (Great Britain, France, Spain, and Portugal) was set up within the REINFFORCE project from 2009–2014. The project aims at establishing 32 arboreta and various demonstration trials distributed over the Atlantic regions of Europe ranging from Scotland to Portugal. In each arboretum a minimum of 30 species are planted with at least 3 provenances per species (a minimum of 12 samples per provenance), assuming that the growing conditions at the planting site meet those at the provenance origin. The selected species come from the project participants' countries as well as from the Mediterranean region and the Pacific coast of North America. The demonstration trials will include plots where typical silvicultural techniques of the region will be applied or have already been applied.

A-13 Climatic gradients in mountains: opportunities for studying forests facing climate change

Organizers: Heinrich Spiecker, *University of Freiburg, Germany, instww@iww.uni-freiburg.de*; Peter Brang, *Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland, peter.brang@wsl.ch;* Roque Rodríguez, Soalleiro *University of Santiago de Compostela, Spain, roquers@lugo.usc.es.*

Influence of forest architecture on carbon assimilation along an elevation gradient in Hawaii: linking field measurements, airborne waveform LiDAR, and modeling. Broadbent, E.B., Almeyda A.M. (*Stanford University, USA; eben@stanford.edu; aalmeyda@gmail.com*), Asner, G.P. (*Carnegie Institution, USA; gpa@stanford.edu*).

Tropical forests cover 12% of the land surface area and are important contributors to the global carbon cycle. Forest architecture controls forest functional processes such as carbon assimilation through differences in the 3-D distribution of photosynthetic capacity and infiltration of photosynthetic active radiation. Environmental factors such as nutrient, water and temperature mediate variations in forest architecture, and these factors are projected to change under future climate scenarios. Few studies have investigated interactions between forest architecture, carbon flux and environmental change and such studies have been limited in scale by the difficulty of acquiring necessary 3-D spatial information on the distribution of leaf area density, forest photosynthetic capacity and PAR availability. This project proposes to develop and validate a rapid, large-scale and cost-effective approach for acquiring this information using high resolution airborne waveform LiDAR obtained using the Carnegie Airborne Observatory. These tools will then be applied along an elevation gradient in the Laupahoehoe Experimental Forest of Hawaii to quantify interactions between forest architecture, carbon assimilation, and environmental change. This presentation focuses on the novel research methods, including remote sensing, modeling and canopy access techniques, developed for this project and future objectives.

Altitudinal gradients to study the impact of climate change on natural forests. Dobbertin, M., Bebi, P., Buttler, A., Wohlgemuth, T., Wermelinger, B., Rigling, A. (*WSL Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland; matthias.dobbertin@wsl.ch; peter.bebi@slf.ch; alexandre.buttler@epfl.ch; thomas.wohlgemuth@wsl.ch; beat.wermelinger@wsl.ch; andreas.rigling@wsl.ch*).

How will expected climate change impact forest ecosystems? This is a key question today for the planning of future forest management and for goods and services issues. Field experimental or quasi-experimental approaches are needed since controlled experiments in climate or open-top chambers are restricted to small trees and cannot easily be up-scaled to field conditions. Manipulation experiments in mature forests are usually restricted to water exclusion or addition. It is almost impossible to experimentally increase air or soil temperature in mature forests without severely affecting the entire ecosystem and having confounding effects. Studies along natural gradients of temperature and precipitation on mountain slopes offer a valid alternative. We can distinguish between gradient studies in natural forests, provenance trials along gradients, seeding experiments, and transplantation of plants from various altitudes with their local soil. In this review presentation we will discuss advantages and disadvantages of the methods and present past and present studies in the Swiss Mountains. We focus on studies with Scots pine (*Pinus silvestris* L.) and Norway spruce (*Picea abies* Karst.) under natural wet and dry conditions and present results with regards to tree growth, tree mortality, tree morphology, and susceptibility of trees to insect infestations.

Long-term consequences of hybridization between high-altitude and low-altitude populations in *Abies sachalinensis*, locally-adapted in their native altitudinal zones. Goto, S., Ishizuka, W. (*University of Tokyo, Japan; gotos@uf.a.u-tokyo.ac.jp; wataru@uf.a.u-tokyo.ac.jp*), Iijima, H (*Yamanashi Forest Research Institute, Japan; hayato.iijima@gmail.com*), Ogawa, H., Kimura, N. (*University of Tokyo, Japan; hitomi@uf.a.u-tokyo.ac.jp; kim@uf.a.u-tokyo.ac.jp*).

Altitudinal gradients are the most powerful 'natural experiments' for predicting ecological and evolutionary responses of forest trees against global warming. We performed reciprocal crossing between high-altitude (1,100–1,200 m alt.) trees and low-altitude (530 m alt.) trees in 1979 and established a common garden (230 m alt.) in 1986 for *Abies sachalinesis* populations that are locally-adapted to their native altitudinal zones. Survival, height, diameter at breast height (DBH), needle nitrogen content, specific leaf area (SLA), and needle area per shoot diameter (NA) of 25-year-old progeny were measured in 2005. Progeny of high-altitude × high-altitude populations and low-altitude × low-altitude ones showed the lowest and the highest growth. F1 hybrids of high-altitude × low-altitude were intermediate but significantly lower than average of parental populations, thus indicated outbreeding depression. Growth of Such reductions may be related to morphological needle traits such as the low values of SLA and NA. Furthermore, dilution of locally-adapted genes might be responsible for performance of F1 progeny. Finally, we discuss long-term consequence of the response against global warming of forest tree populations.

Temperate deciduous forests research network: adaptation of the beech family (*Fagaceae*) to a changing environment. Madsen, P. (*University of Copenhagen, Denmark; pam@life.ku.dk*), Stanturf, J.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us*), Bolte, A. (*Federal Research Institute for Rural Areas, Forestry and Fisheries, Germany; Andreas.Bolte@vti.bund.de*),Terazawa, K. (*Hokkaido Forestry Research Institute, Japan; terazawa.kazuhiko@pref.hokkaido.lg.jp*), Sagheb-Talebi, K. (*Research Institute of Forests and Rangelands, Iran; saghebtalebi@rifr-ac.ir*), Larsen, J.B. (*University of Copenhagen, Denmark; jbl@life.ku.dk*), Collet, C. (*INRA, France; collet@nancy.inra.fr*), Balandier, P. (*CEMAGREF / INRA, France; philippe.balandier@cemagref.fr*), Coll, L. (*Centre Tecnològic Forestal de Catalunya, Spain; lcoll@caramail.com*), Löf, M. (*Swedish University of Agricultural Sciences, Sweden; magnus.lof@ess.slu.se*), Kramer, K. (*Alterra, Holland; koen.kramer@wur.nl*).

Within the IUFRO beech unit (1.01.07–ecology and silviculture of beech) we have considered proposing a global beech project. A *Fagaceae* project including oaks and chestnuts, too, will increase its relevance and applicability across continents. Many members of the beech family are principal forest tree species of the temperate deciduous forests. The environmental gradients on mountain slopes provide excellent opportunities to study particularly the regeneration physiology, methods, and strategies to reveal an important part of the adaptation potential of various species and provenances under various climatic conditions. We will review findings by both researchers and practitioners and emphasize linking the knowledge and valuable cases of forest landscape restoration to goal-oriented adaptation strategies with specified future forest function serving as the red line to guide the selection of desired forest development types and the silviculture needed to achieve them. We seek to identify knowledge gaps and to design research protocols that we find particularly valuable to share in an international forest research network on forest adaptation, including the adaptation potential of refugial populations.

The alpine timberline of Mt. Fuji is moving to a higher altitude. Sakio, H. (*Niigata University, Japan, sakio@agr.niigata-u.ac.jp*), Ohishi, K. (*Shizuoka University, Japan*), Masuzawa, T. (*Shizuoka University, Japan, polkadots_ghost@yahoo.co.jp; sbtmasu@ipc.shizuoka.ac.jp*).

The alpine timberline of Mt. Fuji in central Japan is located at about 2,400 m above sea level. We monitored the dynamics of the movement of this timberline from 1978 to 2008 and found that it had advanced rapidly upward during this 30-year period. Dominant tree species of the timberline, namely, *Alnus maximowiczii*, *Salix reinii*, and *Larix kaempferi*, had invaded into areas that were formerly above the timberline. In particular, an abundance of *Larix* seedlings were observed in this upper area. Results of tree age analysis indicated that *Larix* was the first canopy tree species to invade this area. Because it is drought-resistant, *Larix* can occupy sites with severely dry conditions. Most seedlings of *Abies veitchii* invaded patches of herbs and shrubs. Thus, vegetation patches in the upper kampfzone play an important role as nurse plants in the invasion of tree seedlings. The distribution of the tree form of *Larix* has been changing for several decades on Mt. Fuji, and global warming, thought to be one of the causes of the advancing of alpine timberlines, may accelerate the upward advance of both the timberline of Mt. Fuji and the table-shaped form of *Larix*.

Assessment of phytodiversity, biomass production and carbon stocks in some natural forests of Garhwal Himalaya, India. Sharma, C.M., Gairola, S., Baduni, N.P., Ghildiyal, S.K. (*HNB Garhwal University, India; sharmacmin@gmail.com; sumeetgairola@gmail.com; sumeetgairola@hotmail.com; skghildiyal@gmail.com*).

Twenty major natural forest types, growing in sub-tropical to temperate climatic zones (350 to 3100 m elevation) of Garhwal Himalaya in India were evaluated to assess variation in plant diversity, density, biomass and carbon stocks. Ten sample plots of 0.1 ha each were randomly laid out on four different stands in each forest type. Tree diversity was determined using Shannon-Wiener Diversity Index. The growing stock was estimated using standard volume equations for the respective species. The aboveground biomass density, below groundbiomass density (fine and coarse roots), total biomass density (TBD) and total carbon density (TCD) were calculated using suitable regression equations and expansion factors. Stem density was observed to be highest (850.0 ± 361.7 ind./ha) in lower Western Himalayan *Quercus leucotrichophora* forest and lowest (295.0 ± 48.0 ind./ha) in *Quercus* Scrub forest. Maximum value of Shannon-Wiener Diversity Index was recorded for Moist Deciduous miscellaneous forest (2.56 ± 0.28) and minimum for *Pinus roxburghii* forest (0.46 ± 0.34). The moist *Cedrus deodara* forest had highest TBD (533.28 ± 79.21 t/ha) and TCD (245.31 ± 36.44 t C/ha) values, whereas *Acacia catechu-Dalbergia sissoo* forest had lowest TBD (128.70 ± 30.15 t/ha) and TCD (59.20 ± 13.87 t C/ha) values respectively. Coniferous forests were found to be more productive and had higher carbon stocks than upland hardwood and sub-tropical forests.

Posters

Formulating a spatial hierarchy for addressing climate change. Cleland, D.T., Stanturf, J.A., Crow, T.R. (*U.S. Forest Service, USA; dcleland@fs.fed.us; tcrow@fs.fed.us; jstanturf@fs.fed.us*).

Simple temperature or moisture gradients do not account for spatial heterogeneity or the multivariate nature of plant response to environment, hence the need for quantitative approaches to designing monitoring networks and experiments to detect and predict responses to climate change. At global, continental, and regional scales, ecosystem patterns correspond with climatic regions,

which change mainly due to latitudinal, orographic, and maritime influences. Within climatic-geomorphic regions, water, plants, animals, soils, topography, and disturbance regimes interact to form ecosystems at landscape to local scales. We can conceive of ecosystems as geographically nested, with smaller ecosystems embedded in larger ones. The integration of multiple factors at relevant scales is important for understanding distribution of ecosystems under current as well as future climates. Using multivariate analyses of climate data, we identified latent structures in North America influencing the degree to which continental, orographic, and maritime influences result in a stress attenuation index, whereby climatic moisture and temperature extreme regimes are integrated into a single component. By integrating information on the ecophysiology of keystone species, and keystone processes, we can identify species and communities most vulnerable to climate change and areas most likely to be impacted by subtle changes in climatic regimes for monitoring.

The effect of slope aspects on tree diversity, biomass production and carbon stocks in some natural temperate Himalayan forests. Sharma, C.M., Gairola, S., Baduni, N.P., Ghildiyal, S.K., Suyal, S. (*HNB Garhwal University, India; sharmacmin@gmail.com; sumeetgairola@gmail.com; sumeetgairola@hotmail.com; skghildiyal@gmail.com; sarveshsuyal@gmail.com*).

The present study was undertaken in ten major natural temperate forest types occurring between 1,500 m to 3,100 m elevation in Garhwal Himalaya (India) to understand the effect of slope aspect (north-east (NE), north-west (NW), south-east (SE) and south-west (SW)), on tree diversity, biomass production and carbon stocks in these forests. Ten sample plots of 0.1 ha each were randomly established on four different slope aspects in each forest type. Tree diversity was determined using the Shannon-Wiener Diversity Index. Growing stock was estimated using standard volume equations, aboveground biomass density, belowground biomass density (fine and coarse roots), total biomass density (TBD) and total carbon density (TCD) were calculated using suitable regression equations and expansion factors. The *Cedrus deodara* forest had shown highest TBD (533.28 ± 79.21 t/ha) and TCD (245.31 ± 36.44 t C/ha) values, whereas moist mixed deciduous forest had lowest TBD (144.65 ± 29.65 t/ha) and TCD (66.54 ± 13.64 t C/ha) values. Stem density was highest in mixed Broad leaved forest (990.0 ± 385.4 ind./ha) and lowest in *Quercus* Scrub forest (295.0 ± 48.0 ind./ha). Total stem density, TBD and TCD values were comparatively higher on northern aspects as compared to southern aspects with a general trend of NE>NW>SE>SW, which implies that sites on northern aspects are more productive.

A-14 Impacts of climate change on forest ecology, ecosystem processes, and management

Organizer: Jean-Michel Carnus, *National Institute for Agricultural Research, France, jean-michel.carnus@pierroton.inra.fr.*

Modelled woodland biomass and soil carbon sequestration across Sudanese drylands: current and future climate change scenario-based estimates. Alam, S.A., Starr, M. (*University of Helsinki, Finland; ashraful.alam@helsinki.fi; mike.starr@helsinki.fi*).

The vegetation and soils of semi-arid ecosystems, 47% of the world's land area, potentially offer a means of sequestering considerable quantities of carbon (C), while also improving soil fertility and moisture conditions. Biomass and soil C production is largely constrained by water scarcity. How the climate will change in world's dryland regions remains unclear, however, particularly regarding precipitation. We calculated current C densities for woodland biomass (above-ground) and soil (1 m) across central Sudan (11º–20º N) using spatially aggregated data from various sources, and we estimated biomass C pools under 10 possible SRES (5 GCMs; A1FI and B1 emission scenarios; 2070–2099) for selected grid areas (1.0º latitude × 1.5º longitude) using an exponential relationship between biomass C density and rainfall ($y = 7.1511e^{0.0052X}$; $R^2 = 64\%$). Current biomass and soil C densities were estimated at 4–380 and 1,323–8,172 g C m^{-2}, respectively. Depending on climate change scenario and grid area, annual rainfall either increased or decreased across the region, resulting in changes in biomass C densities ranging from 0.4 (CGCM2_A1FI, wetter area) to 6.5 (PCM_B1, drier area) relative to 1961–90 baseline values. Since soil organic matter contents are related to biomass production, changes in soil C densities may be expected to show similar results.

Climate change impacts on hydrologic processes of the Mount Makiling Forest Reserve, Philippines. Combalicer, E.A. (*Nueva Vizcaya State University, Philippines; eacombalicer@yahoo.com*), Im, S.J. (*Seoul National University, Republic of Korea; junie@snu.ac.kr*), Cruz, R.V.O. (*University of the Philippines/Los Banos, Philippines; rexcruz@yahoo.com*).

A statistical downscaling known for producing station-scale climate information from GCM output was preferred to evaluate the impacts of climate change on hydrologic processes within the *Mount Makiling* Forest Reserve, Philippines. The lumped hydrologic BROOK90 model was utilized for the hydrologic processes assessment of climate change impacts based on two scenarios (A1B and A2) from CGCM3 experiments. The annual precipitation change was estimated to increase by 0.1 to 9.3 per cent for the A1B scenario and –3.3 to 3.3 per cent decrease/increase for the A2 scenario. Difference in mean temperature between the present and the 2080s was predicted to be 0.6 to 2.2 °C and 0.6 to 3.0 °C under A1B and A2 scenarios, respectively. Major hydrologic processes showed that 42 per cent of precipitation is converted into evaporation, 48 per cent into streamflow, and 10 per cent into deep seepage loss. The impacts of climate change from different land cover types reflected dramatic fluctuations in hydrologic events. A study on the changes in monthly water balance provided insights into the hydrologic changes within the forest, agroforestry, and special use watershed systems, which can be used in mitigating the effects of climate change.

Predicting the current potential and future distribution of *Sclerocarya birrea* subsp. *birrea*, in Benin (West-Africa). Gouwakinnou, N.G., Sinsin, B. (*University of Abomey-Calavi, Benin; gougerano@yahoo.fr; bsinsin@gmail.com*).

Sclerocarya birrea is a local fruit tree species of multipurpose use for rural communities in the northern part of Benin. This study used the climate envelope modeling techniques implemented in Maxent to predict the current potential and future distribution of

the species under various climate scenarios. The species occurrence points were recorded through its distribution range. Nineteen bioclimatic variables were derived from monthly minimal and maximal temperature and rainfall obtained from Wordclim database. Climate projection made using CCM3 model under $2xCO_2$ climate conditions was used. Results showed that the most suitable current distribution range of the species remains mainly restricted to the Soudano-Sahelian zone of the country encompassing the two main protected areas. Under the climate projection, suitable potential area would increase and shift toward the southern part of the country, while the species would almost disappear from one of the protected areas. This suggests that the species would face a conservation challenge if proper measures were not taken given the rate of population growth with subsequent agricultural pressure in open areas. However, a larger scale prediction involving land-cover and soil parameters would provide a better insight in the species' future distribution.

Use of eddy covariance to monitor net CO_2 exchange in mixed sub-tropical forest of Uttarakhand, India. Rawat R.B.S., Dhakate, P. M. (*Uttarakhand Forest Department, India; raghubir22@hotmail.com; paragenetics@gmail.com*).

Quantifying net carbon exchange in forests is a necessary step in the validation of carbon capture estimates. Use of the eddy covariance technique has been widely accepted in recent years. In India, the first site to measure the net ecosystem CO_2 exchange using eddy covariance technique has been established in a sub-tropical mixed forest of the Tarai region near Haldwani in North India. Eddy covariance is a micrometeorological technique that allows a non-invasive measurement of the exchange of CO_2 across vegetation-atmosphere interface. The CO_2 flux measurement tower was commissioned in 2009 and is a part of the collaborative project of the Uttarakhand Forest Department, Indian Council of Forestry Research and Education, and Indian Institute of Remote Sensing. The eddy covariance technique is capable of measuring ecosystem CO_2 exchange across a spectrum of time scales, ranging from hours to years, and is also useful in studying ecosystem physiology. Long term measurement of CO_2 exchange between forest vegetation and the atmosphere has potential to significantly improve understanding of the role of terrestrial forest ecosystems in the global carbon cycle, which can be used in the prescriptions of the working plans for scientific management of forests in the region.

Effects of climate change on hydrology of forests in southwestern Australia and implications for future forest management. Stoneman, G., Kinal, J. (*Department of Environment and Conservation, Australia; geoff.stoneman@dec.wa.gov.au*; *joe.kinal@dec.wa.gov.au*).

Rainfall in southwestern Australia has declined significantly in the past several decades and is predicted to decline further in response to climate change. The changes in rainfall have led to major reductions in streamflow and falls in the level of the deep groundwater system. Numerous research catchments in southwest forests have monitored the changes in hydrology and examined the effects of a range of disturbance activities on hydrology. Earlier catchment studies indicated the potential to increase streamflow through reductions in forest density. However, more recent studies indicate that there is now limited potential to increase streamflow. One of the catchment studies has shown that the disconnection between the deep groundwater system and the surface water system is the key driver of the fundamental change in hydrology, whereby there are large reductions in streamflow in response to much smaller reductions in rainfall. If rainfall continues to decline, as projected by climate change scenarios, this disconnection between groundwater and surface water systems is likely to occur throughout most the forest and lead to further major reductions in streamflow. The reliance on surface water from the forested catchments for supply of drinking water will need to decrease further in future decades.

Predicting potential habitats of 10 conifer species under climate change in Japan. Tanaka, N., Nakazono, E., Tsuyama, I., Matsui, T. (*Forestry and Forest Products Research Institute, Japan; ntanaka@affrc.go.jp*).

Based on statistical models predicting actual distribution of species, we predicted potential habitats for 10 conifer species in Japan under two climate change scenarios, RCM20 and MIROC for 2081–2100. The area of suitable habitats was predicted to decrease to 0–20% for cold-temperate species (*Abies mariesii*, *A. veitchii*, *Tsuga diversifolia*); decrease to 8–28% for a cool-temperate species (*A. homolepis*); change to 21–120% for intermediate-temperate species (*A. firma*, *T. sieboldii*, *Pseudotsuga japonica*); changed to 185–326% for warm-temperate species (*Podocarpus microphyllum*, *P. nagi*); and decrease to 18–52% for a boreal species (*A. sachalinensis*). Due to slow migration of tree species, the suitable habitats colonized by the species would be smaller than the prediction. The potential habitats (suitable and marginal habitats) for the cold-temperate and cool-temperate species as well as a rare species, *P. japonica*, were predicted not only to decrease in Japan but also to disappear in some regions, suggesting the vulnerability to climate change. Locations of sustained habitats were detected for these species, suggesting possible refugia. Prediction of vulnerable species and regions, and refugia for the species, is useful for biodiversity conservation management adapting to climate change.

Silviculture for climate change: future scenarios for Australian forests. Vanclay J.K., Jay, V.A.; Nichols, J.D. (*Southern Cross University, Australia; jvanclay@scu.edu.au; alexv.jay@gmail.com; doland.nichols@scu.edu.au*).

Climate change is expected to lead to substantial changes in rainfall patterns in eastern Australia, and this may have substantial consequences for forest management and for conservation outcomes throughout the region. We examine three different forest types across an environmental spectrum from from semi-arid to humid subtropical and consider their response to water shortages and other environmental stresses; we also explore the potential consequences for conservation and timber production by considering impacts on forest structure and limiting stand density. Analysis of a series of scenarios provides the basis for a critique of existing management practices, and suggests practical alternatives to develop resilient forests with minimal diminution of production and environmental services. We specifically discuss practical silvicultural interventions that are feasible at the landscape-scale, that are economically viable, and that have the potential to enhance resilience of forest stands. We also discuss incentives to encourage adoption of these approaches by private forest owners. We draw on these case studies in eastern Australia to offer generic principles to assist forest researchers and managers faced with similar challenges elsewhere.

Posters

Climate change effects on the natural landscape in Turkey. Avcibasi, Z. (*IFSA, Turkey; avcibasizeynep@gmail.com*).

The impacts of climate change on various natural and societal systems in Turkey were studied. Indicators were divided into nine separate categories which are presented in here: atmosphere and climate; cryosphere (glaciers, snow and ice); marine biodiversity and ecosystems; water quantity; freshwater quality and biodiversity; terrestrial ecosystems and biodiversity; soil; agriculture and forestry; and human health. Farming, forestry, and gardening, as well as wildlife, are affected. The timing of tilling, sowing, and harvesting is changing; fruit is ripening earlier due to warmer summers, and grass in municipal parks and on road verges requires cutting more frequently and for longer. Changes in flowering have implications for the timing and intensity of the pollen season; this is showing an advancing trend as many species start to flower earlier. Allied to this, the concentration of pollen in the air is increasing. Phenological changes will alter growing seasons, ecosystem production, population level interactions, and community dynamics. Different species show different phenological responses; for example, annuals and insect-pollinated species are more likely to flower early than perennials and wind pollinated species. Ecological research is evaluating these response thresholds.

Comparision of soil respiration, fine root biomass, and litterfall in young and mature forests in the White Mountains of New Hampshire. Bae, K.K. (State University of New York/Syracuse*, USA; kbae02@syr.edu*), Fahey, T. (*Cornell University, USA; tjf5@cornell.edu*), Yanai, R. (State University of New York/Syracuse*, USA; rdyanai@syr.edu*), Park, B.B. (*Korea Forest Research Institute, Republic of Korea; bbpark@forest.go.kr*), Myeong, S.J. (*Korea Environment Institute, Republic of Korea; sjmyeong@kei.re.kr*).

Soil respiration is a major pathway of flux in the terrestrial ecosystem carbon cycle; even a small change in soil respiration can exacerbate the annual input of CO_2 into the atmosphere. Our understanding of the mechanisms of soil respiration is not fully achieved largely due to the many complex reactions involved in soil ecosystems. This study aimed to measure a seasonal soil CO_2 efflux and compare their values in three old-growth and recently regenerating forests in the White Mountains of New Hampshire during the growing season in 2009. Seasonal patterns of soil CO_2 efflux at both sites showed a high correlation with soil temperature at 10 cm depth. We would expect much higher rates of soil CO_2 efflux at the old sites due to deeper soil layer and greater biological activity, but some sites were not significantly higher ($p < 0.05$). Fine root biomass (>5 mm) was higher in old forests but litterfall biomass showed no difference between young and old forests. Further studies about more factors and continuous measurements that are affected to soil respiration—including climate, vegetation, substrate quality, net ecosystem productivity and others—are needed.

Molecular and physiological approach to study cold tolerance in cypress (*Cupressus sempervirens* L.). Baldi, P. (*FEM-IASMA, Italy; paolo.baldi@iasma.it*), Hietala A.M. (*Skogfosk, Norway; ari.hietala@skogoglandskap*), Pedron, L., La Porta, N. (*FEM-IASMA, Italy; luca.pedron@iasma.it; nicola.laporta@iasma.it*).

Cupressus sempervirens L. is a Mediterranean tree species that is going to shift its area of distribution more northward due to climate warming. In such cases it is important to assess that the level of adaptability of the single clones to the new environment can overcome some critical climatic events. In the case of *C. sempervirens,* a breeding programme for cold tolerance was carried out. Twenty different cypress accessions were tested for freezing tolerance after cold hardening development, measuring electrolyte leakage and chlorophyll fluorescence. Based on the freezing test, two cypress accessions, one showing the highest and the other the lowest freezing tolerance, were subjected to transcript profiling of candidate genes upon the developing of cold hardening. Nine different cypress sequences were selected by cold treatment: heat shock protein, a putative chaperonin, a chlorophyll-binding protein, a serine/threonine protein kinase, a putative exonuclease, a dehydrin, and three different senescence-associated proteins. Expression level of all selected sequences was followed during hardening conditions by real-time RT-PCR. Even though some of the genes showed regulation patterns common to both cypress accessions, in other cases—such as chaperonin, exonuclease, and some senescence-associated proteins—clear differences in rate and level of up- or down-regulation were found.

The effect of root zone temperature on the establishment forest tree seedlings originated in different climates. Brand, D. (*Keren Kayemet LeIsrael* (*KKL-JNF*)*, Israel; davidb@kkl.org.il*), Atzmon, N. (*Agricultural Research Organization/The Volcani Center, Israel; Atzmonn@volcani.agri.gov.il*), Riov, J. (*The Hebrew University of Jerusalem, Israel; riov@agri.huji.ac.il*).

Forest and landscape plantings in Israel are performed in the winter to take advantage of wet soil for seedling establishment, based on the assumption that the planted species are capable of resuming root growth under the relatively low soil temperatures prevailing in this season. However, sometimes we witness high rates of mortality in plantings of species originated in mild climates, possibly because mild-climate species are unable to grow new roots after planting. In the present study we examined the effect of root zone temperature on root growth of several common species from different climatic origins: *Cedrus atlantica* (cool temperate climate), *Pinus pinea*, *Ceratonia siliqua* (Mediterranean climate), *Acacia raddiana*, and *Prosopis alba* (warm climates). There was a good agreement between temperature range and optimum of both tap and lateral root development and climatic origin of the species. Based on the data obtained we concluded that for all species, except *C. atlantica*, soil temperatures in the winter do not allow significant root growth after planting. High temperature (32 °C) also retarded root growth of the species examined, except for *P. alba*. Planting in the fall, when soil temperature is still quite high, was superior to planting in the winter.

Analysis of climate change impacts on litterfall and forest phenology of Nanjenshan Nature Reserve, Taiwan, 1999–2007. Chen, J.C. (*Shih-Chien University, China-Taipei; zzz.john@msa.hinet.net*), Chin, C.C., Chen, C.T. (*National Pingtung University of Science and Technology, China-Taipei; forest@ms48.url.com.tw; cct@gisfore.npust.edu.tw*).

Lowland rainforests consist of abundant wildlife species and complex components. Litterfall is an important source of nutrition for the lowland rainforests without any artificial management. Litterfall has been an important parameter in ecological research for decades because it can help to understand the function and structure of an ecosystem, also to estimate forest productivity, regeneration, and biomass. The main composition of litterfall includes foliage, flower, bark, and fruit. The data used in this study

consisted of the measurements of the litterfall quantity and variety from 1999 to 2007, to analyze the variation of litterfall based on the effects of climate change. The results of this study showed that the average quantity of litterfall was 5.52±0.07 $tha^{-1}yr^{-1}$ in the Nanjenshan area. The climate change in seasonal variation of litterfall quantity has shown two peaks in the Nanjenshan area, from February to March and from July to August, and a large quantity of branches litterfall was seen during the northeastern monsoon at the windward site. The northeastern monsoon would not have significant effect on the quantity of branches litterfall. The disturbance of typhoon is the most affective factor for the long-term variation of litterfall in Nanjenshan area.

Phenology of eight forest species at ecological risk in the natural forest of Tolima, Colombia. Dávila Cuta, Y., Lozano Botache, L., Rojas Gutiérrez, A. (*Universidad del Tolima, Colombia; yolisdavila@gmail.com; llozano@ut.edu.co; amrojas@ut.edu.co*).

The forests of Tolima are distributed over 10 life zones, and there are no major records of changes in cover, composition, structure, dynamics and adaptation caused by urban expansion, unsustainable use and climate change impacts. Since 2008, the regional environmental authority, CORTOLIMA, and the University of Tolima have been developing a study that evaluates, on a monthly basis, the phenology of eight native forest species (*Anacardium excelsum, Cedrela odorata, Bulnesia carrapo, Podocarpus oleifolius, Quercus humboldtii, Aspidosperma polyneuron, Juglans neotropica* and *Aniba perutilis*) that face an ecological risk according to the Ministry of the Environment of Colombia. *Aniba perutilis*, *Bulnesia carrapo*, *Podocarpus oleifolius* and *Anacardium excelsum* are semi-deciduous, retaining some foliage year-round. There is a significant leaf-fall during July-August and less in November–December. *Cedrela odorata* and *Juglans neotropica* lose all their leaves in those months. With regard to fruiting, *Bulnesia carrapo*, *Aspidosperma polyneuron*, *Quercus humboldtii*, produced fruit in all months, especially in September, which coincides with the change of leaves and the end of the summer period, while *Podocarpus oleifolius* did not show any fruiting.

Ecophysiological behavior of woody species in NW Patagonia: are the exotic species better able to cope with climate change than native species? Gyenge, J., Fernández, M. E. (*CONICET, INTA EEA Bariloche, Argentina; jgyenge@bariloche.inta.gov.ar; ecologia_forestal@yahoo.com.ar*).

In this study we analyze the ecophysiological behavior of adult plant of several woody species growing in NW Patagonia (South America), in response to changes in environmental (soil water, vapor pressure deficit (VPD)) and management conditions (tree density), in order to estimate the potential impact of predicted conditions in the framework of regional climatic change (temperature increase with similar or lower precipitation levels). A differential behavior was observed comparing exotic (*Pinus ponderosa* and *Pseudotsuga menziesii*) to all native studied species (*Nothofagus antarctica, Austrocedrus chilensis, Lomatia hirsuta, Schinus patagonicus, Diostea juncea*). The latter always presented an early stomatal conductance decrease under increasing VPD, even when soil water content was high. In contrast, both exotic species presented high canopy conductance levels until threshold VPD values higher than those of native species, maintaining high rates of gas exchange under water deficits in the atmosphere, or even in the soil (in the case of ponderosa pine). These results suggest that, contrary to what could happen with exotic species, the productivity and survival of native species would be seriously limited under air temperature rise, independently of precipitation levels, threatening the sustainability of several forest species of Patagonian forests.

Effects of litter layer treatment on soil respiration in pitch pine and Japanese larch plantations. Hwang, J.H. (*Korea Forest Research Institute, Republic of Korea; jhwang@forest.go.kr*), Son, Y. (*Korea University, Republic of Korea; yson@korea.ac.kr*).

The objective of this study was to investigate the influence of soil temperature on soil respiration after litter layer treatment for 2 years (28 April 2001 to 30 November 2002) using EGM-3 gas analyzer. This study sites were located within the experimental forest of Kyonggido Forest Environment Research Station, Gunpo, Korea. Two 20 × 20 m plots were established within each plantation and each plot was assigned to three replicate sub-plots (2 × 2 m) for each of three litter layer treatments: litter removal (LR: above-ground litter was removed); control (NT: no treatment; undisturbed); and double litter layer (DL). Double litter layer treatment had influence on higher soil respiration rates for all treatments in both plantations ($p < 0.05$). The proportion (%) of above-ground litter decomposition in total soil respiration was 39 in the *Pinus rigida* plantation and 17 in the *Larix leptolepis* plantation. Annual mean soil temperature for LR showed the highest values through all litter layer treatments in both plantations; however, none of the differences in soil temperatures were statistically significant. Soil respiration rates (g CO_2 m^{-2} hr^{-1}) plotted against soil temperatures (10 cm) revealed a curvilinear, apparently exponential relationship.

Earlier spring in Hongneung Arboretum, Seoul. Kim, S.H., Sung, J.H. (*Korea Forest Research Institute, Republic of Korea; sands02@forest.go.kr; jhs033@forest.go.kr*).

Flowering is an important phonological event. Evidence for global warming is inferred from spring advances in flowering time in woody plants. To investigate changes in flowering times we examined the flowering records of 214 plant species for 11 years (1999–2009) and 6 years (1968–1975 [1969 and 1971 not recorded]) in Hongneung Arboretum, Seoul. The trend of average flowering times for the study group shows a significant advance of average 7 days compared to a 40 years ago. When 27 species that exhibit later flowering time are excluded from the data set, the remaining 186 show a significant advance of 10 days. Significant trends for earlier flowering species range from −0.3 to −47.8 days, while those for later flowering species range from +0.2 to +22.0 days. Flowering is especially sensitive to the temperature of the previous month, and earlier flowering species are most responsive. Flowering date was an average 3 days earlier for each degree C increase in the average temperature of the previous month. Advances of 94 species are directly correlated with the year day index (YDI) and Nuttonson's index (Tn). Early spring flowers were more sensitive to the accumulation of warm temperature than late-spring flowers.

Microclimatic effect of a forest fragment in the city of Curitiba, Paraná, Brazil. Leal, L.; Batista, A. C., Biondi, D., Mascarenhas Grise, M. (*Universidade Federal do Paraná, Brasil; luciana_paisagem@yahoo.com.br; batistaufpr@ufpr.br; dbiondi@ufpr.br; mayssa@onda.com.br*).

In the urban environment, vegetation plays an important role in improving microclimate. This study aimed at quantifying the microclimatic effect of a forest fragment on Campus III/Botanic Garden, Federal University of Paraná, in Curitiba, Paraná, Brazil, located at latitude 25°26′52″S and longitude 49°14′16″W, at 920 m above sea level. The experiment was carried out in the course of 5 days (April 2009) between 11h00 and 15h00, a critical time of day, to determine the influence of vegetation. To obtain the meteorological data of temperature (ºC) and relative air humidity (%), six Hobo® Data Logger equipments were put in meteorological mini-shelters (wooden cases with holes in the sides and externally covered with aluminium paper) and set up in two transects in north-south direction with an equidistance of 50 m, one outside the forest fragment in question and one inside the forest. The data that were obtained were statistically tested using the F test and compared using the SNK test with a credibility of 95%. The results showed a significant reduction of temperature (up to 4.6 units) and an increase of the relative air humidity (up to 24 units) underneath the vegetation.

Photosynthesis and growth performances of *Eucalyptus pellita* and *Acacia mangium* seedlings growing under three different temperature regimes. Lee, S.W., Cho, M.S. (*Korea Forest Research Institute, Republic of Korea; lsw361@forest.go.kr*; *gungdong@hanmail.net*), Kim, G.N. (*Chungnam National University, Republic of Korea; tintin2580@hanmail.net*).

We investigated photosynthetic characteristics, chlorophyll fluorescence, chlorophyll contents, and growth performances of two tropical species. Containerized seedlings of *Eucalyptus pellita* and *Acacia mangium* were grown under three different temperature regimes (25 °C, 30 °C, and 35 °C) in a growth chamber. *E. pellita* and *A. mangium* showed the highest photosynthesis rate of 13.59 and 16.29 μmol $CO_2 \cdot m^{-2} \cdot s^{-1}$ at 30 °C, respectively, while the lowest at 25 °C. *E. pellita* and *A. mangium* showed the highest photochemical efficiency (apparent quantum yield) at 30 °C. These results were consistent with the patterns of the photosynthetic capacity of the species. The total chlorophyll contents of two species were significantly the lowest at 25 °C, while the highest at 30 °C. The root collar diameter and height of *E. pellita* and *A. mangium* were the highest at 30 °C, while the lowest at 25 °C. For *A. mangium*, however, height was the lowest at 35 °C. The total biomass of two species was highest at 30 °C. Meanwhile, all the seedlings grown at 25 °C showed the least total biomass. This study suggests temperature should not be over 30 °C during the seedling stage even in tropical species.

Evaluation of habitat sustainability and vulnerability for Siebold's beech (*Fagus crenata*) forests under 110 hypothetical climatic change scenarios in Japan. Matsui, T. (*Forestry and Forest Products Research Institute, Japan; tematsui@affrc.go.jp*), Takahashi, K. (*National Institute for Environmental Studies, Japan; ktakaha@nies.go.jp*), Tanaka, N. (*Forestry and Forest Products Research Institute, Japan; ntanaka@affrc.go.jp*), Hijioka, Y. (*National Institute for Environmental Studies, Japan; hijioka@nies.go.jp*), Horikawa, M., Yagihashi, T. (*Forestry and Forest Products Research Institute, Japan; horikun@fb3.so-net.ne.jp; yagihasi@affrc.go.jp*), Harasawa, H. (*National Institute for Environmental Studies, Japan; harasawa@nies.go.jp*).

To evaluate effects of climate change on the sustainability or vulnerability of Siebold's beech forest habitas in Japan, we developed a predictive distribution model and simulated effects under 110 hypothetical climate change scenarios. The model was developed based on temperature, precipitation, geology, soil type and topographical factors as independent variables and presence/absence of beech forest as dependent variable. The amount of suitable habitat loss and gain was calculated with three migration options. Vulnerable and sustainable habitats (potential refugia) were identified to evaluate potential risks and survival of beech forests. The total areas of potential suitable habitats for beech forests differed considerably depending on the future temperature and precipitation changes: temperature increases more than 2 degrees C always reduced the total areas of suitable habitats, but with a temperature increase of less than 2 ºC, the areas of suitable habitats showed an increase, the maintenance of the status quo, or a decrease, depending on the amount of the precipitation increase. It was concluded that beech forests in western Japan were predicted to be highly vulnerable to climate warming, whereas some mountain areas on the Sea of Japan side were predicted to be possible future refugia.

Relationship between cuticle thickness and cuticle resistance of *Pinus pumila* and *Abies mariesii* needles in the alpine zone of Japan. Nakamoto, A., Ikeda, T. (*Kyoto Prefectural University, Japan; hollyock0630@yahoo.co.jp; tikeda@kpu.ac.jp*), Maruta, E. (*Toho University, Japan; maruta@bio.sci.toho-u.ac.jp*).

Pinus pumila and *Abies mariesii*, which are evergreen conifers, grow in the alpine zone on Mt.Norikura in Central Japan. The color of needles above the snow level in two species changes form green to brown in an early spring, and some shoots with such needles die. It has been generally considered that needle 'browning' occurs because the cuticle of the needle surface above the snow level is damaged due to strong winds and wind-driven snow particles which impact shoots and needles directly. In addition, it has been thought that thickening the cuticle prevents from water loss through needle surface. Decreases in snowfall caused by global warming will induce more browning damage of needles. Therefore we examined the presence of cuticle damage and relationship between cuticle thickness and cuticle resistance. We found that cuticle of *P. pumila* and *A. mariesii* was not abraded severely. Although there was no relationship between cuticle thickness and cuticle resistance in *P. pumila*, an interesting negative correlation was found for *A. mariesii* between cuticle thickness and cuticle resistance. It can be presumed that needle browning is not attributed to cuticle damage and reduced cuticle thickness, but will be related to cuticle quality, structure and components.

Analysis of tree phenology in a non-urban area for 15 years by fixed point observation video at the Tokyo University Forest in Chichibu, central Japan. Nakamura, K. (*The University of Tokyo, Japan; nakamura@nenv.k.u-tokyo.ac.jp*), Yoneya, N. (*Cyberforest.jp, Japan; ynori.k@gmail.com*), Saito, K., Fujiwara, A. (*University of Tokyo, Japan; kaoru@nenv.k.u-tokyo.ac.jp; akio@uf.a.u-tokyo.ac.jp*), Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; iwaoka@fe.rn.tuat.ac.jp*), Kobayashi, H. (*University of Tokyo, Japan; hill_koba@cyber.t.u-tokyo.ac.jp*).

In recent years, it has been observed that the date of flowering of cherries such as Someiyoshino (*Prunus yedoensis Matsum*) has shown an advance in Japan. In this regard, the influence of global warming is feared. However, the cherries that have been the objects of phenology observation are found in the city, and it is highly possible that they are receiving the influence of the "heat island." Therefore, if tree phenology is assumed to be an index of climatic variation, it is thought that it is more appropriate to observe it in a non-urban area where the influence of the "heat island" is lessened. However, frequent observations in non-urban

areas generally have been impossible chiefly because of access limitations. At the Tokyo University Forest in Chichibu, fixed point observation of the forest by video and sound has been continued every day since1995 as a cyberforest research project. Accordingly, the secular change of the tree phenology of the non-urban area can be analyzed on a day-to-day basis. In this presentation, the analysis results on the phenology of a number of broad-leaved trees including cherry are reported.

Temporal and spatial variation of soil respiration in a *Fagus crenata* forest. Naramoto, M., Shinmi, M., Kakubari, Y. (*Shizuoka University, Japan; naramoto@agr.shizuoka.ac.jp; shinmichan@yahoo.co.jp; afykaku@agr.shizuoka.ac.jp*).

Soil respiration, which represents the CO_2 efflux from the soil surface, is one of the key components in the carbon cycle of any ecosystem. Soil respiration rate varies spatially and temporally because the environmental factors that affect this rate can vary dramatically over large areas. Moreover, spatial variation has been related to soil characteristics, root density, or topography. Soil respiration rate was measured at 49 points (within a 6 m × 6 m plot) in a *Fagus crenata* forest at an altitude of 900 m on the southern slope of Mt. Naeba, Japan. The soil respiration rates were 4.09 ± 1.88 μmol m^{-2} s^{-1} in early September; 2.87 ± 0.94 μmol m^{-2} s^{-1} in early October; and 1.62 ± 0.59 μmol m^{-2} s^{-1} in late October. Short-term variation during a few days was not well-described as a simple exponential function of soil temperature at depth of 5 cm because of the lower variation in soil temperature, though long-term variation in seasonal changes of soil temperature was found. The coefficient of variation of each duration ranged from 33 to 46%, and spatial variation was analyzed from the point of view of soil characteristics, micro topography, and the distance from trees.

Growth performance of Siberian larch (*Larix sibirica* Ledeb.) seedlings under different photoperiod regimes from diverse seed sources of Mongolia. Nyam-Osor, B. (*National University of Mongolia, Mongolia; nbatkhuu@biology.num.edu.mn*), Lee, D.K. (*Seoul National University, Republic of Korea*), Han, S. (*Korea Forest Research Institute, Republic of Korea*), Tsogtbaatar, J. (*Institute of Geoecology/Mongolian Academy of Sciences, Mongolia*), Park, Y. (*Seoul National University, Republic of Korea*).

Seedlings of seven seed sources of Siberian larch (*Larix sibirica* Ldb.) from Mongolia were grown from seeds for 3 months in controlled environmental chambers under three different photoperiod regimes (extended-20 hours, control-16 hours, and short-10 hours) with similar air temperature, total daily quantum flux, and relative humidity. All measured variables (root collar diameter, shoot length, root length, needle length, relative growth rate, proportional biomass allocation, root weight ratio, and root to shoot ratio) were significantly different among photoperiod regimes and seed sources, and their interactions were significant. Overall, the source no. 4 (Mongon) showed best growth performance at all measured variables in all treatments, whereas source no. 9 (Uvs) and source no. 1 (Ovorkhangai) were lowest. In case biomass accumulation and its allocation characteristics, source no. 7 (Binder) and no. 4 (Mongon) exhibited best performance, while source no. 9 (Uvs) was lowest performing at all treatments and measured biomass variables. Total plant biomass was greater at the extended photoperiod regime compared to control and short photoperiod regimes. Extended photoperiod induced higher needle (foliage) biomass than the control treatment. Proportional allocation to roots as expressed root weight ratio was higher at short treatment than extended and control treatments.

Phenological study of Yeochon industrial complex. Seo, D.J., Yoon, S.R., Kim, J.K. (*Gyeongsang National University, Republic of Korea; najinda@nate.com; hbtree@nate.com; jkabk@gnu.kr*).

To investigate the relationship between phenology and air temperatures, we surveyed winter bud, leafing time, flowering and deflowering time, and leaf litter time of several woody plants at deciduous forest and conifer forest in the Yeocheon industrial complex area from February to November, 2009. The leafing time of the earliest species—such as *Styrax japonica, Sorbus alnifolia*, *Meliosma oldhamii, Rhus succedanea, Quercus dentata, Carpinus tschonoskii*, and *Symplocos chinensis*—showed to the last of March, and that of *Lindera erythrocarpa, Q. aliena, Q. variabilis, Q. serrata, Eurya japonica*, and *Prunus sargentii* to the middle of April. The leafing time of the earliest species of *Styrax japonica* was 16 days earlier than that of the latest *P. sargentii.* The flowering time of the earliest species—such as *Carpinus tschonoskii*, *Eurya japonica, Pinus densiflora, Prunus sargentii*, and *Q. variabilis*—showed to the last of March, and that of *Q. dentata, Q. serrata*, *Q. aliena, Lindera erythrocarpa, Eurya japonica, Symplocos chinensis*, and *Styrax japonica* in the late season (middle of April). The flowering time of the earliest species *Carpinus tschonoskii was* on 18 March and was 39 days earlier than that of the latest *S. japonica* on 26 April.

The relationship between invasive alien species and major climatic zones. Shi, J., Luo, Y. (*Beijing Forestry University, China; shi_juan@263.net; youqingluo@126.com*), He, P. (*Institute of Botany/Chinese Academy of Sciences, China; he1001@ibcas.ac.cn*).

In the present study, we targeted countries and regions that represent the world's main climate types. By carrying out quantitative and statistical analyses of invasive species in each climatic zone, the connection between diversity of bio-invasion and air temperature and precipitation (two main criteria for classifying world climate types) was studied for each region. The results showed an extremely close relationship between presence of harmful invasive alien species (IAS) and air temperature. When air temperature is within the range of 1–25 °C, the degree of diversity of IAS increases exponentially with air temperature. However, when air temperature falls outside the range of 1–25 °C, the diversity of harmful IAS changes with air temperature in a parabolic pattern, showing a "mid-latitude bulge" with the increase of air temperature. In addition, the present study also showed that invasion of harmful IAS is related to precipitation. Although the relationship is not as strong as that with air temperature, rainfall plays a role in the frequency of invasion. Altogether, different climatic zones showed dramatic differences in resistance to invasion of IAS due to their different characteristic climatic factors, including air temperature and precipitation, among other factors.

Response of functional traits of *Quercus* species to meteorological factors in temperate zone of NSTEC, China. Shi, Z.M., Feng, Q. H. (*Chinese Academy of Forestry, China; shizm@forestry.ac.cn; fengqh@163.com*), Dong, L.L. (*Liaoning Academy of Forestry, China; donglili@163.com*), Liu, S.R. (*Chinese Academy of Forestry, China; liusr@caf.ac.cn*).

Functional traits of *Quercus* dominant trees in their 11 core habitats of temperate zone within the North-South Transect of Eastern China (NSTEC) were measured. The relationships between the traits and meteorological factors were analyzed. The results showed that the *Quercus* dominant trees responded to the changes in meteorological factors by adjusting their functional traits in

temperate zones of NSTEC. From the south to the north, length of growing season of trees became shorter and shorter due to the decrease of temperature, but their photosynthetic rate per unit leaf area (A_{area}) and photosynthetic rate per unit leaf mass (A_{mass}) increased to maintain their physiological behaviors in limited time. Both seed mass without skin and seed skin mass of the trees increased from south to north along with decrease of temperature and increase of mean annual sunlight. These results are due to their adaptations to cold and strong radiant environments. As rainfall changed, the trees could also adapt to the environment by adjusting their leaf dry mass content and leaf mass per area.

Responses of flowering dates of cherry to land use in Korea. Song, H. (*Korea Forest Research Institute, Republic of Korea; shyekyung@swu.ac.kr*), Lee, C.S. (*Seoul Women's University, Republic of Korea; leecs@swu.ac.kr*), Choi, M.S. (*Korea Forest Research Institute, Republic of Korea; hnarbore@forest.go.kr*).

Phenology of cherry was investigated in urban centers, riversides, and greenbelt sites in Seoul. Riverside sites are located at the urban center, whereas greenbelt sites are on the urban boundary. Flowering of cherry was 3 and 7 days later around the restored urban river and greenbelt than in the urban center. Differences in flowering date showed differences of climate change over about 30 years and 40 years, respectively. In comparing flowering date of Seoul and the whole country, Seoul's flowering date in the urban center was consistent with that of Gumi, located 200 km south of Seoul. Therefore, because of the urban heat island effect, the climate characteristics of Seoul, in the central region of Korea, was likely similar to the south region of Korea. Correlation analysis between flowering date and annual mean temperature of cherry from 1922 to 2008 in Seoul revealed that the flowering date was faster by about 3 days when the annual mean temperature rise was 1 degree C. Thus, flowering time appears to be advanced by an increased temperature as a result of the urban heat island effect. Change of flowering date occurred consistently throughout the whole country as well in urban areas particularly.

Live crown tops of Japanese cedar (*Cryptomeria japonica*) in urban forests are becoming lower and more equal in each forest. Ueda, M. (*Kyoto Prefectural University, Japan; uedam@kpu. ac.jp*), Shibata, E. (*Nagoya University, Japan; shibatae@agr. nagoya-u.ac.jp*), Amano, T., Waguchi, Y., Yoneda, Y. (*Nara Forest research Inst., Japan; amano@wing.ocn.ne.jp; wagchi@ nararinshi.pref.nara.jp; yoneda@nararinshi.pref.nara.jp*).

We have found Japanese cedar, *Cryptomeria japonica* D. Don, trees with crown tops affected by dieback in isolated urban forests on the low altitude plain since the 1980s. To clarify future growth of *C. japonica* in these forests, we investigated their decline levels, growth, and water status. The live crown-top heights from the ground (lcths) per diameter at breast height (dbh) were higher in forests with no top dieback than in forests with *C. japonica* top dieback. Furthermore, in a forest with *C. japonica* top dieback, the lcths were similar between trees although dbh and decline levels were different, and water status near the top of the live foliage was very similar although decline levels were different, suggesting that in urban forests, where *C. japonica* top dieback is observed, the lcth is subject of restriction. Since the 1980s, a sudden increase in temperatures may be restricting the lcths of *C. japonica* in urban forests. We decided that lcths of *C. japonica* in urban forests are becoming lower and more equal in each forest. If temperature continues to increase, height restriction will become more severe and lcths of *C. japonica* in urban forests will become even lower.

Study of the CO_2 flux monitoring of reforestation at Pingtung in Taiwan. Wang, Y.N., Hsieh, C.I. Liu, T.F., Yu, R.J. (*National Taiwan University, China-Taipei; m627@ntu.edu.tw; hsieh@ntu.edu.tw; tzufenliu@ntu.edu.tw; 1329@exfo.ntu.edu.tw*).

Based on the theory of eddy covariance method, flux monitoring towers were established at Pingtung in southern Taiwan, with an observation area of about 1 km^2 or 290,66 ha, using 3% systematic sampling in the establishment of sampling areas, consisting of 73 sampling plots each with an area of 0.05 ha. (20 × 25 cm). This system consists of Li-COR/Li-7500 open-path infrared gas analyzer and CAMPBELL/CSAT3 three-dimensional sonic anemometer, to monitor the amount of CO_2 flux. From November 2008 to August 2009, the average atmospheric CO_2 concentration was 384.42 ppm, and the daily variation of CO_2 concentration was 34.29 ppm, with the minimum value of 11.34 ppm in December, and maximum figure of 49.59 ppm in August. The average CO_2 flux is 0.609 μmol/m^2/s, so we can calculate the carbon storage capacity of forest per ha, if forest can absorb 29.282 kg of CO_2 from the air daily or the total experimental plots can sequester 3206.379 m^3 of CO_2 each year. The sensible heat flux is 31.429 W/m^2. The average latent heat flux is 7.154 W/m^2 in January 2009, which increases to 144.401 W/m^2 in August of 2009.

A-15 Strategies for linking climate change mitigation and adaptation: securing livelihood options in tropical forestry

Organizers: Sushil Kumar, *Indian Institute of Management-Lucknow, India, sushil@iiml.ac.in*; Bruno Locatelli, *CIRAD-CIFOR, b.locatelli@cgiar.org;* Bastiaan Louman, *Tropical Agricultural Research and Higher Education Center-CATIE, Costa Rica, blouman@catie.ac.cr;* Daniel Murdiyarso, *CIFOR, Indonesia, d.murdiyarso@cgiar.org.*

A perspective of REDD in the context of community forest management in Nepal. Basnet Parasai, R. (*University of Twente, Nepal; rupa@mos.com.np*).

Community forest management is carried out by many rural communities in developing countries, including Nepal, for a variety of reasons. One of its effects is to reduce the rate of deforestation and to increase the biomass levels of existing forested areas, and thus to increase the rate of uptake of carbon from the atmosphere. Yet, this carbon reduction strategy was not recognised under the clean development mechanism of the first commitment period (2008–2012) of the Kyoto Protocol. Now the discourse on reducing emissions from deforestation and degradation (REDD) has recognised community forest management as an important component of climate change mitigation. There appear to be opportunities under REDD for community forest users to have economical gain by carbon trading. If carbon trading is to succeed as an incentive for sustainable forest management, there has to

be some guarantee that forest-dependent communities will receive financial compensation for their carbon sequestration services. This paper discusses on ownership issues in general with regard to financial incentives of community forest users within forest laws of Nepal. In addition the paper argues that consideration of these issues must be addressed in future policies and development projects for communities to gain from the REDD programme.

Climate change and the tropical forestry sector. Guariguata, M.R. (*Center for International Forestry Research, Indonesia; m.guariguata@cgiar.org*), Haupt, F. (*Germany; franziska.haupt@gmail.com*).

We carried out a global survey on the extent to which adaptation to climate change is being incorporated in tropical forest management. Based on a questionnaire of qualitative and quantitative items, we assessed the attitudes of forest researchers, policy-makers and managers related to awareness, risk perception, and adaptation to climate change (N = 154 respondents). Results indicate high levels of concern but also uncertainty. Respondents perceived climate change as a serious threat to the productive capacity of tropical forests and believed to have observed negative forest changes attributable to climate change. About half the respondents considered scientific certainty of climate change sufficient to justify adaptive action, while one-third was aware of specific management practices to enhance adaptive capacity. The implementation of adaptive measures at both the forest management unit and the institutional and policy levels was ranked as low, related to lack of guidance and human capacity. Most adaptive practices named by respondents can be considered an intensification of sustainable forest management. To the extent that the mitigation capacity of tropical forests to climate change depends on adaptation through management, awareness raising on enhancing their adaptive capacity seems warranted.

Linking climate change mitigation and adaptation in tropical forests: what is at stake? Locatelli, B. (*CIRAD-CIFOR, Indonesia; bruno.locatelli@cirad.fr*), Murdiyarso, D. (*CIFOR, Indonesia; d.murdiyarso@cgiar.org*).

Strengthening the links between climate change mitigation and adaptation in the forestry sector is necessary. Mitigation needs adaptation; as reducing emissions from deforestation and forest degradation (REDD) is more likely to be successful if it considers the impacts of climate change on forests and people and incorporates adaptation measures. Adaptation needs mitigation; as ecosystem-based adaptation projects may benefit from REDD funding if their contribution to carbon conservation can be demonstrated. However, knowledge is currently missing for understanding synergies or conflicts between climate change mitigation and adaptation strategies at different scales. Therefore, greater understanding and information sharing are necessary to establish appropriate guidelines for developing projects or policies that effectively address both approaches to climate change. Tools and methods are also needed for analyzing the synergies and conflicts between mitigation and adaptation. In this communication, we present examples of synergies and conflicts between mitigation and adaptation in forests at different scales: landscape, project, national, and international scales. We present some approaches for studying the linkages between adaptation and mitigation at these different scales and the main challenges for projects and policies related to climate change and forests.

Conditions for REDD implementation in an Amazonian municipality of the Mato Grosso State, Brazil. Simoes, C. (*University of Tsukuba, Japan; sac.cia@gmail.com*).

This study is an initial analysis of conditions for REDD implementation in the Brazilian Amazon municipality of Cotriguacu, Mato Grosso, famous for high deforestation rates. Focused on how would compensations get to people living in the forest area, the aim was to clarify the current land-use model and determine who would be eligible for compensations from REDD schemes. With the use of semi-structured interviews with forest engineers, members of governamental agencies, and 67 randomly chosen landowners, two main actors were identified as responsible for deforestation in the municipality: log companies and cattle ranchers. The currently proposed REDD framework in Brazil establishes that payments could compensate these landowners only for the opportunity cost relative to 20% of the area of their property legally degradable under the Brazilian Forest Code; the other 80% should be kept untouched as a legal reserve. Since most landowners have deforested and/or degraded more than what is allowed, such a scheme would not be effective in this municipality. Furthermore, 20% or 10 ha of a small property would not be enough to maintain cattle ranching as the sole income source. Other options should be presented to REDD framework negotiators to effectively reduce deforestation.

Institutional and governance 'space' for adaptation and mitigation in Congo Basin forests. Somorin, O.A (*Center for International Forestry Research, Cameroon; o.somorin@cgiar.org*) Brown, C. (*University of Guelph, Canada; hcpbrown@uoguelph.ca*), Sonwa, D. (*Center for International Forestry Research, Cameroon; d.sonwa@cgiar.org*) Arts, BMJ, (*Wageningen University, The Netherlands; bas.arts@wur.nl*).

The Congo Basin forest is currently receiving both scientific and political attention for its potential in global carbon budget. In this paper, we investigate the discourse and institutional dynamics surrounding policy goals of adaptation and mitigation in the forest sector, for understanding the 'space' for policy development. In-depth interviews with relevant actors and stakeholders in the climate debate (government, civil society, private sectors, and international organizations) from Cameroon, CAR, and DRC provided data for analysis. Preliminary empirical results show the reality of the climate challenge even at local levels. We also found a "negotiated transition" where climate change has moved from a purely environmental problem to a development challenge. Within the forest sector, we observed that: (i) mitigation generates stronger political attention than adaptation, and this is reflected in coalitions and networks of state and non-state actors in REDD schemes; (ii) policy strategies for adaptation are strongly linked with poverty reduction at different levels; and (iii) local customary systems of governance offer a possible model for both mitigation and adaptation, especially within the context of a high natural-resource-dependent society. A future consideration at the regional level (through COMIFAC) is to identify strategies to synergize both adaptation and mitigation.

Posters

Exploitation of non-timber forest products (NTFP) and climate change in the Congo Basin: the case of Cameroon. Abdon, A. (CIFOR, *Cameroon; a.abdon@cgiar.org*), Ingram, V. (*CIFOR, United Kingdom; v.ingram@cgiar.org*), Shure, J. (*CIFOR, The Netherlands; j.schure@cgiar.org*).

The lives of forest dwelling people and biodiversity are closely related from nutritional, medical, and commercial aspects. Because of repeated economic problems emphasised by the downfall of raw material prices and the devaluation of the FCFA, peopl—in order to adapt to the situation—rushed for the exploitation of non-timber forest products (NTFP). However, an increase of the socio-economic value of NTFP is likely to produce both negative and positive effects on the conservation of forests and biodiversity. Furthermore, the decrease of forest cover by multiple human interventions, contributes to aggravate the phenomenon of climate change, which has become a global concern. Thus, adaptation of vulnerable populations requires both realistic and viable strategies. Therefore, conservation targets need to be harmonised with objectives related to improved human well-being. The sound management of non-timber forest products could be a way to reduce greenhouse gas emissions and to adapt local populations to the negative effects of climate change. This is the main objective of this paper dealing with the results of a study of households and the evaluation of the market performance of NTFP in Cameroon.

Far-reaching impacts of biogas digester introduction on livelihoods of rural people: a case study from Nepal. Ito, K., Hatayama, S. (*Nagoya University, Japan; kasumito@agr.nagoya-u.ac.jp; hatayama.shohei@a.mbox.nagoya-u.ac.jp*).

Introduction of biogas digesters, which can generally produce sufficient amounts of gas for cooking and lighting by using animal manure of domestic livestock, have been increasing rapidly in many developing countries. Nepal is one of the pioneer countries and their success in decreasing fuel-wood consumption has made the biogas digester popular as potential approach for reducing CO_2 emission. However, rapid diffusion has occurred without identifying far-reaching consequences of its introduction, including positive, negative, direct, indirect and socioeconomic impacts on livelihoods of both of users and non-users. This study therefore aims to identify such impacts of biogas digester introduction on livelihoods of rural people in Nepal. Structured interviews were conducted of both biogas users and non-users in several rural villages. Statistical analysis of these data indicate that although fuel-wood consumption of biogas users has decreased dramatically, significant negative impacts were identified among non-users, especially poor households without sufficient number of livestock for introducing the digester. Therefore, climate change mitigation efforts including CDM and REDD mechanisms by introducing biogas digesters in rural area need to include wide-ranging analyses and develop measures against negative impacts on poor households to enhance positive impacts.

Supporting protected area authorities and local communities to conserve forest biodiversity and enhance livelihoods through forest carbon finance. Kümpel, N.F. (*Zoological Society of London, UK; noelle.kumpel@zsl.org*), Maddox, T.M., Suratno, A. (*Zoological Society of London, Indonesia; tom.maddox@zsl.org; agus.suratno@zsl.org*).

Tropical deforestation is a major driver of climate change, biodiversity loss and poverty. The development of forest carbon markets therefore provides a critical opportunity to reduce deforestation and forest degradation and thus provide a tangible value to the biodiversity and ecosystem services that underpin local people's livelihoods. The Zoological Society of London (ZSL), together with public and private sector partners, is working on the ground with conservation forest managers and local communities in Indonesia and the Democratic Republic of Congo (DRC) to enable them to access these markets, to build their capacity to conserve the forest and to create economic incentives linked to deforestation and reduced forest degradation. These include sustainable agroforestry to boost farmer incomes and reduce the need for shifting, slash-and-burn cultivation, reforestation via school tree nurseries to raise awareness and provide an alternative source of charcoal, and fuel-efficient stoves to reduce fuelwood consumption. The socio-economic and non-carbon environmental impacts of each activity will be monitored and evaluated via detailed household and forest surveys to assess its acceptability, cost and benefits, and lessons learnt will be widely disseminated so that they can be applied elsewhere.

Strategies for people's involvement in community-based forest management linking to the A/R-CDM project under the Kyoto Protocol: case study in Indonesia. Matsumura, N. (*Mie University, Japan; nma@bio.mie-u.ac.jp*), Sukandi, T., Suharti, S., Imanuddin, R. (*FORDA, Indonesia; taulana_sukandi@yahoo.com; suharti23@yahoo.co.id; rinaldiimanuddin@yahoo.com*), Amano, M. (*Waseda University, Japan; masahiro_amano@waseda.jp*).

The 9th UNFCCC Conference of the Parties in Milano, Italy, in 2003 approved modalities and procedures for afforestation and reforestation (A/R) project activities under the Clean Development Mechanism (CDM) of the Kyoto Protocol. According to the conclusions of COP 9, several approaches are available to monitor temporary carbon sequestration in A/R-CDM projects. In this paper, we present guidelines for preparing a project design document (PDD) in which growth and yield prediction in plantation forests plays an important role and present a methodology for modeling and estimating carbon stocks using inventory data from *Acacia mangium* plantations in Malaysia and Indonesia. The models of local people involvement in tree plantation need to be identified for the success in implementing A/R CDM scheme. These forest management models have potential to be applied for A/R CDM under Kyoto Protocol in terms of local people involvement, benefit for low income/poor communities, and illegal logging prevention. These management models could also provide strategies for adapting small-scale forestry to climate change. This paper will examine current management practices in some community-based forestry types in Indonesia and consider the potential for a greater cooperative partnership between developed and developing countries.

Small-scale community-based reforestation CDM project in the degraded Pamu Berekum Forest Reserve in Ghana. Opuni-Frimpong, E., Owusu, S.A., Ameyaw, L.A. (*Forestry Research Institute of Ghana, Ghana; eopunifr@mtu.edu; soachie@gmail.com; kofilord@gmail.com*), Amoah, F.S., Bamfo, R. (*Forestry Commission of Ghana, Ghana; kwegyir2004@yahoo.com; bamforobert@yahoo.com*).

The upper Guinean Forest of Ghana has been degraded from 8.3 million hectares to 1.6 million hectares within a century. Though the destruction of Ghana's forest was more intense outside forest reserves, about one-third of the 214 forest reserves have been severely degraded. Pamu Berekum Forest Reserve (FR) was one of the 40 FRs classified as much degraded, and currently the dominant vegetation covers are *Chromolaena odorota* and *Panicum maximum*. There are virtually no seed trees left to produce seeds for natural regeneration to restore the original tree vegetation cover. Diligent effort is required to reforest the 189 km^2 Pamu Berekum FR. However, initial efforts to encourage individual and private tree plantations are failing because of investment

barriers and it is believed that the reforestation program of Pamu Berekum is only viable if public incentives are provided. This belief is confirmed by the relative success of the limited highly indebted poor country assisted plantation program with support from government development partners. We have therefore initiated a small-scale CDM A/R project for the reforestation of Pamu Berekum with the forest fringe communities to provide a financial system that overcomes the barriers to plantation development whilst contributing to poverty reduction.

Livelihood and willingness-to-accept REDD by local people: a case study of the Iban communities in the surrounding areas of Batang Ai National Park, Sarawak, Malaysia. Phua, M.-H., Kodoh, J., Kamlun, K. U. (*Universiti Malaysia Sabah, Malaysia; pmh@ums.edu.my; julius@ums.edu.my; kamlisa@ums.edu.my*).

Mitigating global warming through REDD has been given increasing attentions in government-to-government negotiations. While discussions among decision-makers have been going on, it is important to learn about the perception of local people in relation to REDD because the implementation will affect their lives. We conducted a questionnaire survey on the livelihood and forest dependency of the local people in the vicinity of Batang Ai National Park, Sarawak, Malaysia. Six longhouses (Nanga Ukom Ulu, Menggilir A, Menggilir B, Ng Tutong, Belok and Mengkak longhouses) were surveyed for their income-earning activities and forest resources collected, used, and traded. Participation in tourism-related jobs among the household members was also investigated to gauge the potential of this 'eco-friendly' income generation activity in the local community. There was a general indication of reducing slash-and-burn activities with distance from the park and involvement in tourism-related jobs. Most of the local people were willing to accept compensation not conducting slash-and-burn activities. The monetary value is generally higher than their monthly income. The compensation preferred is in various forms of development of plantation activities.

Challenges, policies, issues and barriers of CDM forestry projects: a case study from Sirsa, Haryana, India. Saxena, V. (*Ministry of Environment and Forests, India; viveksax1@gmail.com*).

The carbon sequestration potential of CDM forestry projects has been recognized under the Kyoto Protocol. However, the share of registered agriculture and A&R projects under CDM is only 5.67% and 0.28% respectively, illustrating the neglect of the agriculture and forestry sectors in comparison to other technically and financially advantaged sectors. The REDD initiative at COP 13 generated high hopes for post-Kyoto climate change mitigation efforts. Policies, issues, and key technical and institutional barriers for realizing the potential of CDM forestry projects are discussed in this paper, while analyzing the case study of the Small Scale Cooperative Afforestation CDM Pilot Project Activity on Private Lands Affected by Shifting Sand Dunes in Sirsa, Haryana, India, the first registered small-scale CDM A/R project, which includes afforestation activities across eight villages, comprising of 369.87 ha belonging to 227 farmers forming Haryana CDM Tree Farmers Society. The project objectives include obtaining benefits of carbon credits, assisting in carbon-sequestration, improving local environmental conditions, increasing income and employment opportunities, and poverty alleviation in local communities. The challenges for CDM forestry projects in enhancing rural livelihood options, financial institutions and REDD mechanisms are discussed, and policy options and institutional mechanisms are suggested.

Comparison of allometric relationships for accurate estimation of forest biomass in tropical secondary forest in Malaysia. Tanaka, K. (*Forestry and Forest Products Research Institute, Japan; mona@affrc.go.jp*), Ichie, T. (*Kochi University, Japan; t_ichie@yahoo.co.jp*).

Accurate methods for estimating biomass in tropical forests are essential to evaluate the base line for nations' carbon storage for REDD schemes. Presently, allometric equations derived from tropical primary forest trees are usually used to estimate the forest biomass on both primary and secondary forests. However, it is uncertain whether these previously developed allometric equations are appropriate for biomass estimation in secondary forest, which consists of significantly different species with different structural traits such as lower wood density compared to primary forest trees, and these traits generally relate to different coefficients of the equations. In this study, we: (1) developed allometric equation for two kinds of secondary forest (logged-over and early successional forest) in Sarawak, Malaysia; and (2) compared various allometric equations including primary and secondary forest to evaluate the adequacy of biomass estimation for studied forests. Comparisons of equations for above-ground biomass imply that allometric equations for the two secondary forests differ largely from the primary forests and even for the pan-tropic general models. Moreover, below-ground equations for early successional forest also showed significantly lower biomass estimation than primary forest. Therefore, choosing the biomass estimation models for the tropical secondary forests requires careful consideration of their suitability.

Above-ground biomass and carbon dynamics in a forest frontier of Venezuelan Guayana: analysis from permanent plots and policy recommendations. Vilanova, E., Ramírez, H., Ramírez, G., Alvarez, A., Torres-Lezama, A. (*Institute for Forest Research and Development, Venezuela; vilanova@ula.ve; rhirma@ula.ve; ragustavo@ula.ve; guiamukumbari@yahoo.com; torres@ula.ve*).

Carbon emissions from deforestation and forest degradation, especially in the tropics, account for at least 20% of global CO_2 release. Accurate estimations of forest carbon are needed to improve our knowledge of carbon cycle in tropical forests and how these ecosystems may be affected by human activities. Estimations of above-ground biomass and carbon are presented based on long-term data from permanent plots in three regions of Imataca Forest Reserve in Venezuelan Guayana. Using allometric equations, which include information of diameter and wood density, results indicate a range of biomass from 349.81 Mg ha^{-1} in the north (Río Grande), 311.70 Mg ha^{-1} in the middle region (Tumeremo), to 305.12 Mg ha^{-1} in the south (El Dorado). Conventional logging operations threaten carbon conservation, reducing its potential by about 50% in the north and center areas of Imataca, while high impact mining activities are the main cause of recent deforestation and carbon loss in the south. Strengthening of local and national conservation policies, including the adoption of reduced impact logging (RIL) for sustainable forest management and control of illegal activities, are recommendations proposed under the REDD and REDD+ schemes to incorporate financial incentives to promote carbon conservation and climate change mitigation.

The forest carbon trading-based CDM in China. Ye, Y., Qi, G., Wang, X.C., Qi, L., Tian, J., Dai, L. (*Institute of Applied Ecology/Chinese Academy of Sciences, China; yeyujing_long522@163.com; qiguang594@163.com; wangxc_382@163.com; mynameiskylin@hotmail.com; tianjie.as@126.com; lmdai@126.com*).

Global climate warming is one of the biggest environmental problems. For the wider range of IPCC emissions scenarios, the Earth's mean surface temperature is projected to warm 1.4 to 5.8 degrees by the end of the 21st century. The Chinese government signed the Kyoto Protocol on May 29, 1998, and became the 37th signatory, formally approving it on August 30, 2002. Therefore, China is eligible to participate in the CDM process. China can take part in CDM through afforestation and reafforestation to get capital and technology, and China has very abundant planted forest resources. There have been five CDM carbon sink trading projects demonstrated in China. This forest carbon trading based on the CDM project will bring many opportunities to forestry in China in return. Natural forest resources protection projects and sustainable development, even the livelihood of workers, will gain positive effects from forestry carbon sink trading and adjusting the structure of forest resources, which is an important measure to improve forest productivity. So it is important to develop a forestry carbon sink in China and erect the carbon trading market available to the Chinese.

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Development of the allometric relationship curves between above-ground and below-ground of the mahogany sapling. Chang, K., Feng, F. (*National Chung Hsing University, China-Taipei; pig313328@yahoo.com.tw; flfeng@nchu.edu.tw*).

There are large areas where big-leaf mahogany (*Swietenia macrophylla*) afforestation or reforestation is being planned for reducing carbon dioxide mitigation and the impact of climate change in Taiwan. Mahogany plantations now cover 2,982 ha in Taiwan. There is little in the literature on below-ground biomass estimation of mahogany, for it is difficult to excavate and quantify. The aim of this study is to estimate carbon storage and biomass of below-ground (root) and above-ground (stem wood, stem bark, branch, and foliage) with easily obtained variables (DBH). Forty-six (46) mahogany saplings ($0 \text{ cm} \leq \text{DBH} \leq 10 \text{ cm}$) were measured for developing allometric functions. Results showed that the correlation of power regression function is higher than other functions in model developing. The coefficient of correlation of the DBH-biomass model is higher than the stump diameter-biomass model. The power function of complete tree biomass is $Y = 174.69 \times DBH^{2.29}$, above-ground biomass ($Y = 111.15 \times DBH^{2.34}$) and below-ground biomass ($Y = 61.65 \times DBH^{2.19}$), and the R^2 are 0.9695, 0.9617 and 0.9610 respectively. The percentage of carbon content in each part of young mahogany is as followings: stem wood (45.83%), root (45.09%), foliage (44.95%), branch (43.74%), and stem bark (42.64%). Length, volume, and biomass of mahogany could be estimated by DBH with allometric relationship equations.

Carbon stock assessment of the mangrove ecosystem in Verde Island Passage and Tayabas Bay, Luzon, Philippines. Gevaña, D.T. (*University of the Philippines Los Baños, Philippines; wuweidix@yahoo.com*), Im, S.J. (*Seoul National University, Republic of Korea, junie@snu.ac.kr*), Pulhin F.B., Pampolina N.M. (*University of the Philippines Los Baños, Philippines; yaypulhin@yahoo.com; nelpampolina@yahoo.*com).

Forest ecosystems such as mangroves have a significant role in addressing climate change because they serve as CO_2 sinks. This study was intended to assess the carbon storage potential of mature mangroves of Verde Island Passage (VIP) and Tayabas Bay in Luzon, Philippines. A nested plot method and allometric equations developed by Komiyama and others in 2005 were used to estimate the carbon density of these stands. Results showed that mangroves in VIP and Tayabas Bay are generally of *Rhizophora* and *Avicennia* types. Carbon density of *Rhizophora*-dominated stands in VIP was estimated to around 115.45 ton/ha. Among the species, *R. mucronata* and *Xylocaropus granatum* were noted as major contributors to carbon sink. In Tayabas Bay, carbon density of *Rhizophora* stands was recorded to around 92.36 ton/ha. *R. apiculata* was observed as the most abundant species in this site. In the *Avicennia*-dominated stands, VIP has a carbon density of around 141.71 Mg/ha, while Tayabas Bay has about 139.07 ton/ha. *A. marina* was observed as the dominant species in both these sites. Overall, VIP and Tayabas Bay mangroves exhibit good carbon storage potential; hence, proper forest management is essential to sustain and improve their capacity to mitigate climate change.

Past, current, and potential resources of carbon and above-ground plant biomass in the landscape with heaths in some selected areas of the Tuchola Forest in North Poland. Jarzębski, M., Nienartowicz, A., Deptuła, M., Domin, D.J. (*Nicolaus Copernicus University, Poland; marcinek_jot@hotmail.com; anienart@biol.uni.torun.pl; deptula@biol.uni.torun.pl; djdomin@umk.pl*).

We assessed the total biomass and biomass for individual layers of forest and non-forest phytocoenoses presently and in the late 18th century, and the potential biomass that would exist without human activity, by applying GIS technologies, historical and contemporary cartographic materials, and data coming from forest inventories and indices of biomass state, in four nature areas in northern Poland: (1) the Tuchola Forest National Park, (2) the Zaborski Landscape Park, (3) the so-called (forest) demesne of Zabory, and (4) the (field) demesne of Tuchola in the former District (Starosty) of Tuchola. Carbon resources in the biomass were also defined, and the extent of biomass displacement caused by human economic activities, both now and in the past, were evaluated. The smallest difference between potential and actual biomass was recorded in the national park, where loss amounted to 28.44%, smaller than in Zaborski Landscape Park with 40.42% loss. The biggest differences occurred in the field demesne in 1796, assessed as 76.47%; today that difference has slightly decreased. In the demesne of Zabory, previously widely covered by heaths and poor xerothermic meadows, afforestation occurred in 1890 and then in 20th century agricultural lands were planted with forest also.

Estimation of woody biomass stocks in forests using aerial photographs. Kuwayama, K., Itaya, A. (*Mie University, Japan; 507334@m.mie-u.ac.jp; itaya@bio.mie-u.ac.jp*).

Forest resources, particularly tree stems (timber), branches and leaves from trees have received increasing attention recently as woody biomass resources. However, there are no inventories about these resources. To use woody biomass resources effectively and appropriately, it is necessary that we know their location and have accurate estimates of their volumes, or stocks, and to avoid harvesting beyond sustainable levels. Aerial photographs have been the most popular remote-sensing tool used in forestry. In contrast to satellite sensor data, historical aerial photographs of many areas are available (e.g., since the 1950s in Japan), and are of high spatial resolution. Aerial photographs are widely used in forest inventories, both to delineate stands and to aid in fieldwork. In this study, woody biomass stocks in forests were estimated both by aerial photographs and on-the-ground forest measurements method. We used not only image but also a digital elevation model obtained from aerial photograph to estimate woody biomass stocks over a large area. In this study, the stock of tree stems (timber), branches and leaves were all estimated separately. By using these results, we will be possible to use their resources effectively and appropriately.

Carbon storage of a 15-year-old mahogany (*Swietenia macrophylla* King) plantation near Mt. Makiling, Philippines. Kwon, K.C. (*National Forestry Cooperative Federation, Republic of Korea; kkch30@yahoo.co.kr*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*).

The objective of the study was to investigate the biomass and carbon storage of a 15-year-old mahogany plantation in the Philippines. The biomass and carbon storage of the plantation were studied at San Pablo near Mt. Makiling. The area of the plantation is about 2 ha and the mean age of the mahogany trees is 15 years old. The biomass carbon content was analyzed three times in each compartment (leaves, branches, stem bark, stem wood, and roots) of 10 tree samples. The understory vegetation and litter layer was also analyzed. For analyzing soil carbon contents, 12 points were selected and 100 cm^3 of soil was sampled in every 10-cm depth up to 50 cm. Carbon storage of mahogany trees and understory vegetation in the mahogany plantation was 145.1 tonC/ha, and more than 50% of the total mahogany tree was stored in stemwood. The biggest carbon storage is in the soil (0 cm to 50 cm in depth), which stored about 70% of mahogany plantation carbon. The carbon content of the plantation was highly stored in descending order: soil, mahogany trees, organic layer, and understory vegetation. Carbon stored in litter layer is 1.7 tonC/ha. Soil carbon content is 361.5 ton/ha.

Investigation of biomass conversion factor and analyzing effect of age classes on *Quercus serrata* stand growing in southern regions of Korea. Lee, S.H. (*Chonbuk National University, Republic of Korea; leesh@jbnu.ac.kr*), Lee, K.H., Son, Y., Lee, K.S. (*Korea Forest Research Institute, Republic of Korea; kyeonghlee@forest.go.kr; treelove@forest.go.kr; beldel660@forest.go.kr*), Kim, H.J. (*Chonbuk National University, Republic of Korea; badboy0837@jbnu.ac.kr*), Yun, S.R. (*Gyeongsang National University, Republic of Korea; hbtree@nate.com*) Kim, H. (*Jeollabuk-do Forest Environment Research Institute, Republic of Korea; kh4548@korea.kr*).

Biomass conversion factors were used to estimate national-scale forest biomass and carbon stocks by using the data of stand stocks. This study investigated biomass conversion factor of *Quercus serrata* growing in the southern regions of Korea, and analyzed the effect of the differences between age classes on biomass conversion factor. A total of 35 representative single trees based on the three different age classes (I-II, III-IV, V-VI) were sampled. We found that stem density based on three different age classes (I-II, III-IV, and V-VI) resulted in 0.53 g cm^{-3}, 0.62 g cm^{-3}, and 0.63 g cm^{-3}, respectively. While these estimates tended to increase in older age classes, there was no statistically significant difference at $\alpha = 0.05$ level between stem density and age classes. Above-ground biomass expansion factor of age classes I-II, III-IV, and V-VI were estimated to be 1.601, 1.506 and 1.540, respectively, with no statistically significant differences among age classes. The total (above-ground + below-ground) biomass expansion factors of three different age classes were 3.389, 2.045 and 2.541, respectively, the differences being significantly different between age classes I-II and III-IV. This information on biomass conversion factors for *Quercus serrata* could be very useful to estimate national-scale forest biomass by species.

Above-ground carbon stocks and growth characteristics of *Liriodendron tulipifera* stands in Jangsung-gun, Jeollanamdo. Lee S.T., Bae, S.W., Chung, J.M. (*Korea Forest Research Institute, Republic of Korea; lst9953@forest.go.kr; bae1144@forest.go.kr; zunmo@hanmail.net*).

Liriodendron tulipifera is one of the major plantation species in Korean forest polices because of its availability, rapid growth, and excellent form. Although information on the characteristics and management of *L. tulipifera* is reported through hundreds of articles by many researchers, little is known about the growth characteristics and carbon stocks on site factors in Korea. This study was carried out to investigate carbon (C) dynamics and growth characteristics on site factors (summit, hillside, valley) in 28-year-old *L. tulipifera* stands, which are among the most important species for bio-cycling forest. Diameter of *L. tulipifera* at 1.2 m above the soil surface was measured and above-ground biomass was estimated. Biomass expansion factors and tree carbon stocks were calculated assuming a carbon concentration of 50% of the biomass. The above-ground C stored on site factors was higher in the valley (182.4 ton C/ha) than in the hillside (127.2 ton C/ha) and summit (84.1 ton C/ha). However, DBH and tree height were significantly higher ($p < 0.05$) in the valley than hillside and summit. The results indicate that growth (DBH, height) and carbon stocks are better in the valley than in the summit and hillside.

Spatial dependence and prediction models of soil carbon stock in three environments in Sao Paulo State, Brazil. Medina Sotomayor, J.F., Couto, H.T.Z., Polizel, J.L. (*University of Sao Paulo, Brazil; sotomayo@esalq.usp.br; htzcouto@esalq.usp.br; jlpolizel@esalq.usp.br*).

Soil variables show a defined spatial dependence needing to be considered to understand forest soils processes. Aiming to know the spatial behavior and useful geostatistics models when studying soil carbon, 406 sampling units were collected in three strata (native forest, eucalyptus, and pasturelands). The depth 0–20 cm was compared with the models: spherical, exponential, and Matern ($\square = 1$ and 2), using the AIC of the model choice's maximum likelihood. The chosen models were tested with cross validation and mean absolute error prediction (MAE). For the depth 0–10 cm, exponential and spherical models had a proper adjustment, with an approximate MAE of 5.2. For depths 10–20 cm and 0–20 cm, the prediction models are the same. At depth 10–20 cm, MAE was lower than 0.5, and at depth 0–20 cm, approximately 8.5. The practical range was 1048 m, 186 m and

301 m (exponential model) at the respective depths. Concluding, the carbon stock has a moderated spatial dependence ($26<\tau^2\%<75$) and spatial behavior varies according to the studied depth, being higher in the superficial layer (0–10 cm). Adjustment of the maximum likelihood allows obtaining models with low prediction errors. These show that geostatistics is a suitable tool for the prediction of the variable.

Effects of climate change on soil respiration according to the vegetation after forest fire of boreal forest. Park, J.H., Woo, S.Y., Han, R.K. (*University of Seoul, Republic of Korea; kissyou009@hotmail.com; wsy@uos.ac.kr; ducking100@nate.com*), Dyukarev, V. (*Institute of Biology and Soil Science, Russian Federation; duykarev@ibss.dvo.ru*).

The IPCC has concluded that average temperature of earth will increase about 1.4–5.8 ºC by 2100. As a result, forest fires will occur frequently and forest ecosystems will be influenced directly or indirectly. The objective of this research was to estimate the effect of climate change on soil respiration and to observe the soil respiration rate with different vegetation after forest fire. Four research sites were selected in Far East Russia (1982QB-forest fire 1982, *Quercus mongolica* and *Pinus koraiensis* dominant; 1973BPS-forest fire 1973, *Betula platyphylla* and *Populus* dominant and shrubs; NFPA-non-burned *Picea jezoensis* and *Abies nephrolepis* dominant, Podzol soil; and NFPANP-non-Podzol soil). We set up three small green houses (1-m diameter and 0.7-m height) randomly in each site and estimate soil respiration rate (Rs) and soil temperature (Ts) with EGM-4 environmental gas monitor. On the whole, Rs increased with the increase of Ts. 1982QB showed higher Rs than 1973BPS, although 1982QB showed lower temperature. Because the existence of shrubs has an effect on the Ts and Rs, it is suggested that Rs undergoes various influences, not only soil temperature but also vegetation on the ground.

Estimating increase in GHG emissions related to fossil fuel combustion in A/R CDM project activities: a case study in tropical plantations in the lowlands of Bolivia. Ruiz-Garvia C. (*FSC Accreditation Program, Germany; c.ruiz@accreditation-services.com*).

Under the Kyoto Protocol, afforestation and reforestation (A/R) could be counted as sinks and are used for achieving the reduction of greenhouse gas emissions. Participants of A/R project activities for the clean development mechanism (CDM) must measure and monitor all significant changes in the five-carbon pools in/around the project area and estimate the actual net greenhouse gas removals by sinks. This research focused on the general protocols and available methods for estimating increase in GHG emissions related to fossil fuel combustion in A/R CDM project activities. Two methods (indirect and direct measurements), under three different management intensity scenarios were applied in a potential A/R CDM project in the region of Porongo, Bolivia. For fossil fuel combustion, only carbon dioxide emissions were taken into account. The sources of emissions were vehicles and mechanical equipment required by the selected A/R CDM project activity. A tool provided by the UNFCCC for testing significance of GHG emissions in A/R CDM project activities was applied to identify whether combustion emissions related to fossil fuel consumption were not significant for a particular A/R CDM project. Results show the impact of mobile sources and mechanical equipment in the overall sustainability assessment of an A/R CDM project.

Carbon storage by urban soils in Seoul, Korea. Seo, K.W. (*Korea Forest Research Institute, Republic of Korea; kwseo@forest.go.kr*), Son, Y., Jo, W.Y. (*Korea University, Republic of Korea; yson@korea.ac.kr; radiojwy@hanmail.net*), Park, G.S., Lee, H.G. (*Chungnam National University, Republic of Korea; gspark@cnu.ac.kr; hanggoo1@naver.com*), Woo, S.Y., Ryang, S.J. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr; tovgoptwo@yahoo.co.kr*), Lee, K.H., Son, Y.M. (*Korea Forest Research Institute, Republic of Korea; kyeonghlee@forest.go.kr; treelove@forest.go.kr*).

To prepare for the post-2012 framework under the UNFCCC, numerous studies on carbon storage have been conducted for various forest ecosystems throughout the world. However, little data are currently available on soil carbon in urban areas. The objective of this study was to provide soil carbon data in urban areas in Korea. First, we divided the urban green areas in Seoul into four categories: a green area on road (RG), an urban park (UP), a green area along stream or river (SRG), and a school forest (SF). We also subdivided the urban green areas by planted dominant tree species: *Ginkgo biloba*, *Platanus occidentalis*, *Prunus serrulata* var. *spontanea*, *Metasequoia glyptostroboides*, and *Zelkova serrata* for RG and UP; and *Salix* spp. for SRG. Then we analyzed soil carbon concentrations and estimated soil carbon storage by species and soil depths (0–10 cm, 10–20 m, and 20–30 cm) for each category. Total soil carbon storage in Seoul was 477 ton for RG, 31,764 ton for UP, 54,254 ton for SRG, and 815 ton for SF. These results could provide useful baseline data for making the inventory of "settlements" on the IPCC guideline of the UNFCCC.

A comparison of carbon sequestration in forestry of China using BEF model, NPP measurement and NEE flux observation methods. Wang, B., Guo, H. (*Chinese Academy of Forestry, China; guohaomail@163.com; guohaomail@163.com*).

Carbon sequestration in forest is a key issue in many countries worldwide, and selection of appropriate measurement methods is important. At present, various methods are available, each with advantages and disadvantages. These include the NPP measurement method, the BEF model method, and the NEE flux observation method. In this paper, carbon sequestration in forest of China were calculated using these three measurement methods The result of this analysis was that estimated carbon sequestration in forests of China during the period 1994–2004 ranged from 1.94×10^8 t C y^{-1} to 5.28×10^8 t C y^{-1}. The minimum estimate was obtained using the BEF model method, and the maximum with the NEE flux observation method, with results using the NPP measurement method close to that obtained with the NEE flux observation method. From these results we conclude that NPP measurement method is economical and practical method for China at the moment, but the NEE flux observation method should be adopted in the future. The BEF model method has low precision and can therefore underestimate the capacity of forest ecosystems to sequester carbon.

Theme B: Biodiversity Conservation and Sustainable Use of Forest Resources

B-01 New perspectives in landscape patterns—changes in edges, connectors, and landscape matrix

Organizers: Kurt Riitters, *U.S. Forest Service, USA, kriiters@fs.fed.us;* Peter Vogt, *European Commission-JRC, Italy, peter.vogt@jrc.ec.europa.eu.*

Landscape change pattern along the altitudinal gradients in a mountainous watershed in Nepal. Bahadur, K.C.K. (*University of Hohenheim, Germany; krishna@uni-hohenheim.de*).

This study analyses the process of human-induced landscape transformations along the altitudinal gradients in a mountainous watershed in Nepal. Spatial and temporal changes in land use and landscapes were analysed by comparing classified satellite images from 1976, 1990, and 2002, coupled with GIS analyses. Results show that during the 26-year period, forest cover has been reduced drastically with increasing population pressure and agricultural activities, and forest landscapes have been fragmented into smaller patches across the watershed. The number of forest patches increased substantially between 1976 and 2002, suggesting splitting of patches in the latter periods due to deforestation on lands that were previously single forest patches. A shape complexity index (SCI) used to study patchiness of land use indicated worsening of the forest habitat in the highland part of the watershed; increased mean deviation between actual and optimal SCI of forest polygons indicated higher edge effects at the forest patch level during the latter periods. A significant change within non-forestry land use was consolidation of upland agriculture due to the expansion of agricultural activities.

Key connectors in forest landscape networks: how can they be identified and when are they really important? Blazquez, S., Saura, S. (*Universidad Politécnica de Madrid, Spain; sandrablazquezcabrera@gmail.com; santiago.saura@upm.es*).

The rapid development of quantitative methods in landscape ecology has resulted in a myriad of metrics for analyzing forest spatial patterns. However, many of these metrics, despite being intuitively appealing, may present important limitations that do not make them fully adequate for decision-making in forest planning or for the assessment of changes in structural or functional connectivity. We describe recent developments for analyzing connectivity in landscape networks that are particularly suited for the identification of connecting elements in the forest landscape and for the evaluation of their relative importance for upholding connectivity. We discuss when these connecting elements are really a key issue for the conservation of forest species. We show how these developments help to place connectivity in a broader context of conservation alternatives, providing a unifying analytical framework that avoids the arbitrary weighting of connectivity considerations in the final planning. We describe the main functionalities of the Conefor Sensinode software (http://www.conefor.org) and other related and freely available tools, and show how they provide complementary capabilities that can be integrated in a single analysis with considerable synergies. Finally, we present examples of application of these developments in forest planning and change monitoring in different parts of the world.

Plant diversity and landscape mosiacs across heterogeneous space. Chen, J. (*University of Toledo, USA; jiquan.chen@utoledo.edu*), Brosofske, K.D. (*Michigan Tech University, USA; kdbrosof@mtu.edu*).

A key challenge in landscape ecology is collecting empirical ecological data at broad scales that can be used to validate models and contribute to theory development and land management. However, data for large landscape mosaics can be difficult to obtain. A long-term landscape study in the Chequamegon-Nicolet National Forest (CNNF), Wisconsin, USA, was conducted in 1993–2005 to illustrate how broad-scale alternative forest management strategies can influence different ecological factors. We synthesized data from several CNNF field studies examining the effects of various landscape elements on the distribution of plant species. Consolidating the data into standard-size plots, we developed a probability matrix of species occurrence and used this to depict species distribution spatially on the landscape. The relative species richness of a particular landscape feature often depended on the spatial setting. For example, roadsides typically exhibited higher richness relative to surrounding forest, but sometimes showed lower richness when surrounded by open-canopy patch types. Our results show that consideration of the entire land mosaic, including context and complex structural elements, is important when managing for ecological values such as biodiversity. Spatial depictions of hypothetical scenarios coupled with field data such as those from this study could provide valuable tools for landscape management.

Measures for effective riparian management based on landscape ecology in Gyeongan-cheon, Korea. Kwon, O.J., Oh, C.H., Ban, S.H., Son, J.W. (*Dongguk University, Republic of Korea; ojtale@dongguk.edu; ecology@dongguk.edu; suhong21@nate.com; wine814@hanmail.net*).

This study was performed for managing riparian environments by applying riparian area and ecological belts. Gyeongan-cheon is a kind of urban river and a tributary to the Han River, flowing through cities such as Gwangju-si and Yongin-si in Gyeonggi-do. From April 2008 to December 2009, a field research was conducted and a biotope map was made. The target area includes a grid of 1 km of both banks. The GIS-based landscape unit was built on digital topographic map, aerial images, IKONOS satellite images. Each site was evaluated by four criteria attributed to combined evaluation criteria with Hemerobie, Wittig's biotope, and Green Naturality grade. As a result, the biotope was classified with 30 groups. The hierarchical classification on land use patterns shows that forest area is 45.02%, and residential area is 15.75%. In biotope evaluation, first grade was 41.18%, and second grade was 14.49%. Many forests and rivers were separated by roads; and wetlands, forests, and farmlands were usually segregated. Therefore, measures need to be taken to link fragmented sites as a network. In conclusion, forests and greens that are not assigned as riparian protection areas should be designated, and it is important that the government acquire these first.

Modeling of potential connectivity of European bison herd ranges in the Carpathian Mountains using a graph theory approach. Laszczak, E., Ostapowicz, K. (*Jagiellonian University, Poland; elzbieta.laszczak@uj.edu.pl; kostapowicz@gis.geo.uj.edu.pl*), Kuemmerle, T. (*University of Wisconsin-Madison, USA; kummerle@wisc.edu*), Kozak, J. (*Jagiellonian University, Poland; jkozak@gis.geo.uj.edu.pl*), Perzanowski, K. (*Polish Academy of Sciences, Poland; StacjaKarpacka@miiz.waw.pl*) Radeloff, V. (*University of Wisconsin-Madison, USA; radeloff@wisc.edu*).

Large mammals play an important role in ecosystem functioning, but today often occur in fragmented populations. The aim of this study was to estimate the potential connectivity of the European bison herd ranges (HR) across the Carpathians. A bison habitat suitability index (HIS) was used to delineate three sets of bison HR patches with various HSI thresholds. We retained only HR patches larger than 200km^2 (the minimum area for a population of 50–60 animals) receiving 39 patches (HSI $\geq$ 0.5), 25 patches (HSI $\geq$ 0.6), and 2 patches (HSI $\geq$ 0.7). Inverse HSI was used to compute a friction surface to proxy dispersal costs and a cost graph model was constructed for each HSI threshold. For HSI $\geq$ 0.5, 95 connections were identified (mean Euclidean length (EL) = 64.8 km, max EL = 692.8 km); 56 connections for HSI $\geq$ 0.6 (mean EL = 139.7 km, max EL = 1043.1 km); and one connection for HSI $\geq$ 0.7 (88.0 km). Comparison of graph models to mean bison dispersal distance showed isolation of several HR patches. However, HR patches smaller than 200km^2 could increase overall connectivity, serving as stepping stones in European bison dispersal across the Carpathians.

Applying landscape perspectives in the 2010 United States Forest Resources Assessment. Riitters, K.H. (*U.S. Forest Service, USA; kriitters@fs.fed.us*).

In a world dominated by humans, forests are managed in a landscape context formed by human preferences regarding spatial patterns of forests in relation to other natural resources and human activities. An interdisciplinary perspective is required to produce and use meaningful assessments of forest patterns that recognize the anthropogenic landscape context. This presentation illustrates new perspectives in landscape pattern analysis as applied in the 2010 United States Resources Planning Act (RPA) assessment. The assessment is based on three fundamental measures of pattern (area density, landscape mosaic, and physical structure), taken at multiple spatial scales from national land-cover maps, mapped at the original spatial resolution of the land-cover data, and summarized at landscape level and sector level for the grassland, shrubland, and forest sectors. The use of consistent protocols ensures harmonization of the pattern assessment across landscapes, sectors, and scales, and forms a basis for integrating the implications of patterns across disciplinary and geographic boundaries. In the United States, natural resources tend to be dominant where they occur, but human activities are so pervasive that fragmentation and proximity to edge pose ecological risks to the majority of natural resource area.

Determining the impacts of fragmentation on forest biodiversity in urban forest fragments in İstanbul. Sağlam, S., Özkan, Y., Asan, Ü. (*University of Istanbul, Turkey; nuhres@istanbul.edu.tr*; *uozkan@istanbul.edu.tr; asanunal@istanbul.edu.tr*), Colangelo G., Sanesi, G., Lafortezza, R. (*University of Bari, Italy; g.colangelo@agr.uniba.it; sanesi@agr.uniba.it; r.lafortezza@agr.uniba.it*).

In recent decades, immigration from rural to urban areas has rapidly increased. As a result, forest areas decreased and became fragmented in and around the city. Fragmentation may cause impacts on a wide range of ecosystem functions and services. This study describes the effects of fragmentation on forest biodiversity in the city of İstanbul. We used inventory data from local management and silvicultural plans (2002–2008) to determine spatial variation in forest biodiversity across six urban forest fragments near the Bosporus. We calculated a core set of patch- and class-level metrics (such as edges distance, patch size, edge density, etc.) and used these metrics to predict forest basal area within sample plots. On the basis of these data we tested a number of regression models and used the best supported model to extrapolate our response variable over other urban forest fragments. Preliminary results from the study indicate consistent relations between spatial and silvicultural variables, meaning that fragmentation is having an impact on forest biodiversity in İstanbul. This study could be applied to any other urban contexts in Turkey.

Embedding spatial pattern analysis in forest cover change assessments. Vogt, P., Strobl, P., Seebach, L. (*European Commission, Italy; peter.vogt@jrc.ec.europa.eu; peter.strobl@jrc.ec.europa.eu; lucia.seebach@jrc.ec.europa.eu*).

Morphological spatial pattern analysis (MSPA) provides an intuitive, repeatable, and scale-independent description of forest spatial patterns. The MSPA analysis, and tailored derived indices, can be used to interpret the relation of forest spatial pattern and forest resources. In this study, this precise MSPA pattern assessment was utilized for a novel robust forest pattern changes analysis. The objective of the change detection is to reliably detect coherent forest change areas and to exclude uncertainties due to differences in image quality, ortho-correction, and classification accuracy of the input images. For this purpose change is being quantified according to changes of morphological criteria. The principal processing steps are explained and illustrated on synthetic and sample data sets. The reliable assessment of forest pattern and its change in time is a prerequisite for a meaningful understanding and interpretation of forest landscape dynamics, as well as measuring progress in biodiversity and landscape planning policies. It will also help to monitor and quantify the impact of human activities on forest pattern in order to establish an effective, feasible, and meaningful design of future forest resource strategies.

Posters

The Guaraqueçaba's mosaic landscape structure: Atlantic forest, Parana, Brazil. Grise Monteiro, M., Biondi, D. (*Federal University of Parana, Brazil; mayssagrise@ibest.com.br; dbiondi@ufpr.br*).

The Paraná State, in Brazil, has the largest contiguous remaining area of Atlantic Forest, the world's most threatened biome. This area comprises a series of protected areas (PA), in different categories, and the Environmental Protection Area (EPA) of

Guaraqueçaba, which is the largest extent and covers the others. This study aimed to analyze the landscape structure (matrix and fragments) of PA that takes place in the EPA to verify the mosaic functionality. The classification of the land cover area and setting of the attributes of area and perimeter were obtained from the supervised classification of maximum likelihood digital image Landsat-5-TM. It was found that the PAs communicate with each other through a native vegetation matrix, common to all units, interrupted by the fragments. In the study area, 21% of fragments belong to classes of changed vegetation, uncovered soil, urban area, sand, and water; most have less than 1 hectare and a regular shape. It follows that, according to fundamentals of landscape structure and mosaic rules, the mosaic of the Guaraqueçaba-PR performs the function of connectivity with other PAs to maintain local biodiversity.

Ecological management of forest biotope in Siheung, Korea. Lee, H.Y., Oh, C.H., Ban, S.H. (*Dongguk University, Republic of Korea; hoyleee@hanmail.net; ecology@dongguk.edu; suhong21@nate.com*).

Biotope fragmentation has been going on in small cities near a larger metropolis, because these cities are totally involved in the big city aspects of economy and culture. Siheung is the representative metropolis-involved city, which is adjacent to the biggest metropolitan area of Korea—Seoul and Incheon. In Siheung, the fragmentation of natural biotopes, especially forest, has been progressing very fast, so an ecological management plan for the natural biotopes of Siheung is necessary. In this study, we drew the biotope map of Siheung, then tried to establish an ecological management plan for a sustainable city. The ratio of the urbanized area is 23.5% and the ratio of green and open space is 76.5%, in which the sum of forest type (21.1%) and crop-land type(19.6%) is over 40%. Thus the ratio of green and open space biotope type is very high but there was little consideration of inter-biotope network between the forest biotopes. For the ecologically desirable management of forest in Siheung, it is necessary to establish a management plan of urban green space considering not only the network between the forest biotopes intra-Siheung but also the network between that of Siheung and that of the near city.

Effects of various timber harvest strategies on forest landscape pattern: a case study of Lushuihe Forestry Bureau. Jia, J., Fangzhou, D., Xiaoze, S., Lu, L. (*Chinese Academy of Sciences, China; jiajia_cy@yahoo.com.cn; fdai@yahoo.cn; zixiaorirao@sohu.com; lulu8733@163.com*).

Reasonable timber harvest strategies are important for forest resources sustainability. This research supports sustainable harvest strategies at the landscape level. Cut-block size, spatial dispersion of harvest units, age of young forests, and rotation length are the main factors affecting harvest strategies. With use of the HARVEST model and neutral landscape, Lushuihe Forestry Bureau was taken as an example to conduct simulations of various harvest strategies. APACK software was used to calculate landscape indices of the simulation results. Results showed that there was a significant overall effect of all components on response variables defined by age class. Increasing cut-block size, rotation length, and clustering of cut-blocks, and thinning of young forest generally reduces measures of age class fragmentation. The results show that the larger the cut-block size, the more aggregated the cut-block is. In addition, non-harvested young forests or extension of the rotation length can reduce fragmentation of the forest landscapes caused by the process of the forest cutting. We should take full account of these factors in the process of designing the cut-blocks.

An analysis of forest landscape structure using landscape indices and the nearest features model in Korean metropolitan cities. Oh, J.H., Kwon, J., Choi, M.S. (*Korea Forest Research Institute, Republic of Korea; jehoh@forest.go.kr; alp96jk@forest.go.kr; hnarbore@forest.go.kr*).

An urban forest is one of the important elements for the sustainability of urban ecosystems, with the potential to minimize external influences of the surrounding landscape and maintain the ecological integrity of urban ecosystem fragments. The condition of urban forests in size and structure has been altered by unpredictable simultaneous urbanization and human demands during the past decade in Korea. The objective of this study is to establish desirable forest network plans through quantitative analysis and to understand the present forest structure of Korea. Forest distribution maps used in this study were reconstructed from digital forest cover type maps. Landscape indices and the nearest feature model were applied to analyze the forests in the six cities. As the result of the analysis for forest structure, forest networks of the Korean metropolitan cities are sub-divided into 3 types, straight line, cross, and radial pattern according to land use patterns and forest density. Although Busan, Daejeon, and Incheon have smaller forest volume in both individual and total size, they show more ‘stable forest network’ than other cities. Forest distributions of the cities show the radial pattern, which is known to offer a better environment for wildlife movement among urban forest patches.

Examination of forest treatment by using landscape metrics and topographic analysis in a mixed forest, Hokkaido, Japan. Sano, M., Miyamoto, A. (*Forestry and Forest Products Research Institute, Japan; masakoto@ffpri.affrc.go.jp; asakom@ffpri.affrc.go.jp*), Furuya, N. (*Japan International Research Center for Agricultural Science, Japan; nfuruya@affrc.go.jp*), Kogi, K. (*Forestry and Forest Products Research Institute, Japan; kogisan@ffpri.affrc.go.jp*).

In this study, we identified the distribution characteristics of a mixed forest of coniferous and broadleaved trees, a typical forest in Hokkaido, by using landscape metrics and topographic factors in an attempt to apply it to forest management. This will provide a new perspective, i.e., the landscape structure, for forest treatment, which has been traditionally determined on a forest stand basis. We made a land cover map of the study area by aerial photograph interpretation. The characteristics of each land cover type were figured out by landscape metrics at class level. Every 20 m contour of a forest administrative map (on a scale of 1:20,000) was digitized into GIS to produce a terrain model. Based on the obtained information, we proposed a guideline of treatment for sustainable forest management. From the land cover map, we simulated an improved land cover map, i.e., when the land developed a high growing stock of forest. Then, we compared the difference between the two land cover maps, and discussed the impacts on fauna. We concluded that the information obtained from landscape metrics or terrain models is essential for various stages of forest planning.

B-02 Aquatic biodiversity conservation in forests

Organizers: Deanna Olson, Melvin Warren, *U.S. Forest Service, USA, dedeolson@fs.fed.us, mwarren01@fs.fed.us.*

Debris from the natural forest watershed in a mountain region in Japan. Nakashima, T. (*Kyoto University, Japan; tnakashi@kais.kyoto-u.ac.jp*).

Watersheds in mountain regions are important in the regional environment as the place in which water and much woody organic matter (litter, stems, branch, and bark) are produced. These watersheds are also important for the global environment because water, woody matter, and its carbon-based components are circulated in the ecosystems of forest, river, sea and atmosphere. For woody matter of mountain watersheds, three unresolved questions remain: "When does woody matter move?" "What woody matter moves?" and "How much woody matter moves?" Recently much research has been focused on large natural forested watersheds in mountainous regions. The structure and dynamics of forest, material movement, and influence of the global environment are being investigated. Here I report the transported mass of stems, branch, and bark and the transported sediment measured from about an 8-hectare watershed of a mountain region in Japan. The wet-to-dry weight ratio of transported litter from the watershed in 2000 was 193.1:69.4 kg. The wet weight of stem, branch, and bark was 47.1 kg. Little wood was transported at base flow conditions. Total wet weight of transported wood in 2000 was 1/20 of that (1,046.1 kg) transported by the typhoon in 1998.

Up and over: extending riparian reserves into headwaters and over ridgelines to integrate fish and amphibian conservation in forested landscapes. Olson, D.H., Burnett, K.M. (*U.S. Forest Service, USA; dedeolson@fs.fed.us; kmburnett@fs.fed.us*).

In the U.S. Pacific Northwest, streams in wet temperate forests are habitat for several species of concern including salmonid fishes and amphibians. Several amphibian species are found in and along small headwater streams. These streams can be sources of wood, boulders, and spawning gravel, important attributes of salmon habitat downstream. Our studies have addressed these species habitat associations and designs for habitat management. Riparian reserves appear to be an effective management provision along the aquatic continuum but are often not extended into headwaters and do not address amphibian habitats outside riparian corridors. We developed alternatives for headwater linkage areas aimed at managing headwater debris-flow-prone areas for downstream fish habitat attributes, and overland connectivity for amphibians. Criteria for linkage area selection included landscape-, drainage basin-, and forest stand-scale considerations such as locations of target species, land ownership patterns, total number of links established, connectivity among discrete major river basins, and climate change predictions. Although the proposed linkage areas target headwater species by design, the resulting web of connection across the landscape would be expected to benefit numerous forest-dependent species.

Are biodiversity patterns concordant on both sides of the forest-stream interface? Suurkuukka, H., Virtanen, R., Muotka, T. (*University of Oulu, Finland; heli.suurkuukka@oulu.fi, risto.virtanen@oulu.fi, timo.muotka@oulu.fi*).

Riparian forests are hotspots of biodiversity in forested landscapes and key biotopes for forest conservation. Streamside forests support numerous terrestrial organisms of high conservation value, yet it is not known whether the protection of these habitats will also provide protection for stream organisms. We used data from 50 headwater stream-forest systems in northeastern Finland to address this question. Our study sites formed a gradient from highly human-impacted to almost pristine habitats. We assessed whether bryophytes and insects (Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, EPTC, fauna in streams compared to coleopterans in riparian forests) exhibit similar patterns of species richness and community structure on both sides of the forest-stream ecotone. All four groups exhibited a pattern of increasing species richness with increasing level of naturalness. Communities of aquatic and terrestrial bryophytes showed quite strong concordance (Procrustes analysis, $r = 0.296$, $p < 0.001$), but invertebrate communities did not ($r = 0.072$, $p > 0.05$). This was because stream invertebrates responded to riparian habitat quality, but terrestrial coleopterans did not; instead, their communities were largely similar in natural and modified forests. Thus, although stream communities may show relatively strong responses to riparian forest degradation, their biodiversity cannot be readily predicted based on riparian communities.

Response of fishes to constructed, woody microhabitats in sand-bed streams of the upper Coastal Plain, Mississippi, USA. Warren, M.L., Jr. (*U.S. Forest Service, USA; mwarren01@fs.fed.us*), Sheldon, A.L. (*University of Montana, USA; andylsheldon@comcast.net*), Haag, W.R. (*U.S. Forest Service, USA; whaag@fs.fed.us*).

We investigated fish use of standardized, constructed woody microhabitats (cane bundles) in four north Mississippi sand-bed streams with different degrees of channel degradation and natural instream woody cover. The streams described a disturbance gradient: Lee Creek (deeply incised, least depth and wood); Cypress Creek (channelized, low depth and wood); Puskus Creek (natural channel, moderate depth and wood); and Chewalla Creek (natural channel, deepest, highest wood). We deployed replicate cane bundles over 1 year (six samples). We focused on three measures of microhabitat use: fish occupancy, abundance, and assemblage structure. Across all streams, we captured 30 fish species representing eight families. Fishes used bundles least in the most disturbed stream (7% occupancy) but showed similar occupancy in the others (20–27%). Mean fish abundance in bundles differed greatly between the two most disturbed streams but was intermediate and similar in the least disturbed streams. Fish assemblages in bundles were distinct among streams. Pairwise effect sizes in assemblage similarity described a gradient from the most- to least-disturbed stream. Small wood in these sand-bed streams is obviously an important but dynamic component of fish habitat, but responses of fishes to that habitat are mediated largely by the disturbance history of the stream.

Posters

Effects of temperature on distribution patterns of Plecoptera and Odonata in streams in Korea. Bae, J.M. (*Kyung Hee University, Korea*), Kwon, T.S. (*Korea Forest Research Institute, Korea*), Park, Y.S. (*Kyung Hee University, Korea; parkys@khu.ac.kr*).

The effects of climate change on ecosystems as well as their organisms are of global concern. Distribution of benthic macroinvertebrates in streams is affected by various environmental factors including temperature. In this study, we obtained benthic macroinvertebrate data from the Korean National Natural Environment Monitoring Program, operated by the Ministry of Environment of Korea, to examine the association of temperature with the distribution of benthic macroinvertebrate communities, especially Plecoptera and Odonata. In addition, we evaluated the relationships between biodiversity and other environmental factors such as stream order and land cover. A self-organizing map was used to explore spatial patterns in the macroinvertebrate communities. We found 42 Plecoptera species at 513 sampling sites and 52 Odonata species at 717 sites. In Plecoptera, the abundance of two species (5.6%), *Rhopalopsole mahunkai* and *Pteronarcys macra*, increased as a function of temperature, whereas 10 species (27.8%) decreased, including *Amphinemura KUa* and *Kamimuria KUa*. In Odonata, the abundance of 9 species (15.5%), such as *Calopteryx atrata*, increased with an increase in temperature, and 6 species (10.3%) including *Davidius lunatus* had their abundance increase as a function of temperature. Plecoptera and Odonata had distribution patterns.

Benthic macroinvertebrates affected by erosion control measures in a torrential stream in Korea. Lee, K.H., Lee, H.H., Jung Y.Y. (*Yeungnam University, Republic of Korea; lure1999@nate.com; hhlee@ynu.ac.kr; ava1983@nate.com*).

We evaluated the effect of erosion control on a mountain torrential stream ecosystem in Korea. The variation in abundance of benthic macroinvertebrates was investigated for 2 years, before and after construction of erosion control measures in the valley. Most species gradually declined in abundance after construction of the erosion control measures. At the location of the erosion control installations, either no species were observed or the lowest numbers were collected. The species dominance value was higher after construction than before, and species diversity, richness, and evenness indices were higher before construction. The ecological score of benthic macroinvertebrate community (ESB) was good at the first survey before construction, but indicated that the water quality deteriorated continuously after construction. Before construction (1st survey), upper, middle, and lower stream sections were graded to EBS scores I, II, and III, respectively, but after construction (2^{nd}–6^{th} surveys), they were graded from III to V except the upper section. Thus, the construction of erosion control measures led to reduction of the number of biological species, water quality deterioration, and stream ecosystem disturbance. These may be shore-term impacts to instream biological communities, and monitoring is needed to assess system recovery.

B-03 Improving livelihoods through research and action in biodiversity-rich tropical forest landscapes

Organizers: Jean-Laurent Pfund, Terry Sunderland, Robert Nasi, *CIFOR, Indonesia, j.pfund@cgiar.org, t.sunderland@cgiar.org, r.nasi@cgiar.org.*

Governance of landscape mosaics: experiences at five tropical sites. Colfer, C.J.P. (*Center for International Forestry Research, Indonesia; c.colfer@cgiar.org*).

Between 2007 and 2010, interdisciplinary teams of researchers worked on tropical landscapes in five countries (Cameroon, Indonesia, Laos, Madagascar, and Tanzania) to develop mechanisms to improve biodiversity conservation and human livelihoods. Part of that research focused on the role of governance at various levels, and some of these governance results have been brought together into an evolving book. Here we discuss several themes that emerged as key at these sites and that are dealt with more fully in the book. These include resettlement, links and conflicts between customary and formal legal systems, and the importance of non-timber forest products (NTFPs) compared to timber in people's daily lives. We also provide two very practical chapters (one on a tool we developed and another reflecting on lessons learned). This presentation concludes with a series of observations and recommendations on the importance of working at multiple governance levels simultaneously, inclusion of marginalized groups and remote landscapes in efforts to improve governance, and establishment of long-term projects that allow researchers to establish rapport and partnerships, build capacity, and follow through on initiatives

Land-use modifications and wildlife security in the Bia-Goaso forest block in western Ghana. Danquah, E., Oppong, S.K. (*Kwame Nkrumah University of Science and Technology, Ghana; ekadanquah@yahoo.com*; *kobbyoppong@yahoo.com*).

As agricultural landscapes continue to expand and replace natural areas, the ability to manage and conserve native wildlife with changing land use is becoming increasingly important. The major challenge is to meet the ever-growing demand for agricultural products while conserving biodiversity, providing critical ecosystem services, and maintaining rural livelihoods. By using a combination of modern and traditional survey approaches, this study investigated species' responses to local-level habitat attributes such as land use in order to develop decision making processes and on-the-ground conservation actions in the Bia-Goaso forest block of western Ghana. Our results indicated that maintenance of forest patches in agricultural landscapes is of conservation benefit to wildlife despite human activity and disturbance, as long as the patches are large enough. However, there was a trade-off between patch length and species abundance that should be taken into consideration when managing agricultural systems. Generally, plantations and permanent cropland had strong adverse influence on biodiversity. This project helps meet the objectives of the Wildlife Division's Protected Areas Development Project conservation strategy by identifying land use strategies that facilitate the long-term survival of dwindling wildlife populations in Ghana.

Carrots and sermons don't work without a baton: economic incentives fail to protect the Bukit Barisan Selatan National Park in Indonesia from encroachers. Levang, P. (*Center for International Forestry Research, Indonesia; p.levang@cgiar.org*), Fitriana, Y.R. (*University of Montpellier 3, France; y.fitriana@cgiar.org*).

The Bukit Barisan Selatan National Park in Indonesia is home to the last tigers, rhinos and elephants of south Sumatra. It has recently been listed as an UNESCO World Heritage site for its exceptionally rich biodiversity. However, since the fall of the

authoritarian regime of General Suharto in 1998 and the implementation of regional autonomy laws in Indonesia, the Park is increasingly encroached by squatters converting its rich forests into coffee plantations. As coercive law enforcement is no longer an option, much hope has been put into economic incentives such as payments for environmental services, and increased environmental awareness of local populations. Eco-labeling and higher prices for coffee produced outside the Park, quality development projects, micro credit operations, and environmental lobbying have been tested with various results. While most protagonists welcome all these measures, they also show an extraordinary ability to circumvent the spirit of these attempts in order to maximize their economic benefits. The main problem faced by conservation initiatives remains the huge attractiveness of free land that provides quick and high returns to the daring squatters. Countering these economic benefits incurs huge costs and would still not work without more coercive law enforcement.

Gender differentiation, rule attributes, and forest condition: user group dynamics and sustainability in the context of forest resource decentralization. Mwangi, E. (*Center for International Forestry Research, Indonesia; e.mwangi@cgiar.org*), Meinzen-Dick, R. (*International Food Policy Research Institute, USA; r.meinzen-dick@cgiar.org*), Sun, Y. (*International Food Policy Research Institute, USA; y.sun@cgiar.org*).

How does gender differentiation in forest user groups affect their management behavior and forest condition in Kenya, Uganda, Bolivia, and Mexico? Data collected every 5 years between 1993 and 2008 from a total of 29 forests demonstrated that in forests where the proportion of women to men in the user group increased over time, forest product harvesting rules relaxed. A declining proportion of women in user groups was associated with the monotonic adoption of more stringent harvesting rules, while a fluctuating proportion of women to men over time was reflected in shifts between lax and stringent rules. Under all three circumstances, there were no identifiable effects on forest condition. We argue that because men and women obtain different products from forests, for different purposes, and with varying frequencies, harvesting rules that do not reflect their relative preferences are unlikely to merit their support, especially if the costs to changing such rules are high. We explore this argument within the context of changing property rights under different variants of decentralization in East Africa and Latin America.

Quantitative analysis of forest fragmentation: biodiversity patterns in northeast Madagascar. Rabenilalana, F.M., Rajoelison, L.G. (*Université d'Antananarivo, Madagascar, rmihajamanana@yahoo.fr; g.rajoelison@yahoo.fr*), Pfund, J.L. (*Center for International Forestry Research, Indonesia, j.pfund@cgiar.org*), Rakoto Ratsimba, H. (*Université d'Antananarivo, Madagascar, rrharifidy@moov.mg*).

Habitat loss and degradation are important threats to biodiversity, and assessment of these risks constitutes a real issue for hotspot countries such as Madagascar. The tropical lowland rainforest in our study area forms a corridor that links two protected areas. Anthropogenic activities such as slash and burn, harvesting, and land use change affect the forest habitats and provoke fragmentation. Analysis of fragmentation was carried out by (a) a multispectral image classification using SPOT 2009 to develop a land cover map, (b) a landscape analysis with a fragmentation index classification, and (c) a floristic inventory to examine fragmentation impacts on biodiversity. The classification showed that fragment size was related to the distance from the nearest villages. Moreover, tree abundance and species richness appeared different through the classes: "low fragmented forest" and "fragmented forest." The analysis also revealed that forest fragmentation is strongly linked to the needs of local people in terms of livelihoods, and that biodiversity bridges can be maintained if the fragmentation remains low. Therefore, all these aspects must be considered in conservation and development actions that aim towards sustainable management of natural resources.

Forests and livelihoods: pursuing spatial concepts for better research, analysis, and action. Shepherd, G. (*IUCN, United Kingdom; gillshepherd@compuserve.com*).

For the past decade and more, discourse about forests and the poor has analysed what the poor get from forests and expressed concern that forests rarely offer obvious exits from poverty. This presentation reports on more recent findings and aspirations. On the forestry side, the correlation between forests and the poor coexisting in more remote areas is now clearer, as is the observation that poverty is exacerbated in remote regions. On the poverty side, we now distinguish the chronic poor from the ordinary poor. Both types of poor people are found in and near forests but the remoter the area, the higher the proportion of chronically poor people. Research is showing that 'alternative livelihoods' are unlikely to take root in remote areas because there *are* no alternatives to use of the resources concerned. Here we should enhance livelihood resilience and ensure that we do not harm unexamined forest dependence. To protect forests we should strengthen rights and allow people to manage the forest sustainably. Meanwhile, for those who live nearer to markets, we can promote the commercialisation of forest products and pursue more conventional poverty reduction goals.

Analysis of pattern, dynamics and driving forces of forest landscapes at the community level in Lingshui Li Autonomous County, Hainan Province, China. Xiaohong, Z., Qinglin, H., Shao, J. (*Chinese Academy of Forestry, China; zhangxh@caf.ac.cn; huangql@caf.ac.cn; shaoja@caf.ac.cn*), Tong, H. (*China Aero Geophysical Survey and Remote Sensing Center for Land and Resources, China; huijietong@163.com*), Ma, Z. (*Chinese Academy of Forestry, China; mazb@caf.ac.cn*).

Using Dagan Village, Lingshui Li Autonomous County, Hainan Province, in China as a case study, this paper presents methods to analyze the pattern, dynamics, and driving forces of the forest landscape at the community level. In view of forest landscape restoration (FLR) concept, eight landscape elements were identified including degraded primary forest, secondary forest, degraded forest land, plantation, paddy field, non-paddy cropland, pond, and human settlement. The patterns of the forest landscape in Dagan Village in 1999 and 2009 were quantified separately using aerial image (1999), world-view image (2008), field surveys, and interviews with different stakeholders. Markov models were constructed to explain and predict the dynamics of the forest landscape based on analysis of these patterns during the different time periods. The forestry programs developed by Chinese Central Government as well as local governments are the positive driving forces, while persistent poverty of local residents, lack of understanding of FLR, lack of financial incentives and compensation to restore forest landscape and lack of stakeholder participation mechanisms etc., are the main negative driving forces for the forest landscape in Dagan Village.

B-04 Uneven-aged silviculture in temperate and tropical forests: towards paradigm expansion

Organizer: Kevin O'Hara, *University of California-Berkeley, USA, kohara@berkeley.edu.*

Threshold level of harvest for mixed dipterocarp forest. Kassim, A.R., Musa, S. (*Forest Research Institute of Malaysia, Malaysia; rahmank@frim.gov.my; samsudinmusa@frim.gov.my*), Dahlan, M.P. (*Forest Department Peninsular Malaysia, Malaysia; puat@penang.gov.my*).

Over-exploitation of forest resources is one of the factors that impairs sustainable tropical forest management. In the tropical forest of Southeast Asia, where the minimum diameter limit approach has been practiced, removal of many large commercial timber trees from the forest had caused severe damage to the residual stands. This paper demonstrates a method to determine the threshold level of harvest by considering level of stocking, number of residual trees, proportion of dipterocarps, number of trees to be cut, maximum volume of harvest, minimum diameter limit, and differences in minimum diameter limit between dipterocarps and non-dipterocarps. The species were grouped into dipterocarp, non-dipterocarp and chengal (*Neobalanocarpus heimii*) with a minimum cutting limit of 50, 45, and 60 cm dbh, respectively. Twenty-eight cutting regimes were tested ranging between 45 and 105 cm minimum diameter limit. The threshold level of harvest will vary depending on the initial stocking level of the primary forest. The paper analyses the data using actual pre-felling field inventory data of a primary mixed dipterocarp forest and discusses the results in relation to selective management system prescriptions applied in Malaysia.

Uneven-aged stocking control for small ownerships in Austria. Klopf, M., Spörk, C., Hasenhauer, H. (*University of Natural Resources and Applied Life Sciences, Austria; hubert.hasenauer@boku.ac.at*).

In this study we analysed uneven-aged forest management strategies at a company level for mixed Norway spruce, common beech, and fir forests in Austria. While in the past uneven-aged forest studies were focussed on long-term research plots, in this study we utilized repeated measurements from permanent inventory plots covering about 3,000 ha of uneven-aged managed forests to assess: (i) stand density, (ii) tree species diversity, (iii) basal area increment, and (iv) stand structure development. The results were compared with even-aged forests and with findings from long-term uneven-aged experimental sites. We explored (i) the management intensity required to maintain uneven-aged forests and (ii) the derivation of measures for sustainable forest management, since forest enterprises are often constrained by insufficient areas or diameter classes to assure sustainability. The results suggest that uneven-aged forest management requires intensive management and a permanent forest inventory design with repeated observations to ensure sustainability, and it may produce higher volume increment rates due to a more efficient use of the forest area compared to even-aged forests.

Determining the optimal selective harvesting strategy for uneven-aged stands in Indonesian natural production forests with a transition matrix growth model. Krisnawati, H. (*Forestry Research and Development Agency, Indonesia; haruni2000@yahoo.com*).

Selective harvesting is a commonly used silvicultural method to manage natural production forests in Indonesia. In practice, the harvesting is based on universal criteria: a minimum diameter cutting limit of 50 cm for all commercial timber species with a cutting cycle of 35 years. The fixed length of cutting cycle applied to all forests is unreasonable due to the variety of forest growth and stand conditions. This study aimed to find the optimal harvesting strategy including cutting cycle and felling intensity for uneven-aged stands in Indonesia. For this purpose, a transition matrix growth model that included ingrowth, upgrowth, and mortality was developed based on re-measured plots. Four stands from natural production forests in Central Kalimantan with various initial conditions were used to evaluate the effects of alternative harvesting strategies on stand structure, basal area, and species composition. The optimal harvesting strategy was achieved with the increment of annual basal area and stand structure maximum. Results showed that an increase in felling intensity decreased basal area and diversity of species and size. As the felling intensity increased, the cutting cycle would be longer. The optimum cutting cycle varied from 30 to 42 years, with the felling intensity of 3–7 trees/ha.

Creativity theory of ecosystems: a new approach to study the mechanisms of biodiversity. Liu, Y.**,** Li, G. L. (*Beijing Forestry University, China; lyong@bjfu.edu.cn; glli226@163.com*), Yu, H.Q. (*Department of International Cooperation, China; yuhq@bfdic.com*), Lv, R.H. (*Beijing Forestry University, China; lvrh514723@126.com*).

The latitudinal gradient in biodiversity is one of the most prominent features of the ecosystems on Earth, and the mechanisms that underlie it have been controversial for over a century. Although many hypotheses have been proposed and ecologists have amassed a wealth of details to explain global patterns in species richness, there are not many integrated hypotheses of how the ecosystems work as a whole evolved entity. Here we develop an integrated model, Creativity Theory of Ecosystems (CTE), to study the mechanisms of biodiversity from the standpoint of complex systems. We find that the creativity index (CI) is an ideal integrated indicator for emergent properties of ecosystems and is positively correlated with energy and environmental diversity but is negatively correlated with adaptability of the ecosystems. A test of this theory is conducted on data of biodiversity and environmental factors from China. Using the methods of principal component analysis and multiple regressions, the results show that CTE successfully predicts the plant species richness distribution on a regional scale. Our results suggest that a new approach to study the mechanisms of biodiversity from the aspect of system thinking is feasible and promising. CTE can be implemented in silvicultural systems and other fields.

Gap mosaic decision for ecological rehabilitation of cedar plantations with complex topography: management of competition between dwarf bamboo and beech seedlings by light regulation. Mizunaga, H., Fujishima, M., Furukawa, S. (*Shizuoka University, Japan; mizunaga@agr.shizuoka.ac.jp; drippy2cats@hotmail.com*).

Structurally complex silviculture might be referred to for understanding patterns of gap mosaic, such as the coarseness of mosaics (from single selection to patch selection), and the shapes of gaps. We had developed a model to evaluate the impact of gap mosaic pattern on the photosynthetic production of seedlings by predicting the compound effect of multiple gaps on the spatial

variance of light intensity in stands. In mountainous areas, however, the adequate gap mosaic pattern for the growth of regenerations will be altered by the topography. Combining a digital elevation model to the model will provide a basis of silviculture for complex structured stands in complex topography. Japanese beech (*Fagus crenata*), which dominates in mature temperate deciduous forests, is expected to be a useful species for the ecological rehabilitation of degraded Japanese cedar plantations in mountainous areas. However, one of the difficulties lies in the competition with dwarf bamboo, which might suppress beech seedlings. We will present how topography affects the gap mosaic designs for better regenerations, showing the examples to control the beech-bamboo competition in degraded cedar plantations.

Growth of wild service tree (*Sorbus torminalis* [L.] Crantz) in former oak coppice forests in southwest Germany. Pyttel, P., Kunz, J., Bauhus, J. (*Albert Ludwigs University/Freiburg, Germany; patrick.pyttel@waldbau.uni-freiburg.de; jörg.kunz@waldbau.uni-freiburg.de; jürgen.bauhus@waldbau.uni-freiburg.de*).

Sorbus torminalis L. (Crantz) is a rare species but not uncommon in oak coppice forests of Central Europe. Although its timber is of high value, there is little quantitative information on its regeneration and growth dynamics. Since coppicing is no longer practiced, it is unclear whether the *S. torminalis* population can persist in a continuous cover forest system or if coppicing is needed for species preservation. Here, we quantified species frequency on three 1-ha sample plots of former oak coppice forest. The age of 62 trees was determined and diameter and height growth was reconstructed for 20 trees by stem analysis. Photosynthesis was measured in leaves growing at high and low light conditions. Dendrochronological data provide little support for the hypothesis that coppicing promotes the establishment of new *S. torminalis* cohorts. Over the past 80 years, continuous recruitment of regeneration occurred. Growth patterns and photosynthesis measurements suggest that *S. torminalis* is an extremely shade tolerant species that is able to survive long periods of intensive competition. We conclude that abandonment of coppicing in these forests does not threaten the status of *S. torminalis*. However, to grow trees to merchantable dimensions in reasonable time, frequent and intensive tending is required.

Forty-two years of stand structure development in a natural sub-boreal forest under selection system in central Hokkaido, Japan. Tatsumi, S., Owari, T., Yamamoto, H., Shiraishi, N. (*The University of Tokyo, Japan; tatsumi@fr.a.u-tokyo.ac.jp; owari@uf.a.u-tokyo.ac.jp; yama@k.a.u-tokyo.ac.jp; siraishi@fr.a.u-tokyo.ac.jp*).

Selection system (single-tree selection) is an uneven-aged silvicultural system, according to which trees are individually and periodically removed from a large area. In Hokkaido, northern Japan, selection system has been used to manage natural forests. To assess the effects of selection system applications on stand structure, we examined the long-term changes in growing stock, tree density, species composition, and diameter class distribution on the forest management scale. A case study was conducted at Tokyo University Forest in Hokkaido, where selection system has been continuously implemented for more than 9,000 ha since 1958. We used a total of 4,433 sample plots (typical size of 0.25 ha) that had been established in selection stands between 1964 and 2005 for the analysis. Results showed that the mean growing stock remained stable, while the mean stem density decreased in stands with intensive management (cutting cycle: 10 years). Small-size class (DBH 5–25 cm) of *Picea jezoensis* trees declined gradually, while the proportion of shade-tolerant broadleaved species (mainly *Tilia japonica*) increased. The results suggest that ensuring a high enough number of succeeding conifers and stimulating the demand for small-sized hardwood timber are indispensable issues for selection forest management in the University Forest.

The negative relationship between volume and tree number in stands of maximum density in the mixed-species and uneven-aged forests of Durango, Mexico. Wehenkel, C., Corral-Rivas, J.J., Solís-Moreno, R. (*Universidad Juárez del Estado de Durango, Mexico; wehenkel@ujed.mx; jcorral@ujed.mx; rsolis@ujed.mx*), Cruz-Cobos, F. (*Instituto Tecnológico de El Salto, Mexico; cobos_cruz@yahoo.com.mx*), Hernández Díaz, J. C. (*Universidad Juárez del Estado de Durango, Mexico; jciroh@ujed.mx*).

The upper limit or maximum density that a site can maintain is reached when all available resources are used by the stock, although each individual tree only gets what is indispensable for survival without the existence of natural mortality. This extreme situation corresponds with the classical definition of "normal forest." The present study investigated the relation between the volume and the number of trees in stands of maximum density in mixed and irregular forests in the forest region of Santiago Papasquiaro, Durango, México. We used a database comprising 15,429 temporary sites.The results of this work point to the existence of a negative relation in the form of an inverted *j,* between the volume with bark and the number of trees in stands of maximum density. The number of trees per hectare as a dependent variable is expressed in up to 88% via the volume with bark per hectare. Owing to various anthropogenic and natural disturbances such as silviculture, cattle farming, and forest fires, this relation has been modified. The results of this study serve as a basis for determining the maximum possible density of a site.

Posters

Selection system as a new silvicultural approach for old-growth forests dominated by *Nothofagus betuloides* in southern Patagonia, Chile. Cruz, G., Promis, A. (*Universidad de Chile; gcruz@uchile.cl; alvaro.promis@gmail.com*).

Naturally old-growth forests dominated by *Nothofagus betuloides* in South Patagonia and Tierra del Fuego are uneven-aged. Since the 19th century this forest type has been selectively logged. Although Chilean Forest Law allows use of the selection system as a silvicultural prescription, only the shelterwood system has been applied in these forests, which has led to a homogenization and structural simplification of the stands. We analyze the application of a first cut into a selection system as a new silvicultural approach in old-growth forests dominated by *N. betuloides* in southern Patagonia. The selection system was applied in a representative stand of approximately 2 ha. Tree density, basal area, and stand volume, before and after the cutting and the status of the regeneration were recorded. The results showed that the sawn wood obtained by the selection system were lower than those by the shelterwood system. However, this system could prevent the negative effects of selective logging and stand effects from larger-scale disturbances on stand that occur with the shelterwood system, which can experience severe wind damage. The system could also maintain biodiversity and thereby enhance sustainable forest use.

Estimation for the growth and allometric relations of beech seedlings under various light environments based on their photosynthetic response. Fujishima, M. (*Gifu University, Japan; o6102005@edu.gifu-u.ac.jp*), Mizunaga, H. (*Shizuoka University, Japan; mizunaga@agr.shizuoka.ac.jp*).

Seedlings of Japanese beech (*Fagus crenata*) are shade tolerant and survive beneath the canopy several years. The allocation of carbon gained may play an important factor for the survival of seedlings under light limited conditions. However the relationships between development of shoots and roots and carbon gain of seedlings under natural forest environments is uncertain. Our objective was to study the allometric relation between shoots and roots and their carbon gain to know the critical light availability for the growth of beech seedlings. We estimated carbon investment in newly produced organs of beech seedlings growing in various light environments through integrating the crown-level carbon gain and allometric relations of the seedlings. The study site is located in a mature beech forest that includes various sized gaps on Naeba Mountain, Japan (altitude 700 m). From center of gaps to beneath canopy, seedlings of various height ranging from 0.1 to 1.5 m were sampled. Light above the seedlings were measured during the growing season (May to October). We present a model for estimating the development of shoot and root structures in beech seedlings under various light conditions.

Natural regeneration of *Pinus densiflora* Sieb. et Zucc. after practicing the seed tree method in Mt. Gariwang, Gangwon Province, Republic of Korea. Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*), Kwon, K.C. (*National Forestry Cooperative Federation, Republic of Korea; kkch30@yahoo.co.kr*), Kim, H.J. (*Seoul National University, Republic of Korea; hjkim0916@gmail.com*).

Natural regeneration of *Pinus densiflora* Sieb. et Zucc. after practicing the seed tree method, which retained seed trees in density of 70 to 80 trees/ha, was investigated in compartment number 163, Mt. Gariwang, Gangwon Province, Republic of Korea. Seedling outputs along the distance from the seed tree and seedling mortality were directly measured Seedling outputs of *P. densiflora* were most abundant 4 m away from the seed tree and declined at further distance. Both seedling outputs and growth increments were higher by weeding. The results investigated on mortality of *P. densiflora* seedlings showed that 1-year-old seedlings almost died due to frost heaving and 30% of 2- to 4-year-old seedlings were damaged by wild herbivores and root snaps due to frost heaving. For a successful natural regeneration of *P. densiflora* by practicing the seed tree method in this area, it is required to practice the reserve-seed tree method with 70 to 80 seed trees remaining per ha. Along with those efforts, also important in this area are: intensive management for rooting during the first 5 to 6 years, efforts to prevent seedlings from predation by herbivorous wildlife, and artificial planting of *P. densiflora* seedlings.

Studying relationships of biodiversity and ecosystem function: a new paradigm for researchers. Liu, Y. (*Beijing Forestry University, China; lyong@bjfu.edu.cn*), Dumroese, R.K. (*U.S. Forest Service, USA.; kdumroese@fs.fed.us*), Li, G.L., Lv, R. H. (*Beijing Forestry University, CHINA; glli226@163.com; lvrh514723@126.com*).

Because loss of biodiversity may negatively affect global ecosystem function and ultimately jeopardize sustainable human development, ecologists have made great efforts to elucidate and understand mechanisms behind the relationships between biodiversity and ecosystem function. Despite advances in observational, experimental, and theoretical studies, debates about these relationship mechanisms are animated. Some of this controversy depends on the researchers' role when carrying out ecological studies, which greatly influences their objectivity when drawing conclusions. Here we present the roles that researchers currently play in ecological studies and how those roles influence experimental results and interpretation. We suggest that researchers need to, firstly, understand their role in ecological studies; secondly, integrate with bottom-up and top-down approaches; and thirdly, perhaps adopt a novel way of engagement as a way to avoid unnecessary controversy and to better meet the biodiversity challenge. By doing so, researchers and administrators should take an adaptive management approach to the forest ecosystem. Only an adaptive approach, just like the evolutionary approach of life, will allow us to confront the challenges of ever-increasing uncertainty caused by human activities.

Distance-independent thinning algorithms for even- and uneven-aged cork oak stands. Paulo, J.A. (*Technical University of Lisbon, Portugal;*), Tomé, M. (*Technical University of Lisbon, Portugal; joanaap@isa.utl.pt*; *magatome@isa.utl.pt*).

Most growth and yield models that consider the thinning operation include algorithms that are dependent on the distance between trees and consequently require the knowledge or simulation of the trees' coordinates. This is true for the existing individual tree growth model for cork oak (SUBER 3.0). The model includes two different thinning regimes: even-aged forestry and continuous cover. Based on a large number of thinning simulations, an alternative model for thinning simulation, distance-independent, was developed. The simulations were made using real data as input (juts plots with a large area were used) and considering thinning regimes for distinct management purposes: cork production under traditional stand density values (sparse stands), cork production under increased stand density, and cork production integrated with grazing activities (agroforestry system). The simulation period varied from 45 to 90 years depending on the initial age/structure of the plots. The probability of a tree to be thinned was modeled with logistic regression using tree and stand variables as well as distance-independent competition indices. The thinning regime was also taken into account through variables expressing the management options. The model obtained was compared with the distance-dependent algorithms and its performance proved to be satisfactory.

Management of man-made forest in selective logging system: a case of the H-forest in Tokusima pref., Japan. Sato, T., Amaki, T. (*Tokyo University of Agriculture., Japan; satota@nodai.ac.jp; 10060010@nodai.ac.jp*), Hashimoto, T. (*Hashimoto Forestry, Japan*), Ueno, Y. (*Tokyo University of Agriculture, Japan; y3ueno@nodai.ac.jp*).

Since natural forest is decreasing around the world, man-made forests have been created and converted to maintain forest area. Objectives of creating man-made forest are mostly production and/or protection. In Japan, to accomplish both aims, multi-story forest or mixed forest has been recommended. However, those silvicultural practices emphasize more the creation of forest but not forest management systems in totality. H-forest in the Tokushima pref. (privately owned area of forest around 100 ha) has been implementing multi-story and mixed species silviclutural management with only family labor, and has been maintaining volume of production and forest stock. The paper focuses on concepts and implementations of the H-forest management system.

The main results show that: (a) the basic concepts of H-forest are forest-oriented: to observe the forest carefully and to find the ability of the trees and efficiency in marketability; (b) for operation facility and efficient management, develop a stable operation road around 300 m per ha; and (c) a long rotation period of more than 60 years is needed to produce high-quality logs and maintain the forest. Concepts of H-forest could be recommended to apply especially where local people are intimately familiar with the forest and its resources.

A comparison of selected soil properties under high and coppice forest in the Vienna Woods. Yan, S., Gerhard, G. (*University of Natural Resources and Applied Life Sciences, Austria; yanshuai111@gmail.com*; *gerhard.glatzel@boku.ac.at*), Viktor, B. (*Commission for Interdisciplinary Ecological Studies of the Austrian Academy of Sciences, Austria; viktor.bruckman@oeaw.ac.at*).

In this study soil properties of a high forest and a coppice forest in the Vienna Woods were compared. Fifteen (15) soil samples were randomly collected from each forest patch on an 80-m-interval grid along the plots by means of a soil core with 70 mm diameter to a maximum soil depth of 60 cm. Soil samples were classified using the FAO-WRB classification system. Each soil profile was divided into ectohumus (O-horizon) as well as vertical geometric mineral soil horizons of 0 to 5, 5 to 10, 10 to 20, 20 to 40, and 40+ cm depths. Dry mass of ectohumus, coarse and fine mineral soil, and roots; soil bulk density; soil pH; total nitrogen; and total and organic carbon of each sample were determined. Statistical analysis revealed differences of ectohumus dry mass, root dry mass, soil bulk density, soil pH, total nitrogen, and total and organic carbon at different soil depths under coppice and high forest. As expected, correlation analysis showed that nitrogen and organic carbon are highly positively correlated in high and coppice forest. Possible reasons are discussed.

Modeling stand-level basal area growth for uneven-aged selection forest in boreal forest: a case in Changbai Mountains, China. Zhao, J., Kang, X., Yang, H. (*Beijing Forestry University, China; Zhao.Junhui@hotmail.com; xingangk@163.com; huayang8747@163.com*), Ning, J. (*Jiangxi Agricultural University, China; Ning.jinkui@gmail.com*), Zheng, L. (*Jindulandscaping, China; hutaojiazi_713@126.com*).

Since there are more natural forests in the world that are mainly uneven-aged forests, the modeling for such a forest type is very critical to make management decisions. The stand-level basal area growth model for uneven-aged selection forest in boreal forest was developed in this study by using longitudinal data from 1974 to 2009. Different competition and site indices were compared and used to calibrate the stand-level basal area growth model. Ordinary least squares (OLS) regression was used to construct the basal area growth model at the beginning. Analytical results indicate that the ratio of basal area for broadleaved tree species and cutting intensity was significant with basal area growth. Additionally, we found that the co-relationship of different measurements at different times for the same plot was significant. The mixed-effect model was then applied to modify the traditional regression model. Analysis of goodness of fit indicates the mixed-effect model could improve precision. By using the calibrated model to predict basal area growth in different cutting strategies, we can conclude that light cutting density at 10–20% by basal area, and cutting cycles from 8–15 years, could generate continuous high basal area growth efficiency.

B-05 Bushmeat in Central Africa: beyond the ecological crisis

Organizer: Nathalie van Vliet, *France, vanvlietnathalie@yahoo.com.*

Bush meat consumption in the Central African Republic. Fargeot, C. (*CIRAD, France; christian.fargeot@cirad.fr*).

In the Central African Republic, wild animals are an important source of protein in human nutrition. Bushmeat trade has become a major element of the informal sector as part of family economy, although diffuse and difficult to quantify. In addition, legislation does not recognise the supply character of this sector for cities and drives it into illegality. This situation (informal, diffuse, and illegal economy) makes it difficult to find a method to identify the economic power of this branch and its impact on wild fauna. Studies conducted in the framework of the PGTCV are based essentially on analysis of household budgets to be able to assess the financial value of consumed bush meat, the share of proteins consumed, and, based on market price, the quantity of biomass consumed. School surveys during which pupils were questioned about the composition of their family meals made it possible to identify a consumer price index based on the number of daily rations containing bush meat, and reduced to the number of rations containing animal proteins. This simple indicator, which is easy to establish and inexpensive, can be integrated into a series of indicators, departing from an index fund of the bush meat sector.

The role of bushmeat and other wildlife products in the local economy: a comparative study from Equatorial Guinea. Kümpel, N.F., Ruffler, H.E. (*Zoological Society of London, UK; noelle.kumpel@zsl.org; hruffler@gmail.com*), Milner-Gulland, E. J. (*Imperial College London, UK; e.j.milner-gulland@imperial.ac.uk*), Rowcliffe, J.M., Cowlishaw, G. (*Zoological Society of London, UK; marcus.rowcliffe@ioz.ac.uk; guy.cowlishaw@ioz.ac.uk*), Allebone-Webb, S.M. (*Wildlife Conservation Society, Cambodia; sallebonewebb@wcs.org*).

In order to ensure the sustainability of bushmeat hunting in Central African forests, we need to understand its position within the wider rural economy. We evaluated wildlife use and dependence within the context of other available livelihoods in Equatorial Guinea, a country currently undergoing a dramatic economic boom. We carried out household surveys and hunter interviews over 12 months in three villages with differing combinations of market and forest access, making comparisons between communities, households and individuals. At community level, better access to markets and traders resulted in higher incomes from hunting as well as from trade and agricultural goods. Within a village, the poorest and most vulnerable households gained a significantly greater proportion of income and production from forest products, largely because of a lack of other livelihoods (particularly trade and paid work). Between individuals, there was a strict gender-divide in all villages, with women practicing agriculture and collecting low-value forest products and men pursuing higher-income livelihoods, including hunting in the absence of preferred paid employment. Bushmeat contributed significant value and income to all communities, suggesting it is an important component of the rural economy across the country. We will discuss the implications for the development of alternative livelihoods.

Sustainability and dynamics of bushmeat trade using market data in Kisangani. Nebesse, C. (*Faculté des Sciences Agronomiques de Kisangani, France; casimirnebessem@yahoo.fr*), Van Vliet, N. (*TRAFFIC, France; vanvlietnathalie@yahoo.com*), Nasi, R. (*Center for International Forestry Research, Indonesia; r.nasi@cgiar.org*).

Bushmeat in Central Africa is consumed in rural areas, in many cases as the only source of protein, but also in cities where consumers continue to buy wild meat for economic, social, or cultural reasons. Urban markets can be used to describe the dynamics of the trade. We monitored bushmeat traded in the market of Kisangani and compared data collected in 2002 and that in 2008. No indication of depletion of larger sized species was observed. This continued supply of larger sized animals does not necessarily indicate sustainability, but is probably explained by the shift in catchment area from Lubutu to Ituri thanks to the end of political conflicts and the improvement of roads. The contribution of large rodents increased compared to 2002 at the expense of small monkeys. The decrease in availability of small diurnal monkeys and bay duikers also translates into a significant increase in carcass prices. Nevertheless, smoked bushmeat remains much cheaper than fresh livestock, and at comparable prices with fresh fish or pork. Most of the bushmeat sold in Kisangani is not a luxury product, and competes with other cheap sources of protein.

Motives for urban wild game players in Central Africa. Randolph, S. (*Stanford University, USA; randolsh@stanford.edu*).

This study investigated the geographic, socio-economic, and cultural motives for urban consumers and traders in the highly politicized Central African wildlife trade. Data were collected from 2008 to 2009 in Yaoundé, the capitol of Cameroon, and along forest trade routes to the city. While kinship ties, social status, and economic status were predicted to be important factors motivating participants in this urban trade, quite distinct patterns emerged between sellers and consumers. Ethnographic and ego-network research in restaurants and markets indicated that elite consumers gained prestige and social alliance benefits as consumers of increasingly rare forest animals. This finding challenges the prevailing notion that urban, poor Africans are the primary consumers and traders of wildlife. Conversely, low-income women constituted the majority of wild meat sellers in the capitol city of Cameroon. The major point of congruence between urban participants, consumers, and sellers was ethnicity and forest tribe affiliation, reflecting the shared cultural valuation of local, non-farmed meat. Further, a point that could shed light on the apparent lack of political will to address this conservation issue in the political capitol, was the high percentage of government employees and law enforcers engaging in this trade.

Empty forests, empty stomachs. Taber, A., Nasi, R. (*Center for International Forestry Research, Indonesia; chacotaber@hotmail.com*; *r.nasi@cgiar.org*), Van Vliet, N. (*France; vanvlietnathalie@yahoo.com*).

Several ungulate species such as duikers, antelopes, deer, pigs, peccaries, and tapirs provide food and economic benefits to local people in the tropics through both subsistence and commercial hunting worth millions of U.S. dollars per year. The vulnerability of these species to human activities is highly variable, with some thriving in secondary habitats while others need large areas of intact primary forest to survive. Similarly, some species are able to withstand hunting while others become locally extinct. These animals are major actors in vegetation dynamics and affect the distribution patterns of plants, as well as the structure of forest ecosystems, through seed dispersal and predation, grazing, browsing, rooting, and other mechanisms. Global attention to their loss to forest ecosystems has been drawn through debates on bush meat and the "empty forest" syndrome, but the impact of their decline on local livelihood systems and their resilience has been largely overlooked and insufficiently addressed. In this talk we will review existing data to assess the local and global cost of the loss or ecological extinction of these species across the tropics to local people and forest ecosystems, including production forests.

B-06 Reporting on sustainability of temperate and boreal forests using criteria and indicators: 1

Organizers: Se Kyung Chong, *Korea Forest Research Institute, Republic of Korea, skchong@forest.go.kr;* Richard Guldin, *U.S. Forest Service, USA, rguldin@fs.fed.us.*

Development of a method for creating a local-level biological diversity map for sustainable forest management. Iehara, T., Sano, M., Okabe, K., Tanaka, H. (*Forestry and Forest Products Research Institute, Japan; iehara@ffpri. affrc.go.jp; masakoto@ffpri.affrc.go.jp; kimikook@ffpri.affrc.go.jp; hirop@ffpri.affrc.go.jp*).

Biological diversity is the top criterion of the Montreal Process, an international framework for sustainable forest management, and so it is essential to consider biological diversity in forest management. Therefore, a useful method for evaluating biological diversity in actual forest management needs to be developed. We developed a method for creating a local-level biological diversity map by using representative taxonomical group species by plotting census data gathered in Ibaraki prefecture, Japan. We counted the number of species by taxonomical group in different types of forest plot. We constructed an index of biological diversity class by integrating the species number for each forest type by principal component analysis. A biological diversity map was made by doing overlay stand-level and basin-level biological diversity class data. We also suggest a method for estimating the future transition of the biological diversity map and for evaluating future trends of biological diversity based on three forest management scenarios. Applying the method to northern Ibaraki, it is shown that changing man-made conifer forests into broadleaf tree forests will increase forests with rich biological diversity, and equalize the distribution of these forests in the area in comparison with other scenarios.

An overview of the national forest inventory of Korea for forest resource monitoring and assessment. Kim, S.H., Yoo, B.O. (*Korea Forest Research Institute, Republic of Korea; shkimfri@forest.go.kr; boyoofri@forest.go.kr*), Shin, M.Y. (*Kookmin University, Republic of Korea; yong@kookmin.ac.kr*).

A new national forest inventory (NFI) has been developed in Korea to meet both internal and international needs for accurate forest resource information. The national forest inventory in Korea began in 1972, and thereafter has been conducted four times

to provide basic information on forest resources for formulating national forest policy. Under the periodic system, forest inventories were conducted on a province-by-province cycle, which caused difficulties in compiling forestry statistics for the whole country because of multi-year inventory data. Furthermore, there has been increasing demand for reliable and timely information on forest resources and ecosystem from international processes and conventions since the late 1990s. From the 5th NFI (2006–2010), the inventory program has been improved, moving from a periodic to an annual inventory system. The new NFI design focuses on assessing and monitoring the extent and state of forest resources in Korea in an accurate and timely manner. The transition has required conceptual and technical changes in the inventory program, and is featured by the following core elements: annual inventory at 5-year intervals, new systematic layout of 4,000 permanent sample plots, new ground plot design, addition of new variables related to forest carbon estimation and biodiversity, collaborative implementing framework, etc.

Forest information and sustainability indicators for serving society's needs. Parviainen, J. (*Finnish Forest Research Institute, Finland; jari.parviainen@metla.fi*).

The present worldwide set of criteria and indicators on sustainable forest management (SFM) has been compiled mainly for the purposes of the forest sector. The demand for forest-related information by various sectors of society has, on the other hand, increased considerably. In particular, the energy sector (with increasing use of wood-based bioenergy), the health sector (using forests as medicinal compounds and therapeutic means), and the construction sector (using wood as an environmentally sound material) require up-to-date forest information for their purposes. In addition there is also increasing need to serve society with forest information in thematic areas such as: climate change, biodiversity conservation, human health, various forest ecosystem services, environmental characteristics, and the manufacturing chain of wooden products. The present SFM indicator sets are not flexible enough to provide the required data. This presentation provides a proposal for how the criteria and indicators could be updated to better serve society's needs. The proposal covers following items: updating quantitative and qualitative indicators in accordance with new demands, overall policies and special policy areas, threshold values, verification issues, and applications on how the criteria and indicators can serve other sectors and thematic areas.

Status and progress in large-scale assessment of biological diversity in the United States. Shifley, S.R., Flather, C.H., Smith, W.B., Riitters, K.H., Sieg, C.H. (*U.S. Forest Service, USA; sshifley@fs.fed.us;cflather@fs.fed.us*; *bsmith12@fs.fed.us;kriitters@fs.fed.us; csieg@fs.fed.us*).

Conservation of biological diversity is one of seven criteria used to evaluate forest sustainability in the United States. The status of biological diversity is characterized by nine indicators that report area, protected status, and fragmentation of forest habitats; number and conservation status of forest-associated species; range and abundance of forest species to describe genetic diversity; and institutional commitments to conserve biodiversity. A long-term, nationwide forest inventory system documents the stability of total forest area with notable shifts in age distributions, species composition, ownership, and management emphasis. Recent mapping of protected forest areas revealed that 14% of forests are protected and function as focal points for biodiversity conservation. Notable advances in the analysis of forest fragmentation have developed internationally consistent methods to quantify land cover and forest fragmentation at multiple spatial scales and indicate that nearly 75% of all forest habitats are within 300 m of an edge. Continued development of species information databases now permit national summaries of occurrence and conservation status of forest-associated vascular plants and most vertebrates–29% of which are presumed extinct or at-risk of extinction. As these databases continue to mature, information on less well-studied species (e.g., forest invertebrates) will be incorporated.

Status and progress in large-scale assessments of the productive capacity of forest ecosystems in the United States. Smith, W.B., Oswalt, S.N. (*U.S. Forest Service, USA; bsmith12@fs.fed.us; soswalt@fs.fed.us*).

Maintenance of the productive capacity of forest ecosystems is one of seven criteria used to evaluate forest sustainability in the United States and other countries that use the Montreal Process Criteria and Indicator framework. Productive capacity is quantified by five indicators: area of forest available for timber production and nonwood forest products, growing stock volume and increment, area and volume in planted forests, timber harvest, and harvest of nonwood forest products. For more than 50 years, the United States has used a nationwide forest inventory system to document the status of and temporal trends in regional forest distribution, volume, composition, ownership, and management or use. In the past, these measures were monitored using periodically implemented state-level inventories. Recently, the United States changed its approach from periodic assessment to an annual assessment to provide current and consistent data at the national and sub-national levels. In this paper, we compare historical inventory and reporting processes with current inventory and reporting processes, discuss the advantages and disadvantages of annual reporting systems, showcase highlights from the most recent report on sustainable forests, and present gaps in our current knowledge.

Assessing the carbon stocks and fluxes for United States forest ecosystems and products. Woodall, C.W., Skog, K.E., Heath, L.S., Perry, C.H. (*U.S. Forest Service, USA; cwoodall@fs.fed.us; kskog@fs.fed.us; lsheath@fs.fed.us; chperry@fs.fed.us*).

National-scale estimates of forest ecosystem carbon pools and fluxes are crucial to comprehensive carbon cycle accounting. In the United States, forest ecosystem and product carbon (C) fluxes provide one of the largest offsets of annual greenhouse gas emissions. Current estimates of forest ecosystem and product pools and fluxes for the U.S. were developed by the U.S. Department of Agriculture, Forest Service, under the framework of the Montreal Process Working Group on Criteria and Indicators, to evaluate the sustainability of forest ecosystem processes that mitigate greenhouse gas emissions. Results of this national assessment indicate that forest ecosystem C pools still provide one of the largest offsets of greenhouse gas emissions. However, in the context of national-scale forest health issues such as fire, land-use change, and invasive species, the direction of C fluxes in the future is in question. Given the diversity of forest ecosystems across the nation, the allocation of C to various forest components is highly variable, thus increasing the complexity of C sequestration activities. In light of possible climate change effects, trends in national-scale forest ecosystem C pools and fluxes may contain even greater uncertainty into the future.

Posters

The adaptability of rough set analysis for clarifying the criteria for selecting to build strip roads. Inomata, Y., Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; ino@fe.rn.tuat.ac.jp; iwaoka@cc.tuat.ac.jp*).

A forest roads network is necessary for sustainable forest management. Strip roads are sometimes constructed instead of forest roads to establish the road network, as it is expensive to construct forest roads in Japan because many of forests are on steep slopes. Strip roads are constructed at carefully selected place for lower construction and maintenance costs. This selection is usually based on empirical knowledge. The purpose of this study is to clarify the criteria for selection with empirical knowledge. For this purpose, rough set analysis is introduced and discussed to be usable or not. Seven topographical factors—slope, vertical profile of the slope, horizontal profile of the slope, slope of lower hill, presences of talus cone, presence of zore-order valley, and presence of past slope collapses—are used for rough set analysis. As a result, about 60% of the selection can be explained with those factors. Four topographical factors—slope, vertical profile of the slope, horizontal profile of the slope, and slope of lower hill—are the most important to explain the selection, followed by two other factors, the presences of talus cone and zore-order valley.

Local-level indicators for monitoring sustainable forest management in the Jeju Experimental Forest, Warm-Temperate Forest Research Center, Korea. Kim, C.M., Chung, Y.G., Park, C.Y., Kim, D.H., Byun, K.O., Lee, S.G. (*Korea Forest Research Institute, Republic of Korea; helmin@forest.go.kr; ygchung99@forest.go.kr; park@forest.go.kr; dhkim1973@gmail.com; Bn1212@forest.go.kr; sulee@forest.go.kr*).

In 2002, the Warm-Temperate Forest Research Center secured 2,741 hectares of forest land on mountainside of Mt. Halla in Jeju Islands, Korea, to be used as an experimental forest for the Korea Forest Research Institute. The management objective in the Jeju Experimental Forest is to realize sustainable forest management(SFM) at the local level and set a model forest in the warm-temperate forest region. The forest was entirely inventoried during 2004 and 2005 and the 1st 10-year SFM Plan was established. The forest consists of evergreen and deciduous broadleaved forests, with some Japanese cedar plantations. As a whole, 99 families/373 species of plants, 14 species of mammals, and 80 species of birds are reported to be present in the forest. In March 2006, we became Korea's first forest to receive Forest Stewardship Council (FSC) certification, evidence that the Jeju Experimental Forest is being managed sustainably. For monitoring and assessing the influence of many components of SFM at the ground level, we developed 47 indicators on 7 criteria which could be applicable in the Jeju Experimental Forests. These indicators are inventoried and monitored yearly and/or periodically to observe the status and changes of ecological and socio-economic sustainabilities of the forest.

Biosoil project: forest biodiversity indicators in Spain. Minaya, M., Cabanillas, G. (*INIA-CIFOR, Spain; minaya@inia.es; cabanillas@inia.es*), Sanchez, G. (*DGMNyPF, Spain; GSanchez@mma.es*), Grau, J.M. (*INIA-CIFOR, Spain; grau@inia.es*).

The Biosoil Project is an European action launched with the aim to assess and describe forest soil and biodiversity at a pan-European scale under uniform and comparable parameters. The project runs on the European level I grid of the International Cooperative Program on Forests (ICP-Forests). For the biodiversity package, several simple parameters measurable at international scale were chosen to assess soil and biodiversity in a joint and homogeneous way. The basis of the study is the forest structure, assuming that increments of complexity and growth of biodiversity are linked. Basic indices are DBH (diameter breast height), richness of the forest flora, and number of standing and falling trees, alive or dead. Deadwood is measured and accounted, taking into account size of the elements and degradation level. The main features of the canopy form are also pointed out, including crown cover and different levels of vegetal strata. Along with those structural parameters, an in-depth inventory of vascular flora is done thorough time. Data collection on the forest has been developed at the European scale between 2006 and 2007, covering more than 4,000 plots around Europe, 620 of which are in Spain.

Assessment of forest cover dynamics for State Forest Enterprise in Vietnam by using GIS and remote sensing. Nguyen, N.Q., Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; ngocquang_272@yahoo.co.n; iwaoka@cc.tuat.ac.jp*).

The purpose of this research is to clarify and analyze the variability of forest cover in Vietnam with the objective of protecting natural resources and prevent the damaging effects of climate change. For this purpose, Truong Son State Forest Enterprise (SFE) in Quang Binh province of Vietnam was selected to be research area. This area is contiguous with Phong Nha – Ke Bang National Park and the national boundary with Laos PR. Many ongoing activities in the region affect forest resources both negatively and positively. The changes of forest cover in Truong Son SFE during the two sub-periods from 1989–1999 and from 1999–2009 were assessed using GIS to identify and analyze forest cover changes, and to analyze the effectiveness of economic function to the demand of timber production. Three change detection methods were used: post-classification, NDVI image differencing, and multi logistic regressions. This study can be divided into two parts. The first was to create forest cover change maps during the period 1989–1999–2009; the second to identify relationships between economic function and social function and their impact on sustainable forest management. The results of this research will be use to help improve sustainable forest management planning.

B-07 Reporting on sustainability of temperate and boreal forests using criteria and indicators: 2

Organizers: Takeshi Goto, *Forestry Agency, Ministry of Agriculture, Forestry and Fisheries, Japan, takeshi_goto@nm.maff,go.jp*; Richard Guldin, *U.S. Forest Service, USA, rguldin@fs.fed.us.*

Localizing the Montreal Process criteria and indicators for local-level forest planning of cool temperate forest landscapes in north Ibaraki Prefecture, Japan. Mitsuda, Y., Ihehara, T., Matsumoto, M. (*Forestry and Forest Products Research Institute, Japan; mitsuda@ffpri.affrc.go.jp; iehra@ffpri.affrc.go.jp; machan@ffpri.affrc.go.jp*).

The member countries of the Montreal Process have been developing criteria and indicators for the conservation and sustainable management of temperate and boreal forests. These criteria and indicators are designed for assessing forest trends and progress toward a sustainable scale at the national level. On the other hand, the issue of how to use the Montreal Process criteria and indicators for local forest management practices has arisen. We show a way to localize the Montreal Process criteria and indicators by developing a forest planning system for local-level forest management. This study covers a cool temperate forest landscape in the north of Ibaraki Prefecture, Japan. We selected two criteria: conservation of biological diversity (criterion 1) and maintenance of productive capacity of forest ecosystems (criterion 2), and then developed indicators: a potential habitat suitability model for *Fagus crenata* forest for criterion 1 and a potential forest productivity model for *Cryptomeria japonica* planted forest for criterion 2. Using these models, we developed a forest planning system to balance timber production with the maintenance of various forest types within the target landscape.

Enhancing our view of sustainable forest management–reviewing the Montréal Process criteria and indicators. Payn, T.W., Barnard, T.D. (*SCION/New Zealand Forest Research Institute, New Zealand; tim.payn@scionresearch.com; tim.barnard@scionresearch.com*), Bridge, S. (*Natural Resources Canada, Canada; sbridge@nrcan.gc.ca*).

The Montreal Process Working Group first developed criteria and indicators for sustainable forest management in the mid 1990s. The seven criteria give a comprehensive view of all components of sustainable forest management (SFM) and are underpinned by 67 individual indicators. Since the C&I were developed, our understanding of SFM has improved. In 2005–2008, the Working Group undertook a review of the indicators. We focussed on the scope and coverage of the indicators, the need for new indicators (to reflect changed understanding), rationales and approaches to indicator measurement, and clarity and simplicity of indicators. The review confirmed the robust nature of the original C&I framework, added new indicators in the area of ecosystem services, avoided emissions through use of bioenergy, and emphasized the importance of forests to people. Some indicators were deleted or merged with others, resulting in a set of 54 indicators that will be used in the 2013 reporting cycle. Overall, the revised indicators build on the strong foundations of the original C&I and provide a clearer, more comprehensive, simple, and easy-to-apply set of indicators that reflect developments in the area of SFM and are a logical evolution for the Montreal Process.

Evaluating the sustainability of socio-economic benefits from forests for the United States using the Montreal criterion 6 indicators. Skog, K.E., Alexander, S., Cordell, K., Emery, M., Howard, J.L., LaPlante, S., Mercer, E. (*U.S. Forest Service, USA; kskog@fs.fed.us; salexander@fs.fed.us; kcordell@fs.fed.us; memery@fs.fed.us; jlhoward@fs.fed.us; slaplante@fs.fed.us; emercer@fs.fed.us*), McDonough, M. (*Michigan State University, USA; mcdono10@msu.edu*), Magis, K. (*Portland State University, USA; kmagis@aol.com*).

To what degree, and how, can we use national level and regional level data on the Montreal criterion 6 indicators to assess if we are sustaining socio-economic benefits for the United States from forests? We respond to this question by answering three subsidiary questions. First, what is a realistic goal for evaluating sustainability using the indicators? Among several goals we suggest a realistic goal is to assess position and progress toward sustaining socioeconomic benefits. Second, how do we organize the 20 indicators and scores of measures within indicators to clarify position and progress? We suggest the indicators primarily provide data on (1) recent levels and (2) recent trends on measures of (a) capacity to provide benefits and (b) amount of benefits provided. Third, what do data on levels and trends tell us about our position and progress? We find that a relatively small proportion of the measures of levels or trends may be judged as adverse to sustaining benefits. But individual adverse levels or trends may be quite important, and there are about third of the measures where information is not yet available or we cannot easily judge if the level or trend is adverse to sustaining benefits.

Posters

Evaluation of data quality in Japanese national forest inventory. Kitahara, F., Mizoue, N., Yoshida, S. (*Kyushu University, Japan; bunsho@ffp.kyushu-u.ac.jp; mizoue@ffp.kyushu-u.ac.jp*; *syoshida@ffp.kyushu-u.ac.jp*).

We evaluated the quality of data being collected for the Japanese National Forest Inventory (NFI). Currently data from NFIs is expected to satisfy not only national but also international requirements arising from international initiatives such as the Montreal Process. The inventory program commenced in 1999 but has not incorporated a quality assurance program; we sought to determine what effect this was having on the quality of data being collected. Forty-eight plots in four prefectures were measured by operational field teams and then re-measured by a control team. The paired data were evaluated, including diameter, total height, tree count, species richness, and topographic condition. Compared to the control team, all field teams of each prefecture tended to significantly underestimate all the continuous variables. Most variables had larger variability in the inventory data than has been reported in the published literature. The findings of consistent bias and large variation in the field team measurements call for urgent implementation of a quality assurance (QA) program (extensive field training and regular re-measurement) in the Japanese NFI to improve data quality, and this conclusion could be applied to the inventory system of any country that does not include a QA program.

Study the effects of tourist activities on species composition and diversity of plant community of Mount Tai. Li, C.R. (*Shandong Agricultural University, China; chrli@sdau.edu.cn*).

In 1987, Mount Tai was listed as a Cultural and Natural World Heritage site and was honored as a "World Geopark" in 2006; it is a state "top 10" tourist attraction in China. By using richness, evenness, and diversity indices, we studied changes in tendency and regularity of plant diversity (four communities) along the main tourist travel path of Mount Tai. Results included: (1) Tourist activities caused decline of the species richness of the communities. (2) Due to frequent trampling from tourists, some intolerant indigenous species such as *Amphicarpaea edgeworthii*, *Humulus scandens,* etc., disappeared, while some resistant species as well as some androphile synarthropic species such as *Plantago asiatica*, *Polygonum aviculare*, *Setaria viridis,* enhanced their functions and status. (3) The impact on biodiversity by tourists was different under different disturbance intensities; further, ANOVA

analysis showed that the effect of tourist disturbance on biodiversity of tree and shrub layers was not significant, but effect on the herb layer was significant($p < 0.05$). (4) Tourist disturbance caused a reduction in the number, quantity, and frequency of regeneration species.

Analysis of a forest sustainability index in Korea. Park, D.K., Kim, K.D., Joo, R.W., Lee, S.Y. (*Korea Forest Research Institute, Republic of Korea; pdk5920@forest.go.kr; kidong100@hanmail.net; joorw@forest.go.kr; leeferas@forest.go.kr*).

International society has tried to develop a tool to monitor, assess, and report forest trends and sustainability at national and global levels. The Montreal Process ended up with seven criteria and 54 indicators for implementation of sustainable forest management (SFM) by member countries. It was recommended that a forest sustainability index (FSI), which consists of three categories (forest health and visibility, forest economic viability, and social and environmental benefits), can assist national and local governments in making data-driven planning, better programs, and improved program decisions for SFM. The objective of this study is to develop an FSI for Korea, to determine the SFM status of Korean forest sustainability. To do so, 377 forestry experts in the fields of education, research, and administration were surveyed to examine priorities among categories and among indicators under categories. Based on results of the survey, a weighted assignment was done through pair-wise comparison against each indicator. It was found that FSI at the national level increases from 100 in 2000 to 139 in 2007, with an average annual increase 4.82%, increasing in all years except in 2001 due to declines in forest health and economic index.

B-08 Conservation of arthropods on forested landscapes

Organizer: John Spence, *University of Alberta, Canada, john.spence@ualberta.ca.*

Contribution of microarthropods on leaf litter decomposition of three dominant tree species in the Phayeng sub-tropical forest ecosystem, Manipur. Binoy Singh, T., Sunanda Devi, K. (*Manipur University, India; binoy_th2007@yahoo.co.in; mabem_cha@yahoo.co.in*).

Leaf litter decomposition rates and the contribution of microarthropods to the leaf litter decomposition process were studied at two different elevational plots of a mixed-oak sub-tropical forest ecosystem of Manipur, northeastern India. In the litter bag experiments, mass losses from litterbags and colonization of microarthropods in the decomposing leaf litter of three litter species (*Lithocarpus dealbata*, *Quercus serrata* and *Castanea sativa*) were measured and analysed for different seasons. Leaf litter decomposition rates and colonization of microarthropods in the decomposing leaf litter exhibited peak values during the rainy season in both the elevational plots. Decomposition rates and the population of microarthropods were found to be more at the lower elevation. The rate of decomposition and the colonization of microarthropods show their maximum in the leaf litter of *L. dealbata* in both the plots. Oribatid mites are the most diverse and abundant of the microarthropod groups in the three different forest litter groups. There were significant positive correlation of the decomposition rates and the microarthropod population with certain abiotic factors such as litter moisture and rainfall. Acarina and collembolans also showed a significant correlation with litter moisture and rainfall in both the plots during the investigation period.

Effects of reserve patches on saproxylic beetles in boreal white spruce stands. Lee, S.I., Spence, J.R. (*University of Alberta, Canada; seungil.lee@ualberta.ca; john.spence@ales.ualberta.ca*), Langor, D.W. (*Canadian Forest Service, Canada; dlangor@nrcan.gc.ca*).

Saproxylic beetles (i.e., beetles that depend on dead or dying wood during some part of their life cycle) are a diverse group of organisms that are well-known to be threatened by traditional forestry activities. Furthermore, saproxylic beetles play important trophic and nutrient cycling roles in forest ecosystems as bark- and wood-feeders, fungivores, predators, and scavengers. We compared saproxylic beetle assemblages among two sizes of aggregated retention patches (0.20 and 0.46 ha) within backgrounds of different harvest intensity at the EMEND (Ecosystem Management Emulating Natural Disturbance) research site. Window traps were deployed on girdled trees, snags, and live trees in the reserve patches and the surrounding matrix. Emergence traps were also placed on downed wood of two decay classes (DC 2 and DC 4) in the same patches. We found 2,873 beetles representing 31 families and 112 species in traps in the first year. Curculionidae was the most abundant family, comprising 88.1% of the total abundance. This study provides information about the role of retention patch size for maintaining diverse saproxylic beetle assemblages, in view of both edge and matrix effects.

Spiders, beetles, and moths in exotic plantations and native woodlands: indicators of forest biodiversity at stand and landscape scales. Oxbrough, A. (*University of Alberta, Canada; a.oxbrough@ucc.ie*), French, V. (*Charles Darwin University, Australia; veronica.french@cdu.edu.au*), Irwin, S., Kelly, T., O'Halloran, J. (*University College/Cork, Ireland; s.irwin@ucc.ie; t.kelly@ucc.ie; j.ohalloran@ucc.ie*).

Plantation forests constitute a large proportion of the forest estate in many countries. However, their potential to support a diverse flora and fauna, particularly specialised forest species, has yet to be fully evaluated. Invertebrates are an important component of forest biodiversity with varying roles in the food web as detritivores, herbivores, predators, and prey. We sampled spiders and carabid beetles using pitfall traps and moths with light traps in mixed and single species plantations and native woodlands in Ireland, with the aim of comparing invertebrate diversity among forest types and identifying characteristics—including stand structure, soil attributes, plant richness, and forest cover—that might act as indicators of diversity. The relationship between invertebrates and environmental characteristics at several spatial scales was examined using generalised linear modelling. Species composition and richness differed between the plantations and native woodlands. At the stand scale, invertebrates were related to litter and vegetation cover and forest type, and at the landscape scale to forest cover. These findings indicate that forest policy aimed at promotion of biodiversity in plantations should support greater diversity of stand structure and tree species composition. This would encourage variation in litter and vegetation layers, which are important determinants of invertebrate diversity.

Occurrence of trees important to biodiversity in urban areas. Peuhu, E. (*University of Helsinki, Finland; elina.peuhu@helsinki.fi*), Siitonen, J. (*Finnish Forest Research Institute, Finland; juha.siitonen@metla.fi*).

In managed forests, preservation of biodiversity has become a widely acknowledged issue. However, more and more forests and green areas are located in urban areas due to the expansion of settlement. Thus it has become more important to conserve biodiversity also in urban areas. In many countries old and hollow deciduous trees exist nowadays mainly on urban and semiurban areas. Hollow deciduous trees provide a diverse habitat, in which many insect, fungi and lichen species are specialised. For many saproxylic insects the size of a tree hollow is a very important characteristic. In a survey of six parks in the Helsinki metropolitan area of Finland, we surveyed the number and condition of all deciduous trees with a minimum diameter of 30 cm. Also the location of the trees was mapped to allow monitoring in the future. Of the 1,292 surveyed trees, about 6% were hollow. We studied which characteristics were the most important for the formation of hollows. Results will give an overview of the situation in Finnish parks and information on the most important tree species and tree characteristics to biodiversity. This way, conservation efforts can be focused more efficiently on significant trees.

Termite biodiversity in tropical savannas: comparing gallery forest versus *Hevea* plantations in Llanos Orientales of Colombia. Pinzon, O., Hernandez, A.,Malagon, L. (*Universidad Distrital Francisco Jose de Caldas, Columbia; opatriciap@udistrital.edu.co; anamforestal@gmail.com*).

The Llanos Orientales of Colombia belong to the tropical macrosystem known as "tropical savannas". Sustainability of crop production, agroforestry and forestry uses of this ecosystem relies on understanding soil functioning, as well as soil susceptibility to changes in use and soil quality. Previous studies in this ecosystem reported the predominance of earthworms, termites and ants in its soil biomass. While earthworm diversity, function and susceptibility of populations to changes in soil uses have been studied, the ecology of termites is poorly known. Using modified transects of 100 × 2 m, we compared termite biodiversity occurring in soil, trees and dead wood in a gallery forest and forest plantations (*Hevea brasiliensis*) of different ages. Fifteen termite species were found in gallery forest while eight species were found in *Hevea* plantations. Results highlight the importance of gallery forest of a well drained area of the Llanos Orientales of Colombia for conservation of a relative higher termitofauna when compared with rubber plantations. In addition, our results suggest rubber plantations may have more diverse termitofauna than other soil uses such as pastures and crops.

Identifying ecological indicator species: a study of a ground beetle assemblage in a managed forest. Shibuya, S., Kubota, K., Ohsawa, M., Kikvidze, Z. (*University of Tokyo, Japan; sshibuya@nenv.k.u-tokyo.ac.jp; kohei@fr.a.u-tokyo.ac.jp; MLA40530@nifty.com; zaal@k.u-tokyo.ac.jp*).

Identifying species that are especially sensitive to environmental changes is important for monitoring ecosystems. Here we present a case study for identifying such sensitive species, with the example of a ground beetle assemblage (Coleoptera: Carabidae) in a managed forest. The procedure consisted of describing the environment and sampling ground beetles, using canonical correspondence analysis (CCA) for ordination, and examining the relationship between the abundance of a species and its position on the CCA diagram (distance from the centroid). For the latter step we used non-linear regression analysis with subsequent residual analysis. We described microhabitats with nine basic environmental variables; CCA revealed clear differentiation of 16 major ground beetle species across microhabitats. In general, abundant species tended to be closer to the center of the CCA diagram and less abundant species departed from the centroid. However, residual analysis found two outlier species more distant from the centroid than expected. We suggest that these two outliers are more sensitive to environmental changes than other species, and thus potentially useful for ecological monitoring of the given forest. The presented analytical approach can be applied to other animal assemblages dwelling in forests**.**

Colonization sequence and co-variation between species of saproxylic beetles and fungi during 15 years on high spruce stumps. Weslien, J. (*Skogforsk, Sweden; jan.weslien@skogforsk.se*), Schroeder, L.M. (*SLU, Sweden; martin.Schroeder@ekol.slu.se*), Djupström, L.B., Widenfalk, O. (*Skogforsk, Sweden; line.djupstrom@skogforsk.se; olof.widenfalk@skogforsk.se*).

Co-variation between insect species and between insects and fungi during wood decomposition, a process that may last for decades, is not well-studied. It is unclear to what extent early colonizing species in the sequence of wood decay influence what species that colonize and develop in the later stages. The first species to colonize a newly dead tree are beetles that feed on the nutrient rich phloem (e.g., Scolytidade and Cerambycidae). Certain fungus species are also early colonizers and many are vectored by insects. Fungus mycelium is also believed to be an important food source for many insect species. In this study we followed the colonization and development of fungi and insects on experimentally cut high stumps of spruce during a time span of 15 years. We found that some common bark beetles and wood borers that colonized the wood during the first and second year after cutting had substantial impact on later successions. This included the occurrence of one threatened beetle species that was found 10–15 years after cutting in every third stump. Better understanding of the mechanisms and processes involved during wood decay may be important for designing cost-effective and species directed conservation programs.

Posters

Moth biodiversity on three forest types of Mt. Jiri-san National Park, Korea. An, J.S. (*Mokpo National University, Republic of Korea; naneon@nate.com*), Park, M. (*Seoul National University, Republic of Korea; akfksk@nate.com*), Choi, S.W. (*Mokpo National University, Republic of Korea; choisw@mokpo.ac.kr*).

We investigated the moth fauna and monthly changes of moth populations in Mt. Jiri-san National Park, South Korea, at three plant community sites (*Pinus densiflora, Quercus mongolica, Abies koreana*). Moths were caught by using a 22-watt portable ultraviolet light trap from May to October, 2007–2009. A total of 554 species and 8,819 individuals in 18 families were identified. Species of Noctuidae were the most abundant with 258 species and 3,385 individuals, followed by Geometridae (165 species and 3,534 individuals) and Notodontidae (35 species and 546 individuals), respectively. In each plant community site, moth species richness was the highest at the *P. densiflora* community site (349 species and 2,394 individuals) while moth abundance was the highest at the *A. koreana* community site (263 species and 3,446 individuals). Comparing dominant species in

each sites, the *P. densiflora* plant community site was dominated by a conifer-feeding geometrid, *Heterothera postalbida* (207 individuals), and *Q. mongolica* and *A. koreana* plant community sites were dominated by a detritivore, *Hydrillodes morosa* (*Q. mongolica* 873 individuals, *A. koreana* 589 individuals). The monthly changes of species and individuals showed a similar pattern, with the highest peak at June.

Comparison of flying beetle (Coleoptera) assemblages between managed and unmanaged red-pine forests in Suzu, Noto Peninsula, Japan. Barsulo, C.Y., Nakamura, K. (*Kanazawa University, Japan; chriswebyan@gmail.com; koji@kenroku.kanazawa-u.ac.jp*).

Flying beetles were collected monthly from May to October 2009 using flight interception window traps at canopy and ground levels from three red-pine (*Pinus densiflora* Sieb. et Zucc.) forest sites, each of which consists of one "managed" and one "unmanaged" plot with size around 0.5–0.6 ha. In the managed plot, most of the vegetation except the pine trees were removed with forest bed raking for mushroom cultivation once a year (September or October). The results were: (1) a total of 2,957 beetles belonging to 52 families and 201 species were collected; (2) number of individuals and species of the beetles peaked in May and then largely decreased in June, followed by slight increase in July or August and then decreased to a low level until October at both layers in all sites; (3) unmanaged plots showed higher numbers of individuals and species than managed ones, and the degrees of difference varied among the sites; (4) similarity of beetle species composition between canopy and ground samples was high in one site but low in two other sites.

Landscape-wide recruitment of a threatened saproxylic beetle: the significance of wood retention on clear cuts. Djupström, L.B. (*Skogforsk, Sweden; line.djupstrom@skogforsk.se*), Schroeder, L.M. (*SLU, Sweden; martin.Schroeder@ekol.slu.se*), Weslien, J. (*Skogforsk, Sweden; jan.weslien@skogforsk.se*).

The frequency of exit holes by the threatened saproxylic beetle *Peltis grossa* (Trogostidae) was inventoried in a boreal landscape. The preferred breeding substrate for this species is brown rotted standing trees. Very few such suitable trees were found in mature forest stands in the relatively intensely managed landscape. The characteristic exit holes were found only tree stems left on clear cuts and the most important source for breeding was mechanically created high stumps. Such stumps are routinely cut during logging in Sweden with the aim of enhancing biodiversity. The study shows that ecological engineering can be important for species conservation in managed forests.

The effects of forest fire intensity on the community structure of litter-dwelling arthropods (spiders and carabid beetles). Kwon, T.S. (*Korea Forest Research Institute, Republic of Korea; insectcom@korea.kr*), Park, Y.K. (*Korea Beneficial Insects Laboratory, Republic of Korea; entomo@kbil.co.kr*), Park, Y.S. (*Kyung Hee University, Republic of Korea;* parkys@khu.ac.kr), Lim, J.H. (*Korea Forest Research Institute, Republic of Korea; forefire@korea.kr*), Yi, H.J., Kim, H.J. (*Seoul Women's University, Republic of Korea; yih@swu.ac.kr; tree1515@swu.ac.kr*).

We collected litter-dwelling predatory arthropods (spiders and carabid beetles) by using pitfall traps at four different fire intensity areas (control, ground fire, canopy fire, and canopy fire with plantation) in Korea in 2005. Our objective was to verify if there was any difference between burned areas and non burned areas, and between canopy fires with plantation and without plantation. From our arthropod community structures, we found there was distinct community composition difference between burned and non-burned areas as well as between control and canopy fire treatment with plantation or non-plantation. However, we are not sure yet that there was any distinct difference between control and ground-fire treatments. Our results from the multivariate analysis, non-parametric multidimensional scaling ordination, could be relatively interpreted that the main difference in arthropod community between burned and non-burned areas and canopy fire with plantation or non-plantation was caused from the difference of arthropod habitat pattern such as litter depth, litter volume, coarse woody debris (CWD) cover, or CWD volume. When we compared control to other treatments, we could also conclude that the canopy fire treatment with non-plantation was relatively closed to control than the canopy fire treatment with plantation.

Indicators of coleopteran diversity in forests: a study using flight interception traps in the central mountainous region of Japan. Ohsawa, M. (*Yamanashi Forest Research Institute, Japan; oosawa-ujk@pref.yamanashi.lg.jp*).

The conservation of biodiversity is an important goal of most forest management efforts, and proper monitoring of biodiversity requires immediate attention. Coleoptera, the largest order of organisms on Earth, should be monitored as a crucial part of overall biodiversity. However, the total number of Coleopteran species is overwhelmingly large. To facilitate monitoring of Coleopteran diversity, indicators at the family level that adequately represent the beetle diversity were investigated. Beetles were captured by Malaise traps in various forests in the central mountainous region of Japan. Judging from correlation coefficients for species richness and similarity in composition between each family and all families combined, three beetle families were determined to be good surrogates for Coleopteran diversity. All significant pairwise correlations between each of these three families and other Coleopteran families were positive, indicating that each was appropriate as a competent surrogate. Other types of flight interception traps also showed similar results. Thus, this study identified adequate diversity indicators in Coleoptera among beetles that can be caught by flight interception traps. The accumulation of data on indicators obtained through different methods or in different climates is necessary to ensure the selection of widely applicable indicator families.

B-09 Scientific theory and practical realities in sustainable forestry

Organizer: Jamie Barbour, *U.S. Forest Service, USA, jbarbour01@fs.fed.us.*

Defining and implementing sustainable management in forests. Barbour, R.J. (*U.S. Forest Service, USA; jbarbour01@fs.fed.us*).

The concept of sustainable forest management seems straightforward: balance social, ecological and economic outputs from a landscape without diminishing the opportunities for future generations. But what does this actually mean? Managers and policy

makers face complex questions with uncertain answers about which approach or mix of approaches will result in the outcomes society wants. Who decides when the balance is reached? What are the appropriate production functions for estimating outputs from a landscape? What are the rights of landowners and other interest groups? Are zoned forests where management is primarily for single purposes such as timber production or the conservation of biological diversity more effective than integrated landscape management that mixes ecological, social, and economic outputs from a single area through space and time? What are effective ways to protect sensitive long-lived ecosystems in the face of shifting socio-political conditions, natural disturbances, or climate change? This presentation will examine these questions to set the stage for the oral and poster presentations that will follow and address the integration of theory and practice in sustainable management of forests around the world.

Great apes and logging: recommendations for viable coexistence of the timber trade and biodiversity conservation. Belokurov, A. (*WWF International, Switzerland; abelokurov@wwfint.org*), Steindlegger, G. (*WWF International, Austria; gerald.steindlegger@wwf.at*).

All species of great apes are (critically) endangered. Their existence depends on the conservation of tropical rainforests. In the Congo Basin, only 10–15% of the area inhabited by chimpanzees, bonobos, and gorillas is legally protected as national parks or nature reserves. The figure for Southeast Asian orangutan habitats is about 20%. The non-protected forest area (up to 90%) is often leased as large forest concessions. As many great apes dwell in concessions, their existence depends on how well they can survive there. Selective logging and responsible forest management in compliance with the requirements of certification under the Forest Stewardship Council (FSC) avoids undesirable side effects. Independent auditors monitor that illegal logging and poaching are controlled, fruit trees important for the apes are spared, and no logging is conducted in high conservation value areas. Western gorillas in the Congo Basin and orangutans in Borneo can be found in high densities in FSC-certified concessions. African chimpanzees and Sumatran orangutans appear to tolerate selectively logged concessions with low hunting pressure. Well-planned landscapes consisting of a mosaic of protected areas and responsibly managed forests can create the large areas necessary to hold viable populations of apes.

An integrated approach to evaluate and design biodiversity management strategies and forest ecosystem services. Luque, S. (*Institute for Agricultural and Environmental Engineering Research/CEMAGREF, France; Sandra.Luque@cemagref.grenoble.fr*).

The present loss of species and genetic diversity decreases the resilience of ecosystems, while at the same time ecosystems experience growing pressures from drivers such as climate change and land use change. The challenge is to translate these threats to biodiversity into tangible and quantifiable factors that can be used by policymakers to promote the development of flexible and effective conservation strategies. Increasing knowledge and awareness of the goods and services provided by ecosystems, and the importance of conserving them for maintaining our own quality of life, aims to address this challenge. There is a need to develop quantitative measures of biodiversity and ecosystem goods and services, in order to achieve sustainable use of forest resources as we propose. Traditionally, commercial forests are managed to maximize timber output. Our recent work suggests a methodology for integrating economic efficiency and biodiversity value. An integrated approach in forest conservation could provide environmental managers with considerable cost savings while increasing biodiversity protection. Landscape ecology proposes a comprehensive and integrative approach from the plot level to the landscape level, considering forest adaptive management and an analysis of ecological thresholds.

Biodiversity conservation incentive programs for European and American forest owners. Tikka, P.M. (*Maj and Tor Nessling Foundation, Finland; paivi.tikka@nessling.fi*), Mayer, A.L. (*Michigan Technological University, USA; almayer@mtu.edu*).

Conservation of forest biodiversity is challenging in such areas where public forests are mixed with a mosaic of private forests with several owners. Statutory protection measures and restrictions of economic forest use are often inadequate to prevent loss of habitat and encourage forest owners to manage areas for biodiversity. Therefore, different incentive programs for sustainable forest management and biodiversity protection have been implemented for private forest owners. We have studied a sample of voluntary incentive programs for private forests in Europe and North America and evaluated the success of these programs with respect to their specific goals and the ecological status of the forests in the country or state in question. We conclude that an allowance for some economic management of enrolled forests, a long period since time of program inception, and little overlap with other incentive programs are likely to improve the success of a program. Even though the design of an incentive program must be based on valid economic and ecological theories, the success of a program is also founded on its acceptability to landowners and ecosystem-specific objectives adapted to local conditions.

The forest concession model in Venezuelan Guayana: lessons learned and the way forward for sustainable management. Vilanova, E., Ramírez-Angulo, H., Ramírez, G., Torres-Lezama, A. (*Institute for Forest Research and Development, Venezuela; vilanova@ula.ve; rhirma@ula.ve; ragustavo@ula.ve; torres@ula.ve*).

Venezuela is one of the countries having made long continuous effort towards natural forest management (NFM) under long-term concession tracts in tropical America. However, after more than 30 years of NFM, of a total area of 16 million ha assigned to national production forests, only 10% in the Guayana region is managed today with few prescriptions for sustainability. A recent survey of three private concessions in Imataca Forest Reserve where logging operations, socioeconomic conditions of local communities, and ecosystem services perception were assessed reveals that a new form of management is needed. Poor planning in logging operations was detected in all concessions, which highly affects forest stands and biomass recovery. Social assessment shows that local communities in all cases demand more participation in wood production benefits and more access to land. Also, people tend to recognize provision services such as food and water above regulation and cultural services. New strategies should include a strengthening of institutional cooperation for private and public sectors and capacity building to promote reduced impact logging operations. In addition, non-timber forest products and ecosystem services should be considered in a multiple-based management policy in order to shape a new image for NFM in Venezuela.

Sustainable resource management in a world of conflicting interests. Wennberg DiGasper, S. (*Umeå University, Sweden; sofiaw_d@hotmail.com*).

Many nations are currently taking measures to implement sustainable resource management and there are numerous challenges facing policymakers and other stakeholders involved in the process. In Sweden a significant conflict exists between the forest industry and hunters regarding the size of the moose populations, because these animals cause grazing damages to valuable tree species and thereby diminish financial profits for the forest industry. A quantitative study of more than 600 local moose management units (MMU) revealed that these could not meet their management goals as to the number of moose, the amount of grazing damages, and so on. Part of the reason is that there is an ecological and social misfit, because MMUs are too small to contain self-sufficient moose populations. A qualitative study of the public administration of moose in Sweden revealed that it could be characterised as a conventional, single-species management system, and had features of both corporate arrangements and legal-rational bureaucratic administrative models. This public administrative structure did not facilitate conflict solving or provide vertical and horizontal linkages that could have mitigated the consequences of the ecological and social misfit of the MMUs.

Ecological design of forest eco-tourism in the perspective of negative planning: a preservation practice of an urban forest in the process of urbanization. Yaoyu, W. (*Nanjing Forestry University, China; henner@163.com*).

The process of urbanization and the blossoming of tourism in China puts a strong pressure on forest parks, especially on those located in or beside the urban area. The conventional approach to economic centered development planning of forest parks failed to meet the challenges of conservation and sustainable use of forest resources. Negative planning has its roots in biodiversity protection and emphasizes that planning should start with control of exploitation. The view of negative planning provides us with a perspective to find a new pattern for urban forest tourism exploitation. It is believed that forest tourism should be strategically planned and developed by using less land and more efficiently preserving ecosystems services. Ecological design in the perspective of negative planning can be used as an effective tool for keeping the balance between natural resource protection and nature-based tourism exploitation in the context of rapid urbanization. Using Nanjing Zijinshan National Forest Park as a case study, this paper demonstrates how to use ecological design as a tool to guide and frame sustainable development of forest eco-tourism in the city.

Posters

Discussion on promoting development of the Beijing green waste recycling industry. Mi, F. (*Beijing Forestry University, China; mifengsun@163.com*), Lv, N. (*Chinese Academy of Sciences, China; nanlv@rcees.ac*), Wu, W. (*Beijing University of Chemical Technology, China; wuweihongbh@vip.sohu.com*), Zhang, D., Wei, H.,Wang, W. (*Beijing Forestry University, China; zhangdahong591120@163.com; Fang12290630@163.com; wangwukui@hotmail.com*).

At present, the amount of green waste is increasing continuously with the extension of greenbelt areas. Inappropriate ways of disposing of green waste will aggravate environmental pollution, destroy the ecological balance, and even endanger the health of residents. However, if used properly, green waste disposal techniques can involve new resources and produce good ecological benefits, social benefits, and considerable economic benefits. Based on the collation and summary of research on green waste, the thesis states that reuse patterns and technology in dealing with green waste have matured both within China and abroad. Green waste can be used as fertilizer, biomass energy, crushing coverage, etc. However, research is still insufficient regarding relevant policy; currently, policies and regulations on garden green waste re-utilization are promulgated only in the United States, Japan, Germany, New Zealand, and Shanghai in China. Besides, based on the research above, combined with status and problems of green waste re-utilization, the thesis suggests that it is necessary to adopt active government actions and establish polices to promote development of the green waste recycling industry, so that it can contribute to the development of a circular and low-carbon economy.

Selecting high-priority conservation areas using surrogate species: consistent with ecological theory? Sætersdal, M., Gjerde, I. (*Norwegian Forest and Landscape Institute, Norway; magne.setersdal@skogoglandskap.no; ivar.gjerde@skogoglandskap.no*).

The selection of high-priority conservation areas is an important topic in conservation biology. As all conservation measures, it should be based on sound ecological theory. At present there are two groups of theoretical models in community ecology to explain the distribution and abundance patterns of species. The first group of models is the niche-based models; the second group is the models based on neutral mechanisms, such as stochastic processes of birth, death, dispersal, and speciation. Surprisingly, the relationship between the two groups of models and conservation has rarely been addressed. Here we discuss to what degree the two types of models matter for the use of surrogate species in selection of sites for conservation. There are at least six types of reported surrogate species being used in site selection: flagship species, umbrella species, keystone species, focal species, species richness indicator species, and species indicating complementarity. We show that most types of surrogate species rest on one or more assumptions about cross-taxon congruence in complementarity or species richness, nested species assemblages, or spatio-temporal consistency in indicator value. We discuss to what degree these assumptions are met by predictions from niche-based models or neutral-based models, respectively.

Basic cost-benefit analysis on the effectiveness of thinning promotion policy for carbon sinks in Japan. Toyama, K., Shiraishi, N. (*University of Tokyo, Japan; toyama310@fr.a.u-tokyo.ac.jp; siraishi@fr.a.u-tokyo.ac.jp*).

Large parts of conifer even-aged plantations in Japan, most of which were planted after World War II, are at ages suitable for commercial thinning or clearcutting. Consequently, thinning and non-clearcutting management are highly promoted so that many plantations will meet the requirements of properly-managed forests or carbon sinks as defined by the Kyoto Protocol. In reality, Japanese government and provincial governments subsidize each silvicultural operation including commercial thinning at a fixed subsidy ratio to the standard operation cost. The ratios are set according to type of subsidy, each of which promotes specified or scheduled forest management, and they are range from about 36% to 85%. This research simulates money yields of standard forest management in Japan including subsidies. It points out that the current policy in Japan, which mainly promotes commercial thinning (for which operational efficiency is relatively low), can have low cost-effectiveness when compared to policies that focus on promoting non-commercial thinning and clearcutting whose aim is to produce timber and manage forest areas properly at the same levels as under the current policy. The economic loss under the current policy corresponds to the cost of reducing clearcutting, and that should be made public for nationwide discussion.

B-10 Advances in the conservation and management of forest genetic resources

Organizers: Yongqi Zheng, *Chinese Academy of Forestry, China, zhengyq@caf.ac.cn*; Heok-Choh Sim, *APAFRI-Forest Research Institute Malaysia, Malaysia*, *sim@apafri.org*; Kyu-Suk Kang, *Korea Forest Research Institute, Republic of Korea, kangks@forest.go.kr.*

Genetic differentiation of Norway spruce (*Picea abies* Karst.) in the western Balkans. Ballian, D., Bogunić, F. (*University of Sarajevo, Bosnia and Herzegovina; ballian_dalibor@hotmail.com; faruk_bugunic@yahoo.com);* Božič G. (*Slovenian Forestry Institute Ljubljana, Slovenia; gregor.bozic@gozdis.si*); Mataruga, M. (*University Banja Luka, Bosnia and Herzegovina; mmataruga@gmail.com*); Kajba, D. (*University of Zagreb, Croatia; davorin.kajba@zg.htnet.hr*).

Molecular genetic identification was performed with recognized iso-enzyme markers in 12 natural spruce populations and one artificial (*Picea abies* Karst.) for the western Balkans, in the wider area of Bosnia and Herzegovina. Variability was analyzed by using 13 iso-enzyme systems on 20 polymorphous loci, with 73 alleles. Average number of alleles per locus ranged between 1.80 and 2.60. Obtained results show the existence of great variability within the populations, and existence of clinal variability for gene locus GOT – C. Genetic multi-locus diversity ranged between 27.5 and 37.0, and gene pool diversity between 1.277 and 1.380. Medium size differentiation for all populations is quite low and is Dj = 1,91. This size shows us the proportion of the total diversity, which can be estimated to around 98%. This is due to the genetic variability among individuals within the populations, as well as the variability and poor differentiation among the populations. On the basis of research, that would mean that each important ecological niche for spruce should have its gene bank, with an appropriate number of individual units, in order to preserve ecological and physiological features of the populations.

Possibility of seed usage of pedunculate oak (*Quercus robur* L.) in Bosnia and Herzegovina on the basis of its genetic structure. Ballian, D.; Bogunić, F. (*University of Sarajevo, Bosnia and Herzegovina; ballian_dalibor@hotmail.com; faruk_bogunic@yahoo.com*), Mataruga, M. (*University of Banja Luka, Bosnia and Herzegovina; mmataruga@gmail.com*), Belletti, P. (*University of Turin, Italy; piero.belletti@unito.it*); Kajba, D. (*University of Zagreb, Croatia; davorin.kajba@zg.htnet.hr*).

In the analysis of genetic variability and differentiation of the pedunculate oak population (*Quercus robur* L.) we used 14 natural populations evenly spread across Bosnia and Herzegovina, with the total of 255 analyzed trees, using four highly polymorphous micro-satellite loci (micro-satellite markers: ssrQpZAG1/5, ssrQpZAG9, ssrQpZAG36, and ssrQpZAG108). This research provided the value of inter-population differentiation of F_{ST} = 0,089 of the total genetic diversity, with large diversity within the populations with the value of F_{IS} = 0,225, i.e., large polymorphism. Based on the above stated, we can draw a conclusion that there are differences among examined populations of the pedunculate oak. Differences in genetic differentiation were maybe caused by different processes of the post-glacial migration—for example, maybe the ability of some gene types to adapt to certain habitats with specific selection processes, and probably also anthropogenic impacts over the past 2,000 years. Since we did not obtain population groups on the basis of genetic similarities, even when climatic factors were included in the calculation, all populations are separate entities and we can have seeds and seedlings from the seed base at our disposal, but with the great risk of genetic contamination of local populations.

Associations between polymorphisms and carbon isotopic composition in *Populus nigra* L. Chu, Y., Su, X., Huang, Q., Huang, X. (*Chinese Academy of Forestry, China; ygchu@126.com; suxh@caf.ac.cn; huangqj@caf.ac.cn*; *axiang@caf.ac.cn*), Ding, M. (*State Forestry Administration, China; dmmjoy@126.com*).

Water scarcity is an increasing threat for the growth and production of forest trees, making breeding of water-economy varieties a need for wood production in water-shortage areas. We used the approach of association study to investigate the relationships between DNA sequence variation and phenotypic variation in water use efficiency (WUE) in *Populus nigra*. L. Analyses of nine candidate genes found that the level of linkage disequilibrium (LD) in *P. nigra* is low, decaying rapidly from 0.45 to 0.20 within a distance of 300 bp. Preliminary studies found that six single nucleotide polymorphisms (SNPs) are significantly associated with stable carbon isotopic composition ($\delta^{13}C$), which is a reliable measure of plant WUE. Among them, SNP2 is a synonymous mutation that belongs to an ethylene-responsive factor gene *ERF*. SNP15 is a non-synonymous polymorphism that locates in a sucrose synthase gene *SuSY1*, resulted in amino acid alteration between Val and Ile. Four other SNPs at *Expa1* (encodes α-expansin 1) loci were associated with $\delta^{13}C$, indicating that *Expa1* might be a promising candidate gene for further study. The results provide a basis for breeding of poplar varieties for improved water-use characteristics.

The genetic improvement of *Betula platyphylla* Suk. Chuanping, Y. (*Northeast Forestry University, China; yangcp@nefu.edu.cn*).

Since the 1980s, we have conducted *B. platyphylla* provenance testing in Northeast China. Through these provenance tests, best provenances were selected from different provenance divisions with genetic gains for height ranging from 12% to 18%, and for wood volume from 10% to 15%. Six technologies were developed through birch intensive breeding. Through these technologies, birch that normally flowers at the age of 17 to 20 years can flower at the age of 2 to 3. Therefore, intensive breeding technologies have accelerated the birch breeding process in China. Efficient tissue culture and genetic transformation systems for birch were generated with the transformation rate of 1–2%. Using this transformation system, the spider toxin gene was introduced into birch, and the transgenic plants can kill the insect efficiently. Cutting propagation research on birch has increased the propagation rate more than 92%. The functional genomics was carried out to investigate the mechanism of wood formation and shoot development. In total, 63 genes involved in shoot development and 17 genes associated with wood formation were identified. Molecular marker assisted selection for improving wood quality of birch has been studied, and 21 SCAR associated with birch fiber length identified.

Rescue of forest timber species at critical extinction risk in Costa Rica. Corea, A. (*Universidad Nacional, Costa Rica; eugeniocorea@hotmail.com*).

A Costa Rican commission identified 30 forest timber species at critical extinction risk. Their populations are mainly conformed by few adult trees, isolated or in small groups. Young trees are very rare or absent, indicating serious reproduction limitations and

a high probability to be under the minimal viable population size. *In-situ* conservation strategy does not guarantee their survival, even in protected areas. In 2006, INISEFOR started a project aimed to rescue these species, establishing *ex-situ* genetic collections (seeds, conservation stands, and juvenile gardens) and developing vegetative propagation methods. At present, INISEFOR continues with genetic collections of *Cedrela salvadorensis, Platymiscium yucatanum, Ruagea insignis, Paramachaerium gruberi,* and *Swietenia macrophylla;* and successful massive reproductions protocols, through rooting and acclimatization of mini-cuttings produced in juvenile gardens, achieving more than 90% of the conversion rate. Results show that the methodology developed has great potential for the rescue of genetic variation and for massive reproduction of endangered tropical hardwood species, making possible its reintroduction in ecosystems where they have become extinct or have suffered severe genetic erosion. Furthermore, it can be also the base for its domestication and use in many agro-ecosystems, genetic improvement programs, biotechnology, etc.

Genetic diversity studies in Kenyan populations of *Acacia senegal* (L.) Willd. based on morphological and molecular (ISSR) markers for improved gum arabic production. Dangasuk, O.G. (*Moi University, Kenya; georgedangasuk@yahoo.com*), Chiveu, J.C. (*Kabianga University College, Kenya; chiveuj@yahoo.com*).

Acacia senegal, a leguminous multi-purpose African tree, is highly valued for gum arabic production. To make *A. senegal* farming in Kenya commercially profitable, information on genetic diversity throughout its natural habitats is vital. This study estimated genetic diversity in Kenyan populations of the species from Garissa, Wajir, Samburu, and Baringo, based on morphological and ISSR markers. Twelve morphological traits were assessed on 20 randomly selected trees in every population. Trees were larger, taller with greater pod and seed traits in Samburu and Baringo than the Garissa and Wajir populations. In contrast, trees had lighter seeds and more branches with higher gum weight in Wajir and Garissa than in Samburu and Baringo. Using five ISSR primers, 17 polymorphic loci were observed, ranging from 564 bp to 983 bp. A high mean gene diversity index was observed (H = 0.293). AMOVA showed 95% of the genetic variation resided within the populations. The DMRT results, the dendrograms derived from combined morphological traits, and the UPGMA of ISSR clustered Garissa and Wajir in one group, Samburu and Baringo in the other, reflecting geographical sub-structuring of the populations. Selection for improvement of gum arabic yield and conservation of *A. senegal* should therefore target individual trees within populations.

Management and deployment options of teak genetics. Goh, D. (*Sabah Foundation Group, Malaysia; dorngoh@hotmail.com*), Maitre, H.F., Chaix, G., Baillères, H., Monteuuis, O. (*CIRAD, France; henri-felix.maitre@cirad.fr; gilles.chaix@cirad.fr; henri.bailleres@cirad.fr; olivier.monteuuis@cirad.fr*).

Despite serious national and international conservation measures implemented recently for preserving teak (*Tectona grandis*) natural resources, these are still depleting at an alarming rate. Concomitantly, the worldwide demand for this timber, which has incomparable technological and aesthetic features, has continued to grow. There is therefore an urgent need to rely on teak plantations for a readily available and sustainable supply. Given increasing land pressure and socio-economical constraints, such plantations must produce high yields of premium quality timber with the shortest delays. Being aware of this situation since the early 1990s, YSG Biotech with the collaboration of CIRAD, has been developing a comprehensive teak improvement project, which included genetic conservation, open-pollinated breeding, selection, and clonal propagation components in Sabah, East Malaysia. Achievements in these areas are described, with emphasis on the usefulness of non-destructive wood analyses and of adapted molecular markers for refining the initial genotypic selections. The selected trees can be clonally propagated by locally developed efficient nurseries and *in vitro* methods for conservation, testing, breeding, or establishment of highly productive plantations, as either monocultures or agroforestry systems with the application of proper silvicultural practices. Well-packaged, contamination-free, *in vitro*-produced plantlets can also be dispatched to overseas destinations for similar purposes.

Genetic variation of Japanese beech (*Fagus crenata* Blume) in Shikoku Island. Hashimoto, R., Kai, C., Harada, K. (*Ehime University, Japan; richan_rabbit@yahoo.co.jp*; *ckaichan@agr.ehime-u.ac.jp*; *kharada@agr.ehime-u.ac.jp*).

Japanese beech is a prevailing tree species in the temperate deciduous forests of the Japanese Archipelago. It grows at altitude more than 1,000 m and shows patchy distribution in the western part of Japan. We collected samples from 15 beech populations in Shikoku Island, where total area size was estimated to be about 25,000 ha, and estimated genetic variation using cpDNA non-coding regions and microsatellite markers in order to examine and compare the long-term effect of isolation after the last glacial age and short-term isolation by human activities. Two lineages (haplotypes) were identified by cpDNA variation. The average observed (*Ho*) and expected (*He*) heterozyogsities are 0.825 ± 0.035 and 0.838 ± 0.029, respectively. These values are almost the same as reported values in Honshu populations; however, reduced values in both expected heterozygosity and allele richness were observed in one of the populations (Furontou). Significant reduction in allele richness was reported in isolated populations by human activity 600 years ago in European beech (*Fagus sylvatica*), but not in heterozygosity. Comparing with this result we concluded that the main effect of the reduction in genetic variation in Furontou population is human activities.

Vanishing forest genetic resources of Bangladesh and the strategy for their conservation. Hossain, M.K. (*University of Chittagong, Bangladesh; mkhossain2009@gmail.com*).

The natural forests of Bangladesh are biologically very diverse. Bangladesh has about 5,700 species of angiosperms, of which 2260 species are reported from the natural forests of Chittagong region only. But the natural forests are declining at an alarming rate due to land clearing for agriculture, shifting cultivation, encroachment and conversion of forest lands to other uses. The annual deforestation rate has reached to 3.3%. Though Bangladesh is one of the signatories of the Convention on Biological Diversity (CBD), the issues of conservation and protection of biological diversity have so far had a low priority. The Chittagong Hill Tracts possessed rich flora and fauna in the past but, most of the native species have now become either extinct or localized in few patches only. Commercial plantations of a few fast growing exotics accelerate the erosion of the native genetic resources both in the hill forests and the lowland sal (*Shorea robusta*) forests areas. The paper briefly discusses the status of forest genetic resources in the hill forests and sal forests areas and the conservation strategy of both *in situ* and *ex situ* programs in Bangladesh.

Identification of genetic resources of *Populous euphratica* in west Iran, and planning to protect and develop these resources. Iranmanesh, Y. (*Research Center of Agricultural and Natural Resources, Iran; y_iranmanesh@yahoo.com*), Ghamari Zare, A. (*Research Institute of Forest and Rangeland; ghamari-zare@rifr-ac.ir*), Jahanbazi Gojani, H., Talebi, M. (*Research Center of Agricultural and Natural Resources, Iran*).

Populus euphratica is one of the most important species in Iran that is distributed in arid and semi-arid lands naturally. This research was conducted in Chaharmahal and Bakhtiari provinces in west Iran. First, we surveyed the distribution of this species in the province. Then, because *P. euphratica* is present in parts of the province, adaptability of hybrids of *P. euphratica* with native species was studied. For this purpose, hybridization between *P. alba* and *P. euphratica* was done with artificial pollination. After that, trees *P. alba*× *P. euphratica* and *P. euphratica* × *P. alba* were produced and saplings were obtained from them. These saplings were planted in the research station in the province with *P. alba* and *P. nigra* as native species, based on RCBD design. Quantitative and qualitative characteristics were measured. The results of distribution of *P. euphratica* showed that only 1.3 ha of this species remained in this province, highlighting the extinction danger of this remaining stand. The results of adaptability showed that height, trunk height, and dbh growth of *P. alba* × *P. euphratica* were significantly more than other treatments ($\alpha < 0.01$). The *P. euphratica* × *P. alba* treatment was intolerant against cold.

Optimal sampling strategies for conservation of *Pinus densiflora* based on genetic variation parameters in Korea and China. Kim, Z.-S., Jeong, J.-H. (*Korea University, Republic of Korea; zskim@korea.ac.kr; florajh@korea.ac.kr*), Wang, R. (*Shandong University, China; rqwang@sdu.edu.cn*), Mao, Z. (*Northeast Forestry University, China; zinjunm@yahoo.com.cn*).

Pinus densiflora forests in northeast Asian regions have shown a tendency to decline due to diverse factors over the past 30 years, which could lead to a decrease in genetic diversity at the species level. Therefore, a rational conservation program is an issue of maintaining the economic and ecological importance of *P. densiflora* in the regions. In this study, an attempt to find optimum sampling strategies for conservation was made based on allozyme and ISSR data that were estimated from Korean and Chinese populations in the distribution area. Allelic and genotypic multiplicities were defined as the main measures to be maximized in each sample. Increase patterns in genetic multiplicity associated with the sequential random sampling of the specific numbers of populations and individuals were depicted by using a simulation program, SGD (sampling genetic diversity). By analyzing the increase patterns in genetic multiplicities associated with the sequential sampling, target amounts were determined as the number of populations and individuals to be retained. Some preferential samplings of the populations with the alleles of putative conservational value were also compared. The implications of the study findings for conservation activities and ideas for future study are presented.

Karyotype diversity in *Larix* species. Muratova, E.N., Sedelnikova, T.S., Kvitko, O.V., Sizikh, O.A., Pimenov, A.V. (*Russian Academy of Sciences, Russian Federation; elena-muratova@ksc.krasn.ru*), Karpjuk, T.V. (*Krasnoyarsk State Agrarian University, Russian Federation*).

The genus *Larix* is one of the most widely spread and prominent genera among conifers of the world. The goal of this study is karyological analysis of eight larch species–*Larix sibirica* Ledeb., *L. sukaczewii* Dylis, *L. gmelinii* (Rupr.) Rupr., *L. cajanderi* Mayr, *L. ochotensis* Kolesn., *L. x amurensis* Kolesn., *L. x czekanowskii* Szafer, *L. decidua* Mill. Karyotype analysis was carried out by a special technique for conifers, with modifications. *Larix* species were investigated in different parts of the area, in normal and extreme conditions. The karyotype of *Larix* consists of 24 chromosomes (2n = 24); the diploid complement includes 6 pairs of symmetric (meta-centric) and 6 pairs of asymmetric (submeta- and inter-centric) chromosomes. In addition to A-chromosomes, in some populations of *L. gmelinii*, *L. sukaczewii*, and *L. sibirica* the B-chromosome was also found. The number of genome and chromosome mutations was higher in extreme conditions. There are irregularities of mitosis in Siberian larch in extreme environmental conditions. Based on the number of secondary constrictions in chromosomes, the genus *Larix* was subdivided into some karyotypic groups.

Metabolite-assisted early selection of *Pinus densiflora* families with fast-growing traits. Park, E.-J., Lee, W.Y., Noh, E.-W., Han, S.U. (*Korea Forest Research Institute, Republic of Korea; pahkej@forest.go.kr; wylee20@ forest.go.kr; ewnoh@forest.go.kr; sanguhan@forest.go.kr*), Pharis, R.P., Kurepin, L., Zhang, R., Zanzen, L. (*University of Calgary, Canada; rpharis@ucalgary.ca; lkurepin@ucalgary.ca; rzhang@ucalgary.ca; ljanzen@ucalgary.ca*).

Metabolic information can often reflect biological endpoints more accurately than transcript or protein analysis and has thus become an important method in assessing genotypic and phenotypic diversity in plants. Here we report on the identification of several metabolic determinants for early selection of families of *Pinus densiflora* with fast-growing traits and on its integration with other profiling tools. We used a retrospective approach where 12 open-pollinated families were grown and ranked in field trials to age 35 years. Then we compared the growth of their seedlings (3- to 6-month-old) in a nursery trial with the age 35-year growth index. Interestingly, the growth index of age 35-year trees was significantly correlated with both stem dry weight and height of seedlings. Additionally, stem tissue GA_{20} levels and *PdGA20OX* expression in seedling shoots also showed significant correlations with growth performances of nursery seedlings and age 35-year trees across the 12 families. Other potential metabolic markers will be also discussed. The integration of phenotypic, metabolic, and genomic profiling in very young seedlings with age 35-year performance in a retrospective manner provides important insight into the usefulness of metabolite-assisted breeding as a valuable tool to accelerate the selection process for fast-growing traits in *P. densiflora*.

Genetic variability in a common garden test of an American pine (*Pinus elliottii*) and a Chinese pine (*P. massoniana*) planted in the southeastern USA. Schmidtling, R.C., Nelson, C.D. (*U.S. Forest Service, USA; rschmidtling@fs.fed.us; dananelson@fs.fed.us*), Zheng, L.H. (*Institute of Tropical Forestry, China; zlinghai@263.net*), Hipkins, V. (*U.S. Forest Service, USA; vhipkins@fs.fed.us*).

While eastern China and the U.S. have very similar climates, the history of their forests are very different. Pines from the southeastern U.S. have been widely planted in China, especially slash (*Pinus elliottii*) and loblolly (*P.taeda*) pines, where they

out-grow the native species. Transfers of species from China to the U.S., however, have not been successful. It has been proposed that because of centuries of clearing and high-grading, genetic variability is less in Chinese pines than in American pines. In this experiment, variation in allozymes of range-wide seed sources of six *Pinus elliottii* and ten *P. massoniana* populations were examined in a common-garden experiment in the southeastern US. The average number of alleles per locus was identical for the two species, 2.0. The percentage of loci polymorphic was lower in *P. massoniana*, 56.4% versus 63.6% for *P. elliottii*. Direct count (actual) heterozygosity was 0.133 in *P. elliottii* versus only 0.069 in *P. massoniana*. Hardy-Weinburg expected heterozygosities were also less in *P. massoniana*, 0.128 versus 0.169 in *P. elliottii*. The alleles appear to be present in*. massoniana*, but are less likely to be in the heterozygous state. This may indicate a higher level of inbreeding in *massoniana*.

Posters

Genetic diversity analysis of *Dalbergia monticola* (*Fabaceae*) for sustainable genetic resources management. Andrianoelina, O., Ramamonjisoa L. (*Silo National des Graines Forestières, Madagascar; silonagf@moov.mg; lolona.sngf@moov.mg*).

Dalbergia monticola is one of the rose wood species of Madagascar. It has a large natural distribution along humid natural forest at medium altitudes in the eastern part of the country. The species is overexploited because of its high productivity and the good quality of the wood. Consequently, *D. monticola* may be threatened; since 1996 it is designated as vulnerable on the IUCN Red List. To help protect this species, a survey on its genetic diversity was conducted using combination of microsatellites and chloroplast markers. In addition, this research was complemented by studies on sexual propagation and early growth of the species. The study found high level of heterozygosity, and low genetic structure but with gradual variation from north to south of the species' distribution area. Concerning the physiological study, seed germination and young growth in *D. monticola* showed intra- and inter-provenances variability. Growth in height was shown to have high genotypic heritability. This investigation has provided data necessary for more effective *in situ* and *ex situ* management of *D. monticola.* Finally, the study can be used as a model for predicting genetic diversity and propagation potential for other rose wood species in Madagascar.

Making the potential distribution map of useful plant resources using the GIS technology. Choi, K., Park, K.W., Ku, J.J. (*Korea National Arboretum, Republic of Korea; kchoi69@forest.go.kr; park1035@forest.go.kr; jjku@forest.kr*), Kang, D.J. (*Seoul National University, Republic of Korea; kadoji@naver.com*).

Predicting plant distribution is not simple because it needs to consider many factors such as climate, topography, soil, air condition, moisture, etc. Today, the application of global positioning system (GIS) technology is very effective for the analysis of relationships between plants' location and their environment. By using GIS technology, we are trying to find out potential area for restoration and to produce a potential distribution map. As a case study, we studied the rare and endemic species in Korea. GPS technology was used to determine the position of each habitat. Derived effective soil depth map, forest density map, forest age map, integrated moisture index map, flow-accumulation map, hillshade map, soil type map, and forest type map were obtained from digital topographic maps, digital forest maps, and soil maps. All the data-sets were combined together based on location, and an attribute table was made for each survey point location using the environmental information. Binary logistic regression was adopted in the statistical analysis. In this paper some of the applicability of GIS technology to plant conservation and utilization will be discussed.

Characteristics of Korean wild-simulated ginsengs and cultivated field ginsengs according to morphological characters and stable isotopes of seeds. Choi, M.S., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; hnarbore@forest.go.kr; sands02@forest.go.kr*).

Cultivation of wild-simulated ginseng became a new approach for Korean ginseng farmers and consumers because of the similarity with wild ginseng based on traditional common thought. However, the difference between the wild-simulated ginseng and cultivated field ginsengs is not clear and has been a core of argument. A comparison of morphological characters and stable isotopes of seeds between wild-simulated ginseng and cultivated field ginseng was carried out. The length, width, thickness, and number of seeds per gram were measured and the ratio of stable isotopes of carbon and nitrogen was also analyzed. The seeds were collected from the *Geumsan,* which is the most popular area of ginseng cultivation in Korea. Compared to the seed of cultivated field ginseng, the seed of wild-simulated ginsengs were significantly smaller and lighter, and the natural ^{15}N abundances of wild simulated ginsengs was lower than the cultivated plants. We believe the value of the natural ^{15}N abundances could be used as the one of the detection elements to recognize the cultivation regime between a chemically fertilized one and an organic farmed one.

Genetic diversity of *Quercus robur* L. in Romania: implications for conservation. Curtu, A.L., Sofletea, N., Toader, A.V., Enescu, M., Moldovan, I.C. (*Transilvania University Brasov, Romania; lucian.curtu@unitbv.ro; nic.sofletea@unitbv.ro; alin.toader@unitbv.ro; mihaienescu21@yahoo.com; calin.moldovan@unitbv.ro*).

Genetic diversity is very important for species long-term survival and adaptation to a changing environment. Here we present data gathered in a genetic survey on *Quercus robur*, one of the main species of the European temperate forests, which has suffered a severe reduction in natural range in Romania over the past centuries. The genetic data are useful for assessing conservation priorities and developing a national conservation strategy for this tree species. The level and structure of genetic diversity was assessed by means of nuclear (allozymes) and chloroplast DNA markers in eight populations distributed throughout the country. The analysis of nuclear markers revealed low divergence among populations across the species range (F_{ST} = 0.02), suggesting high rates of gene flow between currently isolated populations. The seven identified chloroplast haplotypes belong to three cpDNA European lineages and support the native origin of the selected stands. One divergent haplotype, very similar to those described north of the Black Sea and in the Caucasus, was observed in the easternmost population, which is situated in the Danube Delta, indicating that this population should be a priority for conservation. Oak populations showing different evolutionary histories and high allelic compositions should be among the candidate populations for conservation.

Allelic diversity in cellulose synthase gene in *Eucalyptus tereticornis*: implications in candidate gene association studies. Dasgupta, M. (*Institute of Forest Genetics and Tree Breeding, India; modhumitaghosh@hotmail.com*), Palanisamy, C. (*Tamil Nadu Newsprints and Papers Ltd, India; chezhian2724@gmail.com*), Balachandran, K.R.S.; Ramasamy, Y. (*Institute of Forest Genetics and Tree Breeding, India; biokarpagam@gmail.com; yasodha@icfre.org*).

Cellulose forms the structural framework of plant cell walls and is the most abundant biopolymer. The enrichment of better-quality cellulose and the nondestructive identification of genotypes with high cellulose using DNA markers is a major goal in forest biotechnology. With the rapid advancement of genome projects in trees, a growing interest in identification of genes underlying quantitative traits has emerged, providing possibility of investigating sequence variation directly in genes and their association to the trait of interest. In the present study, three primer pairs targeting the cellulose synthase gene (*CesA 1, CesA 2* and *CesA 3*) were designed and amplified in individuals representing eight *Eucalyptus tereticornis* provenances with contrasting cellulose/lignin profiles. The primer pair *CesA2* amplified two alleles at 174bp and 176bp, which significantly correlated with hollocellulose (0.950), lignin (–0.925), and pentosans (–0.840) content of wood. Further, to understand the specific expression of cellulose synthase gene families in developing secondary xylem, six transcripts representing different classes of *CesA* superfamily were identified and their differential expression was analyzed. The specific expression of a transcript *EtCesA5* in the secondary xylem tissues was observed, implying its suitability as a candidate gene in association analysis for developing pulping trait marker in *E. tereticornis*.

Conservation of forest biodiversity in Central and Eastern Europe–a case study of Romania and Bosnia Herzegovina. Dautbasic, M. (*University of Sarajevo, Bosnia and Herzegovina; mirzad@bih.net.ba*), Ioras, F. (*Buckinghamshire New University, Romania; fioras01@bucks.ac.uk*).

Adoption and implementation of biodiversity conservation are essential for sustaining sustainable use of forest resources. Forest biodiversity conservation has drawn considerable attention as to where the funding is available in order for governments concerned with the conservation of biodiversity to fulfill their obligations. This paper examines whether financing resources provided through the Global Environmental Facility (GEF) in Bosnia Herzegovina and Romania could be supplemented with locally volunteer-provided funding to lead to an appropriate level of forest biodiversity protection. The Convention for Biodiversity (CBD) proposes a solution to solve the problem of insufficient biodiversity protection in Central and Eastern Europe: developed countries are to provide financial resources to developing countries to enable them to protect their own biodiversity (Article 20). It is argued that the amounts of money provided should equal the benefits derived from biodiversity protection. A survey was conducted on a 1,189-person sample in both countries to establish local population willingness to contribute to GEF-sponsored forest biodiversity conservation projects. It is found that these local people are willing to contribute positively higher than the actual spending of the GEF.

The epigenetic regulation of flowering by GA_3 in a conifer, *Cryptomeria japonica*. Fukui, M. (*Forestry and Forest Products Research Institute, Japan; mitsue@ffpri.affrc.go.jp*).

The flowering of saplings of one of the Japanese conifers, *Cryptomeria japonica*, can be initiated by applying GA_3 and controlling temperature and photoperiod. Two- and 3-year-old saplings of *C. japonica* remained dormant when maintained at 15 °C with an 8-hour photoperiod. When these saplings were treated with GA_3 (100 ppm or 500 ppm) at least twice and kept in the same condition for 7 weeks and then transferred to the condition, 20/15 ºC (day/night) or 30/25 ºC (day/night) with a natural photoperiod, male and/or female cones were induced after the vegetative growth. Under the higher temperature condition, only male cones were induced continuously and at a high frequency. Thus, in this condition, the male cones were induced from almost all the GA_3-treated terminal apical meristems, except those in the upper part of the saplings. This result indicated that the flowering process was switched on by the GA_3 treatment in the terminal apical meristems at the dormant stage except in a few cases. This tendency was also observed in saplings grown in the lower temperature condition. More detailed observations are now in progress for establishing an experimental system for molecular analyses.

Enhanced drought and salt tolerance of transgenic poplars producing glycine betaine. Han, M.S., Noh, E.W., Choi, Y.I., Lee, J.S., Nam, J.I. (*Korea Forest Research Institute, Republic of Korea; mshan99@forest.go.kr; ewnoh@forest.go.kr; yichoi99@forest.go.kr; jasolee@forest.go.kr; yoshybot@naver.com*).

Both *betA* and *betB* genes involved in biosynthesis of glycine betaine from *Escherichia coli* were modified to be expressed under *CaMV 35S* promoter and transferred to poplars via double transformation using *nptII* and *hpt* genes for each round. Seven transgenic lines were tested for drought and salt tolerance by using the media containing different levels of PEG or NaCl. The transgenic lines produced more calli than non-transgenic poplars in the presence of 10% PEG. At 125 mM NaCl, most transgenic plantlets survived while non-transgenic died. Transgenic lines grown on pots were also stressed by withholding water or by providing either 20% PEG or 125 mM NaCl solution. Withholding water for 7 days resulted in severe wilting of leaves in non-transgenic lines but did not cause any visible symptoms in the transgenic lines. The transgenic lines also had higher rate of photosynthesis than did non-transgenic poplars under water stress. The transgenic lines exposed to either 20% PEG for 2 weeks or 125 mM NaCl for 5 weeks had higher rates of both photosynthesis and growth than did non-transgenic poplars. Taken together, these results showed that the expression of two transgenes in poplars improved the tolerance levels to drought and salt.

Isolation and analysis of a gene encoding a potassium membrane transport protein from *Cryptomeria japonica*. Hosoo, Y., Kimura, Y., Imai, S., Takeda, T. (*Shinshu University, Japan; hosoo@shinshu-u.ac.jp; y-hosoo@sannet.ne.jp; y-hosoo@sannet.ne.jp; takeda@shinshu-u.ac.jp*).

Potassium is the most abundant cellular cation in higher plants containing trees. It plays a central role in stoma movements, osmoregulation, xylogenesis, and adaptation to changes in environmental conditions. Membrane transport proteins classified as channels and transporters are involved in the movement (uptake or release) of potassium across the cell membrane and vacuolar membrane of the cell. Elucidating the molecular basis of membrane transport of potassium would lead to a better understanding of stress tolerance and environmental adaptation of trees. We attempted to isolate a gene encoding a potassium membrane

transport protein from *Cryptomeria japonica* and analyze its expression and function. Total RNA was extracted from *C. japonica*, and cDNA for potassium channels or potassium transporters were amplified using a reverse transcriptase-polymerase chain reaction method. Amplification of one cDNA fragment revealed that the sequence of the obtained cDNA was homologous to two-pore potassium (TPK) channels of other plants at the amino acid level. This TPK cDNA was expressed in needles, inner barks, differentiating xylems, and male cones. These results indicate that the isolated TPK gene is involved in the uptake or release of cellular potassium in various organs of *C. japonica*.

Genetic diversity and structure of natural populations of *Acer tegmentosum* in Korea, revealed by I-SSR markers. Hur, S.D., Yang, B.H., Song, J. H., Hong, Y.P. (*Korea Forest Research Institute, Republic of Korea; protenaf@forest.go.kr; time1124@forest.go.kr; sjh8312@forest.go.kr; yphong@forest.go.kr*).

Acer tegmentosum Maxim., a type of Korean maple, has been used as a medicinal resource for the treatment of inflammatory or hepatic disorders in Korea. We studied genetic diversity and structure of natural populations of *A. tegmentosum* in Korea, by analyzing 44 I-SSR amplicons in 160 individuals distributed among the main eight natural populations. Shannon's index (*S.I.*) based on 6 I-SSR polymorphic loci was an average of 0.348 (ranged from 0.298 to 0.430) for eight sampled populations. This value is similar to or slightly higher than that of other tree species with similar ecological traits and life history (Aceraceae). According to the results from AMOVA, most of genetic variation existed among individuals within populations (86.23%), and genetic differentiation among populations (Φ_{ST}) was 0.138. A dendrogram clustered the eight populations to three groups by the UPGMA and the match of genetic and geographic type, depending on whether groups might match or not. The Hongcheon population revealed the highest level of genetic diversity (*S.I.* = 0.430) and was genetically distinct from the other seven populations. Consequently it is highly recommended that three populations, including Hongcheon, should be designated as an *in-situ* conservation forest.

Genetic study of mountain-cultivated ginseng and wild ginseng in Korea. Kang, H.D., Lee, S.G., Lee, S.H. (*Dongguk University, Republic of Korea; hdk0225@dongguk.edu; i820316@dongguk.edu; nash7700@hanmail.net*).

ISSR PCR technique was applied to investigate genetic variations among five mountain-cultivated ginseng populations (Jinan, Hongcheon, Punggi, Andong, and Yeongju). cDNA libraries of wild ginseng roots were constructed and analyzed for functional genes related to morphogenesis via EST. Twenty-four ISSR markers tested produced 127 polymorphic loci from the five regional mountain-cultivated ginsengs. Among the regional samples, Yeongju had 18 polymorphic loci, which was the highest level of variation among the cultivated regions. The range of similarity coefficient was 0.46–0.58, and the regional samples of Punggi and Hongcheon, Jinan, and Andong were classified to similar groups respectively, whereas Yeongju was shown to be separate group with high level of genetic variation in UPGMA cluster analysis. As a result, there was no relationship according to geographical distance and genetic similarity. Eleven cDNA clones consisted of 9 known genes and 2 unknown genes analyzed by the BLAST program of NCBI. One of them was related to the Homeodomain transcription factor that is effective in plant morphogenesis. To find the expression pattern of Homeodomain transcription factor related genes, northern blot analysis was performed for wild ginseng's leaf and root. We found that the gene was expressed only by mountain wild ginseng root.

Genetic conservation of major timber trees in a protected area in Hokkaido, northern Japan. Kawahara, T. (*Forestry and Forest Products Research Institute, Japan; kaba@ffpri.affrc.go.jp*), Mori, Y. (*Hokkaido University, Japan; yomori@ees.hokudai.ac.jp*), Yamagishi, H. (*Kyororo, Japan; hyama@ees.hokudai.ac.jp*), Matsuzaki, T., Nagamitsu, T. (*Forestry and Forest Products Research Institute, Japan; tomonori@ffpri.affrc.go.jp; nagamit@ffpri.affrc.go.jp*).

In order to conserve ecosystems, genetic resources, or corridors, several kinds of protected areas are established in forests. But the areas are not decided based on genetic information. We performed genetic analysis for three major native timber trees, *Abies sachalinensis*, *Picea jezoensis,* and *P. glehnii* to estimate the validity of protected areas from the genetic resource point of view. Microsatellite DNA markers were used with a total of 50 populations from protected areas. For *A. sachalinensis*, genetic diversity is conserved within populations while genetic differentiation among populations is low (Gst = 0.015). The populations in the southwestern part or highlands had the tendency toward low genetic diversity. For *P. jezoensis*, low genetic differentiation was observed again (Gst = 0.013). The population close to the southwestern border of the distribution has a little decline of genetic diversity. For *P. glehnii*, genetic differentiation level is slightly higher than the other two species (Gst = 0.018). Genetic diversity level is related to altitude of the populations rather than latitude or longitude. Area size is not related to genetic diversity for any species. Consequently, genetic diversity is still maintained for these species in protected areas. We are likely to notice genetic loss especially in southwestern populations in near future.

Vascular plant diversity of Jeju Island, Korea. Kim, C.S., Byun, K.O. (*Korea Forest Research Institute, Republic of Korea; kimdaram@korea.kr*; *bn1212@forest.go.kr*).

Vascular plants in Jeju are composed of 21 families, 62 genera, 190 species, and 7 varieties with 197 taxa in Pteridophyta; 3 families, 5 genera, 7 species, and 3 forma with 10 taxa in Coniferophyta (gymnosperm); and 143 families, 703 genera, 1,622 species, 114 varieties, and 47 forma with 1,783 taxa in Endospermae. The total number of taxa is 1,990, consisting of 167 families, 770 genera, 1,818 species, 121 varieties, and 50 formas. Three families, 4 genera, 4 species, and 1 variety in Pteridophyta; and 1 family, 1 genus, 1 species, and 1 forma of coniferophyta are endemic to Jeju. Five families, 8 genera, and 8 species in the Monocotyledonae of Endospermae; 23 families, 32 genera, 21 species, 16 varieties, and 7 forma with 44 taxa in Cholipetalae; and 9 families, 24 genera, 12 species, 13 varieties, and 7 forma, totalling 32 taxa in Sympetalae are endemic to Jeju. A total of 90 taxa with 41 families, 69 genera, 46 species, 29 varieties, and 15 forma are endemic plants in Jeju. As the numbers show, Jeju has more biodiversity, especially plant diversity, than any other place in Korea. It is an important region with regard to geographical position.

Endangered plants in Jeju Island, Korea. Kim, C.S., Kang, Y.J., Son, S.G. (*Korea Forest Research Institute, Republic of Korea; kimdaram@korea.kr; yjkang@forest.go.kr; sonsak@forest.go.kr*).

The rarity of 1,990 taxa on Jeju Island was evaluated and the Red Lists were compiled based on IUCN categories and criteria. Such objective data are necessary to prepare protective policies for endangered wild plants, and to propose the reduction plan of

environmental impact assessment. We found there is one species in each category, extinct (EX) and extinct in the Wild (EW); these species are *Rhododendron saisiuense* Nakai (Ericaceae) and *Asplenium antiquum* Makino (Aspleniaceae), respectively. Three taxa, *Rhododendron dauricum* L. (Ericaceae), *Lycopodium sieboldii* Miq., and *Lycopodiella cernua* (L.) Serm (Lycopodiaceae) are extinct in the region (RE). Sixty-one taxa are critically endangered (CR), 13 are endangered (EN), and 83 are near threatened (NR) at the regional level. At the global level, there are 19 taxa in CR, 4 in EN, and 1 in VU (Vulnerable) as the category of threat. Remaining taxa are classified as least concern (LC). According to the results of the assessment, conservation measures must be taken for total of 157 species that are categorized as threatened to some degree.

Cryopreservation of forest seed of 36 native species in Korea. Kim, D.H., Han, S.H., Lee, J.C. (*Korea Forest Research Institute, Republic of Korea; dhkim@forest.go.kr; simhee02@forest.go.kr; jaeclee99@forest.go.kr*).

The ability of seeds of native Korean forest species to be stored using cryopreservation methods was investigated by subjecting seed of 36 native species representing 30 genera and 21 families to storage in liquid nitrogen. Seeds of 36 native species were germinated after storage in liquid nitrogen for 1 week following direct plunging into liquid nitrogen. The largest number of species (28) responded positively to direct plunging without pretreatments. Ten species had enhanced germination and 8 species depressed germination after liquid nitrogen treatments. There were no trends in a species' ability to survive liquid nitrogen storage, moisture content, seed size, and taxonomic relatedness. However, the families Betulaceae, Cupressaceae, Ericaceae, Oleaceae, Pinaceae, Salicaceae and Ulmaceae showed a consistently high degree of tolerance to liquid nitrogen storage. Physical damage to seed coat was occurred in *Pinus thunbergii* and *P. rigida* but this did not hinder germination. This study indicates that seeds of a large proportion of native species may be amenable to storage in liquid nitrogen and that four species among six of the listed and rare and endangered species of Korea that were investigated in this study could be maintained in this way.

Development of a prototype for seed orchard management system using RFID and GIS. Kim, K.M., Kim, C.M. (*Korea Forest Research Institute, Republic of Korea; greenann@forest.go.kr; helmin@forest.go.kr*).

Maintenance of records is an important part of seed orchard management. But there have been some problems in existing seed orchard management, such as a loss of identification labels, tedious data management, and difficulty in revisiting the exact location of a plus tree because of the lack of coordinate data. In this study we developed a prototype for a seed orchard management system using RFID and GIS. This technology uses radio waves to automatically identify individual items. We attached RFID tags to the trees instead of existing identification labels. The prototype structure for the RFID system consists of a RFID tag, a handheld RFID reader, and a database server. We used a passive tag with 900 MHz frequency and EPC class 1 Gen 2 protocol. From the RFID tag reading, we can see various details such as planting year, species, coordinates, parent tree, fertilization, pesticide application, and so on. A coordinate data of plus trees can be especially effectively when used as a navigation information to the plus tree. Also we designed a real-time transmission function for the main server using wireless network. We expect that this RFID system can promote an efficiency of seed orchard management.

Rapid selection of catechins-rich tea-trees (*Camellia sinensis* L.) using a colorimetric method. Kim, Y.D. (*Institute of Hadong Green Tea, Republic of Korea; kyduck21@hgreent.or.kr*), Jeong, M.J., Min, J.Y., Song, H.J. (*Gyeongsang National University, Republic of Korea; jmivy121@naver.com; j-yoon0830@hanmail.net; hyunjin617@hanmail.net*), Hwang, J.G. (*Institute of Hadong Green Tea, Republic of Korea; eng97@hgreent.or.kr*), Cheong, G.W., Heo. C.M. (*Gyeongsang National University, Republic of Korea; gwcheong@gnu.ac.kr; miya0726@nate.com*), Karigar, C.S. (*Bangalore University, Bangalore; cskarigar@yahoo. com*), Choi, M.S. (*Gyeongsang National University, Republic of Korea; mschoi@gnu.ac.kr*).

A rapid and efficient colorimetric method based on Fast Blue B-salt (FBB) was established to select catechins-rich tea-trees (*Camellia sinensis* L.). Catechins measurements this method under optimized reaction conditions was highly correlated with estimations by HPLC analysis. Fresh tea tree leaves (FW 500 mg) were homogenized and extracted with 8 ml of distilled water on a hot water bath at 80 °C for 30 min after filtered. The change in the color of the reaction mixture was determined by spotting a 10 µl of supernatant on to a TLC plate**.** FBB colorimetric method was successfully used to select 160 tea trees on the basis of their catechins contents as rich and poor lines. On HPLC analysis of the FBB selected tea tree extracts, it was shown to contain: (-)-epigallocatechin (EGC) 186 mg/g in HR-29; (-)-epicatechin (EC) 43.7mg/g in HR-82; (-)-epigallocatechin gallate (EGCG) 4.32 mg/g in HR-29; and (-)-epicatechin gallate (ECG) 0.22 mg/g in HR-52 tea tree lines. Classification of Hadong region tea-trees into catechins rich and poor trees was independent on the growing season. Thus the FBB colorimetric method can find application as a reliable tool in screening and selection of tea trees on the basis of their catechins content.

Estimation of hybridization risk between transgenic and native birch species in Hokkaido, northern island of Japan. Kuramoto, S. (*Forestry and Forest Products Research Institute, Japan; shkura@ffpri.affrc.go.jp*), Tsuda, Y. (*Uppsala University, Sweden; ytsuda.gt@ gmail.com*), Takeda, T. (*Oji Forest Museum, Japan; takayoshi-takeda@ojipaper.co.jp*), Matsumoto A., Mohri T., Yoshida. K., Shinohara K. (*Forestry and Forest Products Research Institute, Japan; asakon @ ffpri.affrc.go.jp; mohri@ ffpri. affrc.go.jp; ykazu@ ffpri.affrc.go.jp; kenjis@ ffpri.affrc.go.jp*).

Biodiversity conservation is important in light of potential risks posed by genetically modified trees. In Japan, estimation of hybridization risk between transgenic and related native trees is enforced by law based on the Cartagena Protocol on Biosafety. Birch (genus *Betula*) species require primary attention, since transgenic lines have already developed mainly of silver birch in Europe, which can grow in Japan, and 11 native species are distributed in Japan. We examined hybridization possibility between silver birch (*B. pendula*; Bpen) and three predominant *Betula* species in Hokkaido, northern Island of Japan. Artificial pollination experiments and parentage analysis using nuclear DNA simple sequence repeats revealed that silver birch could be easily hybridized with Japanese white birch (*B. platyphylla* var. *japonica*; Bp), slightly with Japanese mountain birch (*B. ermanii*; Be), but rarely with monarch birch (*B. maximowicziana*; Bm). The characteristics of these hybrids were determined by analyzing their germination and growth traits. The survival rate of Bp–Bpen seedlings was slightly lower than Bp-Bp, whereas their annual growth was significantly higher. Thus, a potential risk of hybridization between transgenic silver birch and native birch species in northern Japan, especially Japanese white birch, has been estimated.

Isolation and expression analysis of ABA-induced gene in poplar cell (*Populus alba* × *P. tremula* var.*glandulosa*). Lee, J.-S., Lee, H., Bae, E.-K., Jo, A., Noh, E.-W. (*Korea Forest Research Institute, Republic of Korea; jasolee@forest.go.kr; hslee@forest.go.kr; betsy@hanmail.net; aruna1212@gmail.com; ewnoh@forest.go.kr*).

Abiotic stress can impinge significantly on forest health and the establishment of productive tree plantations and thus there is great interest in understanding the mechanisms of ABA-induced response in trees. To understand the ABA-dependent signaling mechanism in poplar, we have isolated 827 cDNA clones, which are inducible to exogenous ABA treatment, from poplar (*Populus alba* × *P. tremula* var. *glandulosa*) suspension cells by suppression subtractive hybridization (SSH). We used 532 unique clones to construct a poplar cDNA microarray chip for subsequent microarray analysis. Changes in the expression levels of cDNAs on the chip were investigated at various time-periods (0.5, 2, or 10 hrs) after ABA treatment (25 μM) by comparing with non-treatment controls. ABA upregulated 42 genes, of which relative expression levels were increased by at least 1.5-fold after 10 h and other upregulated genes were involved in plant growth, metabolism, transcription, and stress response. This study showed the fact that ABA induced various signal transduction pathways, providing insights into the variety of genetic mechanisms underpinning the *Populus* ABA response and further laying out candidates for future experiments aimed at understanding this response in this economically important tree species.

Improvement in ozone tolerance of poplar plants with an antisense DNA for 1-aminocyclopropane-1-carboxylate synthase. Mohri, T., Kogawara, S., Igasaki, T. (*Forestry and Forest Products Research Institute I, Japan; mohri@ffpri.affrc.go.jp; kogawara@ffpri.affrc.go.jp; iga@ffpri.affrc.go.jp*), Nakajima N. (*National Institute for Environmental Studies, Japan; naka-320@nies.go.jp*), Shinohara K. (*Forestry and Forest Products Research Institute, Japan; kenjis@ffpri.affrc.go.jp*).

Ozone is an air pollutant in many industrialized and developing countries. It is the main oxidant component of photochemical smog and causes leaf damage in many plant species. Genetically transformed lombardy poplar (*Populus nigra* L. var. *italica* Koehne) plants were regenerated after co-cultivation of stem segments with *Agrobacterium tumefaciens* strain LBA4404 that harbored a binary vector, which included an ozone-inducible 1-aminocyclopropane-1-carboxylate (ACC) synthase from poplar and the genes for neomycin phosphotransferase and hygromycin phosphotransferase. Lower rates of ozone-induced ethylene production were observed in transgenic antisense plants than in the wild-type plants. Ozone-induced visible damage was attenuated in these lines, and the extent of damage was positively related to the level of ozone-induced ethylene production. In one of these ozone-resistant lines, level of transcripts for ozone-inducible endogenous ACC synthases was suppressed compared with that in wild-type plant, demonstrating that ozone-inducible ACC synthases have an important role in the expression of leaf damage by ozone exposure. In contrast, transgenic sense plants exhibited ozone sensitivity. Thus, we have succeeded for the first time in the development of genetically modified trees with air pollution tolerance.

Adaptive genetic diversity of four coniferous forest trees of the Alps. Mosca, E. (*University of California/Davis, USA; emosca@ucdavis.edu*), La Porta, N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*), Vendramin, G.G. (*Plant Genetics Inst. CNR, Italy; giovanni.vendramin@igv.cnr.it*), Neale, D.B. (*University of California/Davis, USA; dbneale@ucdavis.edu*).

Coniferous trees are key components of the alpine landscape that are actually shaped by climate change and anthropogenic factors. Our goal is quantify and understand the standing adaptive genetic diversity in Alpine conifers. With this baseline reference it will be possible to monitor genetic change in populations and to have diagnostic tools for forest management. Almost 800 candidate genes for adaptive traits originally developed in loblolly pine were re-sequenced in four species: *Abies alba* Mill., *Larix decidua* Mill., *Pinus cembra* L. and *P. mugo* Turra. For each species, 12 individuals were included in the sequencing panel. Seeds were sampled from several diverse Alpine locations across European mountains and the DNA was isolated from the megagametophyte tissue. Single nucleotide polymorphisms (SNP) were identified in the four species and several parameters of population genetics were estimated for each species. As expected, *P. mugo* Turra showed the highest percentage of polymorphic amplicons (410 polymorphic amplicons), while diversity (Theta) was higher in *L. decidua* Mill. (around 0.0062). A genotyping chip was designed for each species and genotyping was conduced for almost 1,000 trees per species in Italian Alps. Trees were sampled along altitudinal gradient and in two different soil types.

Management plan for the protected area for forest genetic resources conservation in the civilian control zone in Korea. Oh, C.H., Lee, H.Y., Ban, S.H. (*Dongguk University, Republic of Korea; ecology@dongguk.edu*; *hoyleee@hanmail.net*; *suhong21@nate.com*).

The civilian control zone (CCZ) is an area where civilian entry has been limited for more than 50 years since the Korean War. The total length of the zone is 248 km from the eastern seashore to the western seashore. Main forests that have stayed natural because of the limits are mostly spread in the middle and eastern part of CCZ. The Protected Area for Forest Genetic Resources Conservation—which is designated for protecting and conserving virgin forests, rare plants, forest wetlands, Korean native forests, etc.—is about 500,000 ha in the CCZ. Main vegetation communities are *Quercus mongolica, Pinus densiflora,* and *Acer ginnala*. There are some rare vegetation communities such as *Juglans mandshurica, Ulmus laciniata, Alnus hirsuta,* and *Carpinus cordata;* and some boreal plant communities such as *Betula ermani, B. cosdata, Acer barbinerve,* and *Tilia amurensis*. For conserving these forests, the management area was designated by core zone, buffer zone, and transition zone. For sustainable use, forest visiting programs that will be operated by local residents are planned. Also we established several other plans such as routine monitoring, compiling of forest GIS databases, etc. As a long-range plan, pushing for a designation of UNESCO MAB is necessary.

Role of genetic characteristics on mode of branching in beech (*Fagus sylvatica* Lipsky). Salehi Shanjani, P., Assareh, M.H., Calagari, M. (*Research Institute of Forests and Rangelands, Iran; psalehi@rifr-ac.ir; asareh@rifr-ac.ir; calagari@rifr-ac.ir*).

Commercial Hyrcanian forests in Iran were nationalized in 1963 and managed mostly by shelterwood silvicultural system. Since then, the area has declined significantly from 3.4 to about 2 million ha in 2002. Six nuclear simple sequence repeats (nSSRs), nine chloroplstic SSRs, sixteen gene enzymatic markers, seed storage proteins, seed and tree phenotypic traits were used to profile a collection of 585 forked and monopodial beech trees from Hyrcanian forests. The results of allozymes, chloroplstic SSRs

and seed morphological characteristics did not show any differentiation between the forked and monopodial groups of beech trees, indicating that application of these markers in differentiation of adaptive treats should be considered with caution. However, nSSRs and seed storage proteins separated forked and monopodial groups of beech trees in different clusters. In spite of this, selection and conservation of desirable trees in shelterwood system must be considered carefully. Because the selection for conservation of some genotypes is one of the most important processes in forest management practices, it changes the genetic variation of tree populations. During this process, frequency of some genes and overall genetic variability and future adaptability, would be greatly reduced.

Genetic structure and adaptive genes of natural Alpine populations of Norway spruce: a high- throughput genotyping approach. Scalfi, M., Troggio, M. (*FEM-IASMA, Italy; marta.scalfi@iasma.it; michela.troggio@iasma.it*), Wegrzyn, J.L. (*University of California/Davis, USA; jlwegrzyn@ucdavis.edu*), Vendramin, G.G. (*Plant Genetics Inst. CNR, Italy; giovanni.vendramin@igv.cnr.it*), La Porta, N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*), Neale, D.B. (*University of California/Davis, USA; dbneale@ucdavis.edu*).

Single nucleotide polymorphism (SNP) genotyping assays have become widely used technologies for studying population genetic differentiation to identify adaptive genes and to understand the relationship between genes and environment. Our study aims to identify the genes putatively involved in local adaptation in natural populations of *Picea abies* K., by analysing the SNP variation along altitudinal, longitudinal, and latitudinal clines. Here we report some results on the two altitudinal transects, one to south and the other to north aspect, established in a natural population of *P. abies* in the Trentino region, (northeast Italy). Each transect covers ca. 1,000 m of altitude and is subdivided in six plots, one every 200 m. A total of 290 trees were sampled and genetically characterized at 384 SNPs, representing 290 expressed sequence tags (ESTs), using the Illumina's Golden Gate assay. Among the 384 SNPs analysed, 228 were polymorphic with a high call rate in more than 95% of the individuals. Genes potentially under natural selection were identified by estimating the differentiation in SNP frequencies among populations (F_{ST}) and identifying outliers. Among all genes, 7% and 4% were identified as high significant outliers on the south and the north slopes respectively.

Landscape genetics of endangered tree species in cool-temperate forests. Shen, H.L. (*Northeast Forestry University, China; shen6259@yahoo.com.cn*), Hu, L.J., Uchiyama, K., Saito, Y., Ide, Y. (*University of Tokyo, Japan; hu@es.a.u-tokyo.ac.jp; kruchiyama@affrc.go.jp; yoko@es.a.u-tokyo.ac.jp; ide@es.a.u-tokyo.ac.jp*).

Landscape genetics is a novel interdisciplinary field that quantifies effects of landscape composition, configuration, and matrix quality on gene flow and spatial genetic variation. Identifying genetic barriers is increasingly focused in landscape genetics; however, landscape acting as functional connectivity is rarely explored in tree genetics. This study aimed to examine effects of landscape connectivity on population genetic distribution of *Fraxinus mandshurica* and to facilitate conserving local genetic diversity for this endangered tree. We used nine nuclear microsatellite loci to examine spatial genetic structure of *F. mandshurica* over a riparian-mountain landscape in northeast China. Genotype data were analyzed using *F*-statistics, spatial analysis of molecular variance, and principal coordinate analysis. All these analyses consistently revealed that this species exhibited clear landscape genetic structure between riparian and mountain habitats. Conversely, no spatial genetic structures were identified among riparian populations, indicating that all the riparian populations formed a panmictic gene pool. Overall, this study suggests that seed dispersal is very low among mountain populations; however, seed transport is probably enhanced by hydrochory (water-dispersal) among riparian populations during flooding. This study provides important empirical evidence of landscape connectivity in forest trees and gives insights into conserving the local genetic diversity of *F. mandshurica*.

Variation in leaf and samara morphology of natural populations of *Acer tegmentosum* Maxim. in Korea. Song, J.H., Jang, K.H., Hur, S.D. (*Korea Forest Research Institute, Republic of Korea; sjh8312@forest.go.kr; jang123@forest.go.kr; protenaf@forest.go.kr*).

The aim of this study was to examine geographic variation to support a genetic resource conservation plan for *Acer tegmentosum* Maxim. in Korea. Seven populations of *A. tegmentosum* were analyzed using multivariate analysis for 14 characteristics of leaf and samara morphology. In the morphological characters, 10 characters of leaf were 12.8 cm in blade length (Bl), 12.7 cm in upper lobe width (Ulw), 10.6 cm in lower lobe width (Llw), 1.01 in Bl/Ulw, 1.23 in Bl/Llw, 1.21 in Ulw/Llw, 96.0° in lower lobe angle, 6.47 cm in petiole length, and 2.10 in Bl/ Pl, 113.0 mm^2 in leaf area, respectively. Four characters of samara were 25.5 mm in samara length (Sl), 7.51 mm in samara breadth (Sb), 3.45 in Sl/Sb, and 0.20 g in samara weight, respectively. Nested analysis showed there were statistically significant differences among populations as well as among individuals within populations in 12 quantitative characters. In 13 of 14 characters, variance components among individuals within populations were higher than those among populations. Cluster analysis using complete, average, centroid, median, and ward methods showed all three groups. However, populations that were close geographically did not show the tendency of clustering into the same group.

B-11 The contribution of science to the fight against illegal logging

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Beyond legality: exploring synergies between FSC and FLEGT. De Freitas, A., Waack, R., Karmann, M. (*Forest Stewardship Council International Center, Germany; a.freitas@fsc.org*; *roberto@amatabrasil.com.br; m.karmann@fsc.org*).

The problem of illegal logging is well-recognized. Governments and the private sector have joined together and developed a number of initiatives to address this. Legality is often the first step towards—but often remains far from—sustainable forest management. Lack of a globally agreed definition for legal timber, of legality verification (VLC) criteria, and discrepancies among national laws makes the legality approach inconsistent to the point where 'legal' timber can be harvested through the worst kinds of practices involving human rights violations and conversion of old-growth forests. This paper explores workable synergies between the European Union Forest Law Enforcement, Governance and Trade (FLEGT) action plan and the market-led

Forest Stewardship Council (FSC). It also elaborates a potential adaption of FSC principle 1, based on the recommendation of the Greenpeace report on legality verification schemes to cover aspects of the VLC and FLEGT action plan. Although the FSC and FLEGT approaches differ on the broader conceptual scale, at the implementation level many similarities and thus real opportunities for synergies and a sharing of experiences and tools exist between the key government and market-led initiatives.

Potential forensic application of DNA profiling in combating illegal logging. Lee, C.T., Lee, S.L., Ng, K.K.S., Tnah, L.H., Norwati, M. (*Forest Research Institute Malaysia, Malaysia; leechait@frim.gov.my*; *leesl@frim.gov.my*; *kevin@frim.gov.my*; *leehong@frim.gov.my; norwati@frim.gov.my*), Goodwin, W., Iyengar, A. (*University of Central Lancashire, UK; whgoodwin@uclan.ac.uk*; *AIyengar@uclan.ac.uk*).

Unlike the application of DNA profiling in forensic investigations involving humans, which is already well established, the application of DNA fingerprinting in forensic botany is relatively new. However, as highly variable DNA markers become more accessible to many plant species, it is envisaged that the scenario will change in the near future. We report the potential forensic applications of DNA profiling in an important tropical timber species in South-East Asia, *Koompassia malaccensis*. A suite of microsatellite markers have been developed in this species for population genetic studies. Based on the microsatellite data generated, the potential strength of genetic evidence that could be presented in court and the effect of using local in comparison with Peninsular Malaysia databases were evaluated. The results showed that, with this species, using 18 microsatellite markers, the most common DNA profile occurred at a frequency of less than one in every 6.448×10^{16} trees. Hence, the application of the available genetic database for individual identification in the case of illegal logging is highly feasible, taking into consideration the caveat that DNA isolation from dry wood can be technically difficult and can yield degraded DNA, which is more challenging to profile.

Modeling the impact of EU FLEGT and other trade policies on the use of wood for energy in the EU. Moiseyev, A. (*European Forest Institute, Finland; moiseyev@efi.int*), Solberg, B. (*Norwegian University of Life Science, Norway; birger.solberg@umb.no*), Kallio, A.M.I. (*Finnish Forest Research Institute, Finland; maarit.kallio@metla.fi*), Michie, B. (*USA; bruce.michie@usa.net*).

EU RES is the most important policy expected to have a large impact on the European forest sector. Besides EU internal policies, EU's forest sector future depends on trade policies linking the EU with other regions. One such policy is EU FLEGT, which aims at eliminating the trade of illegal wood. The Russian log export tariff is already having a substantial impact on trade with the EU. The presence of such trade policies will have an additional impact, which will alter the expected impact of the RES policy. The global forest sector model EFI-GTM was utilized to study the impact of FLEGT policies on the use of wood for energy. The EU is expected to continue increasing imports of raw wood from Russia and other countries without FLEGT and other trade policies present, which will help to increase supply of wood for energy and minimize the impact on the forest industry while ensuring that there is less pressure on EU forests. However, a declining supply of wood from outside the EU and decreasing imports of wood into the EU under FLEGT will lead to slower growth of wood use for energy and result in more pressure on European forests.

Socio-economic implications of chainsaw milling on the rural and national economy of Ghana. Obiri, B.D., Damnyag, L., Marfo, E., Nutakor, E. (*Forestry Research Institute, Ghana; bdobiri@csir-forig.org.gh; damlaw@csir-forig.org.gh; emarfo@csir-forig.org.gh; enutakor@csir-forig.org.gh*).

Commercial chainsaw milling in Ghana is officially illegal. Nevertheless, it is the major source of lumber for the domestic market. This paper examines the drivers of illegal chainsaw milling and estimates the economic impact of the practise on the nation. Data were obtained from a questionnaire survey of 102 chainsaw lumber stakeholders across eight forest districts in southern Ghana and analyzed descriptively. Results show that price, availability of chainsaw lumber, and weak institutional infrastructure are the key drivers to illegal chainsaw milling, which employs 100,000 people nationwide. In rural economies it contributes significantly to employment and provides community infrastructure and other benefits. More than 50% of chainsaw operators earn 80% of their household income from the practice, considered the best alternative to agricultural income. Stumpage loss to the state from chainsaw operations was estimated at USD 105.7 million. Further, USD 14,200 revenue from payments for access to trees and conveyance to market was lost through informal payments to law enforcement agencies and local communities. Legalization of the practice, effective monitoring, and regulation of forest revenue flows as well as equitable distribution of benefits to primary stakeholders in timber resource management may curtail revenue loss and sustain livelihoods and forest resources.

Comparative evaluation of anti-illegal trade policies in Europe and the United States. Ottitsch, A. (*University of Cumbria, UK; andreas.ottitsch@a1.net*).

The European Union as well as the United States have recently introduced policy packages aimed at curbing the trade in illegally logged forest products. This paper compares the development of and the general approach behind the U.S. Lacey Act Amendment and the proposed "EU Due Diligence Regulation" (European Commission proposal 5036/09 and related documents). Likely impacts of respective policies are presented based on stakeholder consultations and the analysis of trade- and production statistics. Regarding policy implementation the impact of different administrative systems (e.g. Federal Institutions implementing federal policy vs. National Institutions in 27 EU member states implementing EU policies) is of particular interest. Apart from the implications within the two implementing regions (US and EU-member states) impacts in external trade partner regions are analysed, both as regards intended as well as potential unintended effects and other public (e.g. EU-FLEGT) and private sector (e.g. certification schemes) initiatives. The conclusions highlight challenges as well as opportunities arising from the implementation of the respective approaches as well as potential for further development, which are of particular interest given the ongoing discussions on the final formulation and eventual implementation of policies.

Forest certification chain-of-custody analysis: perspectives of manufacturers and suppliers in the Asia-Pacific region. Seol, M., Cao, X. (*University of Washington, USA*; *mistral@u.washington.edu; caoxz@u.washington.edu*).

In the Asia-Pacific region, Indonesia has been a nexus of wood manufacturers and tropical timber suppliers, while China has dramatically increased numbers of issued forest certifications. Authors participated in FSC audits, which the Rainforest Alliance SmartWood Asia-Pacific regional team conducted from August 2008 to July 2009; interviewed stakeholders in regards to forest certifications; and analyzed 23 companies/organizations/communities consisting of 16 chains of custody. It was demonstrated that respondents pursued FSC forest certification to access new niche markets (innovation strategy), meet requirements from their buyers (customer orientation), promote their environmental image (marketing promotion), and put their ethical business themes into practice (environmental commitment). Adoption of forest certification was pulled from buyers to suppliers in chains of custody: their foreign buyers, usually major companies such as IKEA, Mitsubishi, or Gibson, fulfilled environmental policies such as Lacey Act or FLEGT; manufacturers in the Asia-Pacific region were required to adopt forest CoC certification; finally, suppliers were led to adopt forest FM certification. However, when forest certification was pursued, cost for audits became a burden on all chains of custody participants, who felt compelled to comply due to fear of losing market share and access, although participation in principle should be voluntary.

The use of microsatellite markers to confirm the flow of Bangkirai timber (*Shorea laevis*): a field testing in a forest concession holder in Central Borneo. Yunanto, T., J. Siregar, U., Z. Siregar, I. (*Bogor Agricultural University, Indonesia; genom_tedi@yahoo.com; ulfahjsiregar@yahoo.com; izsiregar@yahoo.com*).

Forestry activities that start from planting stock procurement to logging cannot be freed from criminal activities to gain big profits in a short time. A clear example occurred in West Kalimantan and Central Kalimantan Provinces, where illegal logging practices are rampant, illegal trading is easily practiced, and meranti wood (for instance *Shorea laevis*) flows easily to neighboring countries without being accompanied by valid documents. Plant materials used in this study were sampled in the form of wood discs and pieces (n = 40 samples) collected in logging sites and log yards (TPK) with the objective to test the accuracy of the existing recording and marking system for timber flow in a concession holder by applying an "apple to apple" conformity test. This study was performed using cross-species amplification of other *Shorea* microsatellites identified from a previous experiment. Results of the timber tracking test based on three polymorphic loci for matching wood in a logged area and a log yard of a concession holder showed a high level of allelic structure conformity (97.08%). Based on the results of this study, the molecular tool may be used in the near future to strengthen the exisiting system of chain of custody (CoC).

Posters

Modeling the impacts of policy measures to prevent import of illegal wood and wood products. Moiseyev, A. (*European Forest Institute, Finland; moiseyev@efi.int*), Solberg, B. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*), Michie, B. (*USA; bruce.michie@usa.net*), Kallio, A.M.I. (*Finnish Forest Research Institute, Finland; maarit.kallio@metla.fi*).

The impact of using alternative measures to curb EU imports of illegal wood are compared based on the simulation runs of the EFI-GTM global forest sector model. Four policy options are considered: 1) Baseline Scenario – Voluntary Partnership Agreements (VPA) between EU and six countries, 2) Option 1 – expanded VPAs increased to include 12 countries covering most of the sources of illegally traded wood, 3) Option 3 – border control actions stopping illegal imports from all non-EU countries entering into the EU, 4) Option 4 assumes that all illegal wood coming both from the EU and non-EU countries is eliminated. The first Baseline option has the strongest impacts with respect to reduced harvests and industrial production, in particular, in the baseline VPA countries. Under the Option 1 scenario all VPA countries are expected to suffer from lowering of harvests and production. The low and high/moderate risk countries increase their harvests, production and value added. These positive changes are substantially more significant, since the suggested 12 VPA countries cover most of trade of illegal wood. Under Option 3 & 4 the impacts are rather minor, since these options do not foresee elimination of illegal logging for high-risk countries under VPA arrangements.

B-12 Sustaining tropical timber species: is science making a difference?

Organizer: Sheila Ward. *Mahogany for the Future, Puerto Rico, USA seward@caribe.net.*

Are molecular data influencing forest management? Results from American and African species. Cavers, S. (*Centre for Ecology and Hydrology, United Kingdom; scav@ceh.ac.uk*).

The development over the past 20 years of diverse and accessible molecular tools for studying population genetics has generated a large amount of data on tree species. Much of this work has been justified on the grounds that it will help to guide management and conservation of forests. It is true that significant advances in understanding have been made, and both generalisable guidelines and species-specific data are available. However, the impact of these studies on forest management is hard to quantify. Using results from a series of international projects, a brief review of potentially useful guidance for management of tropical forest genetic diversity will be presented. Subsequently, the following questions are addressed: Are current research priorities generating the 'right' sort of information? For example, the most existing data derive from non-coding markers, providing information on selectively neutral population processes, but should greater focus now be placed on coding markers? Are results making a difference to (or even reaching) the practitioner? How effective is communication between the academic and forestry communities? Is the academic community adequately assessing its impact on forest management?

Verifying the geographic origin of mahogany (*Swietenia macrophylla* King) with DNA-fingerprints. Degen, B. (*VTI, Institute of Forest Genetics, Germany; bernd.degen@vti.bund.de*), Ward, S. (*Mahogany For The Future Inc, USA; seward@caribe.net*), Navarro, C. (*Universidad Nacional, Costa Rica; carlosmanuelnavarro@gmail.com*), Cavers, S. (*Centre for Ecology and Hydrology, UK; scav@ceh.ac.uk*), Sebbenn, A. (*Instituto Florestal de São Paulo, Brazil; alexandresebbenn@yahoo.com.br*).

Illegal logging is one of the chief causes of worldwide deforestation that, by releasing green-house-relevant gasses, contributes to climate change. Moreover, trade with illegal timber and wood products creates market disadvantages for products from sustainable forestry. Although various measures have been established to counter illegal logging and the subsequent trade, we lack practicable mechanisms to identify the origin of timber and wood products. Using eight nuclear microsatellites as DNA-fingerprints we have created the basis of a genetic reference database for determining the geographic origin of Mahogany timber in Latin America. We have sampled leaves from 1589 trees from 26 stands from Mexico to Bolivia. We found more than 150 different genetic variants (alleles), a strong genetic differentiation, and a clear correlation between genetic and spatial distances among stands. Based on differences in allele frequencies it was possible to achieve statistical assignment of unidentified individuals (e.g. wood probes) to stands, regions, or countries. Using anonymous wood samples from timber traders we demonstrated the power of the DNA-fingerprints to determine geographic origin. We will discuss the applicability of this technique to the tropical timber trade in general.

Using the genetic diversity of mahogany and Spanish cedar in plantations in Costa Rica. Navarro, C. (*Universidad Nacional, Costa Rica; carlosmanuelnavarro@gmail.com*), Ward, S. (*Mahogany For The Future Inc, Puerto Rico; seward@caribe.net*).

Swietenia macrophylla (big-leaf mahogany) and *Cedrela odorata* (Spanish cedar) are among the world's highest-value timber species. Extraction of these woods has been mainly in natural forests, and inadequate management of logging and regeneration has caused the depletion of many populations. One of the best options for satisfying the high demand for these species is plantations using techniques for producing high yields. Plantations of these species can also yield 10 times more return than pines or *Eucalyptus* for coffee farmers and other forestry operators, and can be competitive with conversion of forest to other crops. Based on patterns of genetic variation observed in microsatellite analysis and common garden experiments (neutral and adaptive markers), selection of mahogany for plantations and Spanish cedar for coffee shade is now being done in Costa Rica in conjunction with local producers. For example, seed sources are being selected for *C. odorata* that are best adapted to location, and for *S. macrophylla* that extend its use beyond the natural altitudinal range of local sources.. Tested Spanish cedar is now being cloned to for use as coffee shade over extensive areas by a Costa Rican company. Choice of materials for plantations must keep in mind future climate change.

Application of mahogany and Spanish cedar research in Mexico. Negreros-Castillo, P. (*Universidad Veracruzana. Mexico; pnegreroscastillo@yahoo.com*).

Research institutions normally support the dissemination of forest research results through peer-reviewed articles, which are usually out of reach of people who make their living or part of their living from forests, especially in developing countries. In Mexico some forest advisers/consultants have a long-term (in some cases more than 20 years) relationship with forest owners that can help overcome this problem. For example, in Quintana Roo in the late 1980s, enrichment plantings were done under forest canopies and in openings to replenish mahogany (*Swietenia macrophylla* King) and Spanish cedar (*Cedrela odorata* L.). A study, requested by forest advisers, to evaluate the success of the practice revealed that enrichment planting was unsuccessful under forest canopies but successful in openings. When the forest advisers informed the forest owners, planting under forest canopies was almost immediately abandoned, and enrichment planting was limited to sites that were at least 75% open. The almost immediate application of research results was possible because of the relationship of researchers to forest advisers and forest advisers to forest owners. Researchers need to reach out to forest advisers to establish a relationship that will encourage advisers to raise important concerns and be receptive of research findings.

Dynamics and developments of timber trees in different production systems in the high forest zone of Ghana. Oduro, K.A. (*Forestry Research Institute of Ghana, Ghana; kwameoduro@gmail.com, koduro@csir-forig.org.gh, Kwame.oduro@wur.nl*), Mohren, G.M.J. (*Wageningen University, The Netherlands; frits.mohren@wur.nl*), Kyereh, B. (*Kwame Nkrumah University of Science and Technology, Ghana; kyerehb@gmail.com*).

Decline of timber resources in the high forest zone (HFZ) has reached a critical stage in the history of forestry in Ghana. Forest resources are over-exploited and degraded, and future timber production prospects and sustainable forest management are of concern. Timber harvests come from different production regimes in HFZ, namely forest reserves and off-reserve areas (farmlands, fallow, and secondary forest patches). Restoration and reforestation efforts have been promoted in off-reserve areas and in degraded forest reserves using various schemes. However, information is scarce on how timber trees develop in HFZ and the factors affecting such development. This paper presents an assessment of timber trees planted under various schemes in different production regimes. It identifies and discusses factors affecting timber tree development. Data were collected on factors and management practices affecting tree development on farmlands through inventory of trees within different timber production regimes and personal interviews with 175 farmers randomly selected from five communities in four forest districts in Ghana. Results show that factors affecting tree development are economic, political, social, and ecological in nature. Incentive schemes motivate tree planting, and the sort of incentive scheme significantly affects how timber trees are managed and develop.

Integrated approach to restore African mahogany in Ghana's forest estate. Opuni-Frimpong, E., Owusu, S.A., Kwakye, L.A. (*Forestry Research Institute of Ghana, Ghana; eopunifr@mtu.edu; soachie@gmail.com; ameyawkwakyelord@yahoo.com*), Storer, A.J. (*Michigan Technological University, USA; storer@mtu.edu*).

Afro-tropical forest loss has exceeded that occurring elsewhere and threatens rare and high valued economic trees like the African mahoganies. Inventories available in Ghana indicate that the mahoganies will become commercially extinct at the current rate of exploitation if consistent effort is not made to restore these valuable species in degraded forests. Exacerbating the situation is the inability to establish mahogany plantations in their native range as a result of attack by the *Hypsipyla* shoot borer. Studies started about a decade ago have stimulated huge interest in replanting of African mahogany by industries, communities, and government-supported plantations, as we begin to manage for the impact of the *Hypsipyla* in these plantations. Our silvicultural trials were mostly conducted on farmers' fields, making the results readily available for implementation. The beneficial association between ants and mahogany trees in managing *Hypsipyla* as a biological control tool has been encouraging in most of our

plantations. Mechanisms to operationalize the vegetative propagation of the field tested *Hypsipyla*-tolerant mahogany trees are being put in place. Investors in plantations adopting our research findings have planted at least 40 hectares of mahogany in mixed plantations each year for the past 3 years in Ghana.

Occurrence and pressure of logging through forest management in Acre State, Brazil. Thaines, F. (*Tecman Consultoria, Brazil; fabio.tecman@gmail.com*), Braz, E.M., Mattos, P.P. (*Embrapa Florestas, Brazil; evaldo@cnpf.embrapa.br; povoa@cnpf.embrapa.br*), Oliveira, M.V.N., Ribas, L.A. (*Embrapa Acre, Brazil; mvno@cpafac.embrapa.br; laribas@cpafac.embrapa.br*), Thaines, A.A.R. (*RTC Florestas, Brazil; ribeirothaines@hotmail.com*).

The management of tropical forests has evolved over the years from the application of silvicultural treatments to techniques for reduced impact logging. To ensure the sustainability of any management plan, it is necessary to know the distribution, structure, and potential of the species to be managed. Among the criteria to be considered in a management plan are environmental and forestry legislation. Due to the lack of technical information on the sustainability of their exploitation, many Brazilian species with economic potential have been listed as endangered as a preventive policy. We assessed the geographical distribution and population structure of *Amburana cearensis* var. *acreana.* We also evaluated timber use as a pressure based on analysis of management plans for sustainable forestry, thereby contributing to decisions about its endangerment. The sustainable cutting rate was also calculated according to the cycle length estimated from periodical annual increment (PAI) and available volume. Results did not corroborate that this species is endangered in Acre State. However, a reduction of the cutting rate is recommended, since it is currently above sustainable rates.

Posters

Olfactory cues of female *Hypsipyla robusta* (Moore) (Lepidoptera: Pyralidae) to mahoganies of the genera, *Entandrophragma* and *Khaya*. Abraham, J. (*University of Goettingen, Germany; jonnieabraham@gmail.com; jabraha@ufobi6.uni-forst.gwdg.de*), Angeli, S. (*Free University of Bozen, Italy; sergio.angeli@unibz.it*), Schuetz, S., Weissbecker, B. (*University of Goettingen, Germany; stefan.schuetz@forst.uni-goettingen.de; bweissb@gwdg.de*), Opuni-Frimpong, E. (*Forestry Research Institute of Ghana; eopunifr@mtu.edu*).

The mahogany shoot borer, *Hypsipyla robusta* (Moore) (Lepidoptera: Pyralidae), is a serious pest insect attacking and damaging indigenous mahogany plantations. It is believed that *H. robusta* relies on olfaction and that gravid females are attracted by volatile compounds of mahogany trees. This research was conducted to determine which volatile compounds influence the attack of mahogany trees in the genera *Entandrophragma* and *Khaya*. Volatile samples were collected from shoots of *Entandrophragma angolense*, *E. utile, Khaya anthotheca* and *K. ivorensis* in field and laboratory studies in Ghana by closed loop stripping analysis (CLSA). Gas chromatography-mass spectrometry, electroantennographic detection, and electroantennogram experiments were performed with the volatile samples. The results revealed significant responses of the female moth antennae to 1-hexanol, 2-ethyl-1-hexanol, *ß*-caryophyllene, *cis-ß*-ocimene, *cis*-3-hexenyl acetate, *cis*-3-hexenyl butyrate, *cis*-3-hexenyl hexanoate, decanal, germacrene D, naphthalene, and nonanal. Dose-response curves of electroantennogram responses for these compounds showed that female *H. robusta* are able to perceive 1-hexanol and nonanal at very low concentrations. We therefore propose that these compounds may serve as long-range attractants for female *H. robusta* to mahogany host trees and may be used as trap baits.

***Pericopsis elata* (Harms) Meeuwen in southeastern Cameroon: ecological and pedological approaches to improve the management of an endangered commercial timber species.** Bourland, N.; Kouadio, Y. L.; Colinet, G.; Doucet, J.-L. (*University of Liège, Belgium, nils.bourland@aigx.be; fortrop@fsagx.ac.be; Gilles.Colinet@ulg.ac.be; jldoucet@ulg.ac.be*).

Pericopsis elata (gregarious *Fabaceae*), a moist semi-deciduous hardwood logged in Central African forests, is on the IUCN Red List and in CITES Appendix II. Our study evaluated its main ecological and pedological parameters in Cameroon. We obtained a mean diameter increment of 0.32 ± 0.04 cm.year^{-1}. Minimum fertile and effective fruiting diameters were 32 and 35 cm, respectively. Flowering started in March-April, and fruits ripened over 7 months. Seed rain was studied in 1 × 45 m cleared corridors in each cardinal direction around 4 isolated mother trees. Indehiscent pods (average weight: 131.6 ± 10.1 cg) were dispersed mainly to the west: 86% of the variation of the number of collected fruits could be explained by the distance to the mother tree and the direction (GLM analysis, $p < 0.001$). The proportion of seeds eaten by insect larvae depended on the mother tree (10–95% – $\chi 2$ test, $p < 0.001$). Soils were compared at a regional scale: soils with *P. elata* contain higher levels of C (2.2 ± 0.5 SD- g.100g^{-1}), Fe (261 ± 83 mg.kg^{-1}), and P (33 ± 10 mg.kg^{-1}), and were more acidic (pH 4.0 ± 0.2). A planting method in logging gaps is currently being tested taking into account physicochemical soil parameters

Neutral and selective drivers of diversity in *Cedrela odorata*: a rangewide study. Cavers, S., Telford, A. (*Centre for Ecology and Hydrology, United Kingdom; scav@ceh.ac.uk; annt@ceh.ac.uk*), Arenal Cruz, F. (*Instituto de Investigaciones Forestales, Cuba; arenal_cruz@yahoo.es*), Navarro, C. (*Universidad Nacional, Costa Rica; carlosmanuelnavarro@gmail.com*), Valencia, R. (*PUCE, Ecuador; LRVALENCIA@puce.edu.ec*), Buonamici, A., Vendramin, G.G. (*CNR-IGV, Italy; anna.buonamici@unifi.it; giovanni.vendramin@igv.cnr.it*).

Spanish cedar (*Cedrela odorata* L.) is a globally important tree species that has been heavily exploited throughout its natural range for more than 200 years. Its high-quality timber is still highly valued and widely used, most famously for Cuban cigar boxes. Continued demand, in conjunction with forest clearance and fragmentation, means that natural populations have now become seriously degraded, despite the species' ability to regenerate strongly. There is considerable interest in evaluating and understanding the drivers of genetic diversity in the species for conservation and improvement purposes. Recent work has demonstrated non-coincident phylogenetic subdivision and phenotypic differentiation of the Central American populations, showing the influence of both population history and selection on contemporary genetic diversity. However, the species is distributed across the neotropics, including the Caribbean and South America as far south as northern Argentina. We present new work that reassesses previously identified population structure using additional organellar and nuclear markers. This new work extends coverage to the full distribution of the species to address the significance of the Andean division, island populations in the Caribbean, and hypotheses on the direction and timing of range expansion.

Genetic improvement of *Swietenia macrophylla* (mahogany). Corea, E., Navarro, C. (*Universidad Nacional, Costa Rica; eugeniocorea@hotmail.com; carlosmanuelnavarro@gmail.com*).

Research to confront the attack of *Hypsipyla grandella* in mahogany have focused principally on the tree and have generally omitted its genotype, without satisfactorily solving the problem. INISEFOR initiated a project for identifying genotypes of mahogany with rapid growth and high capacity to respond to attack. A nursery experiment was carried out with 168 families from 10 provenances. The main stems were cut manually to simulate *Hypsipyla* attack, and tree height growth and the number of new sprouts were subsequently measured. The results showed significant differences among provenances and families for both variables. In 19 families, more than 90% of the trees produced only one vigorous sprout after decapitation. The best trees from the best families were cloned and established in a common garden with 300 promising clones, which will be evaluated in 2010 in clonal field trials. It is hoped that the use of superior clones, together with adequate management techniques, will permit the development of technological kits for the sustainable cultivation of this species, especially in agroforestry systems.

***Hypsipyla* shoot borers on red cedar in Australia–the search for resistance.** Griffiths, M.W., Hayes, R.A., Mills, J. (*Department of Employment, Economic Development and Innovation, Australia; manon.griffiths@deedi.qld.gov.au; andrew.hayes@deedi.qld.gov.au; jacinta.mills@deedi.qld.gov.au*).

Worldwide, shoot borers in the genus *Hypsipyla* are the greatest deterrent to growth of high-value trees of the family Meliaceae. In the Asia/Pacific region, damage from *H. robusta* has effectively prevented the commercial growing of the endemic *Toona ciliata* and *Chukrasia* spp. During Australian field trials damage to *T. ciliata* was intense, and all trees were attacked within a few years. However, there were differences between seedlots and individual trees in the frequency of damage and subsequent growth performance. Clonal trials incorporating the better-performing trees were again heavily attacked but revealed genetic differences in oviposition rates, larval performance, and recovery following damage. Although not providing complete resistance, the presence of heritable traits offers potential for future breeding. The results of these trials form the basis for ongoing chemoecology work. In particular, investigation is being carried out on the host location cues for this specialist feeder so adept at locating its hosts over long distances and in complex environments. The identification and subsequent testing of these plant chemicals will provide valuable information on the insect's host location and selection processes, as a first step towards developing host-plant based lures to aid in the monitoring and management of this pest.

Sustainable production of African mahogany: effect of anatomy, stock-plant age, and potting media on rooting of leafy stem cuttings of *Khaya* and *Entandrophragma* species. Owusu, S.A., Opuni-Frimpong, E., Ebanyenle, E. (*Forestry Research Institute of Ghana, Ghana; soachie@gmail.com; eofrimpon@csir-forig.org.gh; ebanyenle@csir-forig.org.gh*), Antwi-Bosiako, C. (*Kwame Nkrumah University of Science and Technology, Ghana; cantwiboas@yahoo.com*).

The relationships among anatomical properties, species identity, age of stock-plant, and potting-media, and the growth of leafy stem cuttings of *Khaya grandifoliola, K. ivorensis, Entandrophragma angolense,* and *E. utile* were investigated. Results showed significant differences in vessel proportions, and width and length of fibre and vessel elements, in relation to juvenility or maturity of the mahoganies. This suggests that variation in shoot anatomy can be used as a reliable marker of juvenility/maturity in mahogany propagation. Root formation was highest and fastest (2 weeks) in the *Khaya* spp. than in the *Entandrophragma* spp. (8 weeks). *K. grandifoliola* had the highest and fastest rooting in single node leafy stem cuttings amongst the four species. In *K. grandifoliola,* rooting of cuttings decreased as age of stock-plants increased from 1 year to 12 years. The effect of rooting media on rooting of cuttings varied with the mahogany species. Rooting and survival of the *Khaya* spp. were not significantly affected by the rooting media used; however, survival was lowest in top-soil for the *Entandrophragma* spp. Survival and rooting of cuttings was lowest in *E. utile,* which also had the least rooting in all three rooting media used.

Leaf ecophysiological responses in six dipterocarp timber species to strong light conditions in Peninsula Malaysia. Yoneda, R., Kenzo, T. (*Forestry and Forest Products Research Institute, Japan; joneda@affrc.go.jp; mona@affrc.go.jp*), Alias, M.A., Majid, N.M. (*Universiti Putra Malaysia, Malaysia; azani@putra.upm.edu.my; nik@forr.upm.edu.my*).

Leaf photosynthetic responses to strong light condition were studied on six dipterocarp species (*Neobalanocarpus heimii* (*Nh*), *Shorea curtisii* (*Sc*), *S. leprosula* (*Sl*), *S. macroptera* (*Sm*), *S. resinosa* (*Sr*), and *S. singkawang* (*Ss*)) in Peninsula Malaysia. All seedlings were fostered in the nursery where the light intensity was controlled at approximately 6%. Five seedlings for each species were transferred to an open site and their ecophysiological traits were monitored. Leaf photosynthetic rate at light saturation (A_{max}), leaf nitrogen content, maximum photochemical efficiency of photosystem II (Fv/Fm), and leaf osmotic potential (ψ_o) were measured before transfer and 3 days, 1 week, 1 month, 2 months and 3 months after transfer, respectively. A_{max} and Fv/Fm decreased dramatically for all seedlings after transfer to strong light, although different recovering responses from the stress were observed among species. For example, almost all leaves of *Sl* fell under the strong sunlight, but the newly flushed leaves had the highest A_{max}. In contrast, leaves of *Nh* did not fall and values of A_{max} and Fv/Fm recovered slightly. The ψ_o of *Nh* increased after the treatment to maintain leaf water under strong sunlight. These results will improve the planting techniques for degraded tropical forest in Malaysia.

B-13 Speaking with one voice – scientists and stakeholders in forestry

Organizers: Daniela Kleinschmit, *Swedish University of Agricultural Sciences, daniela.kleinschmit@sprod.slu.se*; Ingwald Gschwandtl, *Federal Ministry of Agriculture, Forestry, Environment and Water Management*, *Austria, ingwald.gschwandtl@lebensministerium.at.*

Turning the tide? The European Forest Week 2008 as a communication case. Janse, G. (*Swedish Forest Agency, Sweden; gerben.janse@skogsstyrelsen.se*).

In Europe, the forest sector faces difficulty in reaching other policy sectors in trying to influence their policy-making, which more and more takes over the "traditional forest policy field." Moreover, public opinion does not reflect the actual state of Europe's

forests. In general, forests and sustainable forest management (SFM) seem to be poorly understood by everyone outside the forest sector. European Forest Week 2008 (EFW) was an attempt by intergovernmental bodies involved in forest policy in Europe to increase the visibility of the forest-based sector; to raise awareness of forests' contributions to mitigating climate change, providing freshwater, protecting the environment; and to increase understanding of SFM. Ultimately, this was supposed to lead to other policy sectors' (energy, climate, environment, etc.) engagement in a participatory dialogue on forest-related issues. Against this background I will explore why it is that forests, forestry, and forest policy are perceived as major communication challenges. I will take a closer look at the science-policy interface, intersectoral communication, and forest advocacy. I will partly found my exploration of the theme on the European/EU policy making arena and the position of forest policy. Based on the specific character of forest policy I will identify some key communication challenges.

Forestry communication model: case study in Slovakia. Marusakova, L., Sarvas, M., Vanco, M. (*National Forest Centre, Slovakia; marusakova@nlcsk.org; sarvas@nlcsk.or; gvanco@nlcsk.org*).

The paper deals with forestry communication and explains what role communicative processes play for positive perception of the forestry sector. The paper analyzes the specifications and layout of communication in forestry and identifies main actors and target groups involved in Slovakia. SWOT analysis was used to identify strengths, weaknesses, opportunities, and threats of communication in the forestry sector. The results of research on effectiveness of communication tools used by forestry bodies are presented in the paper. Forest-related environmental education (FREE) is introduced as an example of an effective way for informing the public about sustainable forest management and increasing awareness about the importance of forests for environment and society. The main obstacles and challenges in FREE are identified. Models of management of communication process and integrated marketing communication tools are introduced in the paper as a way to strengthen effective and proactive forest inter-sectoral cooperation and communication. The Communication Strategy of the National Forest Centre is used as an example of a systematic concept based on mixture of activities and cooperative actions in the field of forest research, public relations, education, and consultancy, which are carried out by the organization.

Recognition of stakeholders in management of a forest science organization. Miner, C.L., Barbour, J. R. (*U.S. Forest Service, USA; clminer@fs.fed.us*; *jbarbour@fs.fed.us*).

The Pacific Northwest Research Station is a subunit of the U.S. Department of Agriculture, Forest Service research program, with about 90 scientists. In 2009, the station reorganized to improve its responsiveness through flexibility and by becoming more efficient. The effort was based on strategic planning with input from stakeholders gathered in summer 2007. Stakeholders asked for the benefits of long-term research, with an outcome of development of knowledge and tools for immediate application to issues. The station developed foundational themes of ecological processes and function; land and watershed management; threat characterization and management; goods, services, and values; and forest resources monitoring and assessment. These themes are linked to short-term priorities that help direct the work of scientists. Since 2007, however, the nature of key issues and their interconnections have changed along with priorities. In 2010, given its new approach and organization, the station asks what defines its stakeholders, what constitutes success in their support of the station, and how is success described over time and across a dynamic social landscape? This presentation describes a framework used to address these questions and methods for measuring stakeholder support over time. The potential of this framework for adoption by other organizations is described.

Posters

The role of forestry scientists in the decision-making process. Nurrochmat, D.R., Darusman, D, Ekayani, M. (IPB/*Bogor Agricultural University, Indonesia; dnrochmat@yahoo.com; akecuina@cbn.net.id; metieka@yahoo.com*).

There has been a long debate about the roles of scientists in policy-making process. In differentiating with the other stakeholders, the role of scientists is to provide the possibilities, instead of deciding between the possibilities. It means that scientists expect to gather facts and provide predictions to current and proposed policies rather than to determine policies. In the forest policy-making arena, forestry scientists are seeking to play a positive role in policy-making and contribute to a better process and results of policy. In fact, however, forestry scientists are playing a minor role in a public discourse; for example, the contribution of scientists through their statements about forest fire in the global public media was only about 12% and in the Indonesian public media even less than 3%. Enhancing the role of forestry scientists is required because it is critically important in a functioning democracy and to achieve a better forest policy. The objectives of this paper are to understand the various views of scientists in defining forestry problems and to evaluate the role of forestry scientists to contribute in the policy-making process in Indonesia.

Collaboration between scientists and journalists in forest communication. Park, M.S. (*Seoul National University, Republic of Korea; mpark@snu.ac.kr*).

In the process of forest communication, stakeholders in forestry can cooperate with each other to achieve their goals. South Korea provides an example of collaboration between scientists and journalists. The Korean daily newspaper, *Hankyoreh,* designed a special series on nature conservation titled *Let's keep the places: Urgent appeals to conserve the ecosystem,* in 1991–1992 and in 2003. Journalists and scientists conducted field trips to survey environmental and social situations and published the series weekly, consisting of a report by the journalists and a column by the scientists. The series not only reported the destruction of the ecosystem but also criticized the inattentiveness of the government to the need to conserve and manage ecosystems. Actually, the seven reported places were incorporated into ecosystem protection zones. In this case, the scientists and journalists contributed to the decision-making on these areas by putting them at the center of the political system. The media's agenda was developed into a policy agenda. This phenomenon reflects the Habermasian theory of power, wherein the government translates civil society's communicative power into administrative power. It is a bottom-up process from the periphery to the center of the political system.

Best practices examples of forestry communications in Slovakia. Sarvaš, M., Marušáková, L., Vančo, M., Hrbáĺ, P. (*National Forest Centre, Slovakia; sarvas@nlcsk.org; marusakova@nlcsk.org; vanco@nlcsk.org; hrbalvnlcsk.org*).

The poster presents successful projects dealing with communication in forestry sector in Slovakia. National Forestry Days presented in the poster are the greatest event prepared by a coalition of forestry institutions for broad public. Mutual projects

provide the potential to speak with one voice, to concentrate attention on set aims and target groups, to save money and human resources. Globally common activities and mutual cooperation increases the effectiveness of communication processes and enable us to reach a broad public. National Forestry Days focuses on forming positive attitudes and perceptions of forests and the forestry profession. One of the purposes of this poster is to analyze the core activities and main actors involved into the project. SWOT analyses–strengths, weaknesses, opportunities, and threats–of the project made by main actors, stakeholders, and responsible bodies will be presented. The results of research on feedback of project attendants will be mentioned in the poster as well as on the project web page. Other proved projects and events such as forest-related environmental education, forest educational trails, the Forestry Open Air Museum, and examples of media communication are also mentioned.

B-14 Multiple-use management and sustained use of tropical production forests

Organizers: Plinio Sist *Cirad, France, sist@cirad.fr*; Manuel Guariguata, Robert Nasi, *CIFOR, Indonesia, r.nasi@cgiar.org, m.guariguata@cgiar.org.*

Developing tools for monitoring biodiversity in forest carbon projects: lessons from timber certification. Arnhem, E., Ransom, C., Kümpel, N.F. (*Zoological Society of London, United Kingdom; eric.arnhem@zsl.org; chris.ransom@zsl.org; noelle.kumpel@zsl.org*).

Biodiversity–in particular, keystone species such as seed dispersers and pollinators–is critical for the long-term viability of tropical forests. Maintenance of biodiversity will, therefore, be an implicit if not yet explicit element of an international agreement for reducing emissions from deforestation and forest degradation (REDD) under the United Nations' Framework Convention on Climate Change, and there is potential for 'biodiversity carbon' credits to be sold for a premium under the voluntary carbon market. However, measurement and monitoring of biodiversity are often technically and financially prohibitive, so simple, cheap, and scientifically robust biodiversity indicators and methods of monitoring them are needed. Using data collected in forest concessions in Ghana and Cameroon to help companies to improve their wildlife management as part of the timber certification process, we compare the efficacy and utility of monitoring a broad selection of taxa using direct and indirect methods including camera trapping, line transects, and recce surveys, and discuss their applicability for monitoring biodiversity in REDD projects under different types of management. These include other projects being developed by the Zoological Society of London (ZSL) in Indonesia and the Democratic Republic of Congo, alongside protected area authorities, local communities, and the private sector.

Evaluating the opportunities and barriers to multiple-use forest management in Western Amazonia. Guariguata, M.R. (*Center for International Forestry Research, Indonesia; m.guariguata@cgiar.org*), Duchelle, A.E. (*University of Florida, USA; duchelle@ufl.edu*), Less, G. (*Universidade Federal do Acre, Brazil and WWF, Brazil; giuliano.less@yahoo.com.br*).

Multiple-use forest management (MFM)—which includes timber, non-timber forest products, and environmental services—is considered a promising tropical conservation and development strategy; however, empirical research on assessing the viability of implementing MFM is largely lacking. In the tri-national frontier region of Madre de Dios, Peru; Acre, Brazil; and Pando, Bolivia, in western Amazonia, we evaluated perceptions of representatives from four stakeholder groups–communities/cooperatives, non-governmental organizations, government agencies, and industries–on integrated management of timber and Brazil nuts (from the canopy tree *Bertholletia excelsa*) at the community and industrial scales. A strengths, weaknesses, opportunities, and threats (SWOT) analysis was used to accomplish this task in combination with an analytic hierarchy process (AHP). Overall, results showed that capacity-building of producers and foresters was considered the dominant strength of integrated management of Brazil nuts and timber, and high management costs and policy barriers were considered the main weaknesses. In Madre de Dios and Pando, logging damage to Brazil nut stands was the dominant threat, whereas in Acre the main threat was reinvestment of forestry income into cattle expansion. We used these results as a platform for a tri-national multi-stakeholder workshop to identify research and development interventions toward policy change.

Fruit production of *Carapa guianensis:* a multiple-use timber species of the Amazon forest. Kanashiro, M. (*Embrapa Amazônia Oriental, Brazil; milton@cpatu.embrapa.br*), Melo, S.M., Almeida, E.C. (*Ministry of Environment, Brazil; marcelo.smelo@gmail.com; evertonselva@yahoo.com.br*), Ruschel, A.R. (*Embrapa Amazônia Oriental, Brazil; ruschel@cpatu.embrapa.br*), Sist, P. (*CIRAD, Brazil; plinio.sist@cirad.fr*).

Carapa guianensis is a multiple use monoecious species commercially used both for its high timber value and for the oil extracted from its seeds. This species is widely distributed throughout the Amazon, with spatial clumped pattern. Fruit production generally occurs during the rainy season from February to March, although scarce production occurs throughout the year. In the region of Santarém (Brazil), we monitored 101 trees with dbh ≥10 cm during the fruit dispersion peak season, which occurred from February to March 2009. Fruit production was assessed according to characteristics such as diameter at breath height (dbh), crown form, crown position, and presence of lianas. On average, 65% of the trees produced fruits, and the average production per tree was 7.5 kg of seed. However, individuals with 30–60 cm dbh showed the highest mean production (8.6 kg/tree), whereas smaller (10–30 cm dbh) and larger trees (dbh > 60 cm) produced significantly fewer fruits. Our results suggest that trees with dbh 30–60 cm should be preferred for seed collection and preserved from logging, while larger individuals with dbh > 60 cm could be selected for logging.

What is the potential role of carbon payments in adding value to timber-oriented approaches? Mazzei, L. (*CIRAD/CAPES, Brazil; picmazzei@yahoo.com.br*), Piketty, M.G. (*CIRAD, France; marie-gabrielle.piketty@cirad.fr*), Sist, P. (*CIRAD/EMBRAPA, Brazil; sist@cirad.fr*), Gourlet-Fleury, S. (*CIRAD, France; sylvie.gourlet-fleury@cirad.fr*).

In the Brazilian Amazon, sustainable extraction of non-timber forest products is in many regions poorly developed. Markets for such products are rare and often incomplete. That is one of the reasons why forest management remains very often focussed exclusively on timber production. Additional forest resources valorisation may have to be found through the remuneration for the

environmental services sustainable timber management may provide. Implementation of planned logging, better known as reduced-impact logging, instead of predatory logging in tropical forests not only significantly reduces carbon emissions but also stimulates natural regeneration and biomass accumulation. In this study, we address the question of how logging affects the carbon balance on a long-term basis in a tropical forest in eastern Pará (Brazil). Our objectives were to predict the impact of different logging intensities on the time needed for this forest to recover its initial above-ground biomass. If carbon-neutral logging is desired and the 30-year minimum cutting cycle defined by Brazilian law is adhered to, current logging intensities (6 trees ha^{-1}) need to be reduced by 40–50%. We assessed how such a reduction in logging intensity will reduce financial incomes, and how it might be compensated for by payment for environmental services.

Managing for both timber and biodiversity in the Congo Basin. Nasi, R. (*CIFOR, Indonesia; r.nasi@cgiar.org*), Billand, A. (*CIRAD, France; alain.billand@cirad.fr*), Vanvliet, N. (*France; vanvlietnathalie@yahoo.com*).

Multiple-use forest management is considered by many as a preferable alternative to single-use (generally timber-dominant) management models. In the Congo basin, integration of timber and non-timber forest resources plays a key role in the subsistence and market economies of rural communities. However, this is largely happening as an informal sector economy. Managing for multiple use in "legally" designated land-use types (e.g., logging concessions) appears hampered by the spatial overlap of different interests and bargaining power, the multiple (often antagonist) uses of some favorite timber species, inadequate institutional support, inappropriate policies and incentives, poor law enforcement, and unclear tenure and use rights. We explore the management models in Central Africa logging concessions and the possibilities for actively managing both timber and biodiversity with a special emphasis on residual timber stands, wildlife, and certification. A few promising but 'unfinished' examples do exist in the region and we review these cases to draw lessons and recommendations. We contend, however, that true multiple-use could only be realized through new innovative land-use units, allowing a spatial cohabitation of the interests of local people, conservation proponents, and extractive industries in the same unit with an optimized and equitable share of the various goods and services.

Multiple use forest management strategies in Ghana: opportunities and challenges. Oduro, K.A., Marfo, E. (*Forestry Research Institute of Ghana, Ghana; kwameoduro@gmail.com; emarfo@csir-forig.org.gh*), Kyereh, B. (*Kwame Nkrumah University of Science and Technology, Ghana; kyerehb@gmail.com*), Britwum Acquah, S. (*Forestry Research Institute of Ghana, Ghana; sbritwum@csir-forig.org.gh*).

Interests in tropical forests vary. While some assert that forests are needed for wildlife and watershed protection and to store carbon, others depend on forests for wood, food, recreation and aesthetics. In Ghana, attempts at managing forest resources for multiple uses have not been very satisfactory, although past forest management strategies have generally aimed at capturing all important uses for the benefit of society. Past efforts towards planning and management of forest resources for multiple use have led to a dwindling and degrading forest resource base. Since 1994, however, new attempts have been made to manage the forests for multiple uses. These were backed by a new forest and wildlife policy and a forestry development master plan that highlight the critical importance of multiple use of forests, with the overall aim of achieving sustainable forest management in Ghana. This paper examines the strengths, weaknesses, opportunities, and threats of current policies with respect to multiple use forest management. It reviews existing management strategies for achieving multiple use on sustainable basis and highlights the main challenges in their implementation. The achievements and limitations of these strategies are discussed. The paper concludes with some recommendations for future research.

Multiple-use forest management in the tropics: between concept and reality. Sist, P. (*CIRAD, Brazil; sist@cirad.fr*), Guariguata, M. (*CIFRO, Indonesia; m.guariguata@cgiar.org*), Nasi, R. (*CIFRO, Indonesia; r.nasi@cgiar.org*), Sabogal, C. (*CIAT, Brazil; c.sabogal@cgiar.org*).

Multiple-use forest management (MFM) is widely considered a prime objective within the sustainable forest management paradigm. Multiple-use forest management systems are certainly a promising and potential answer for how to better integrate and accommodate all stakeholders interests in the forestry sector and how to conciliate timber production with other products and services of the producing forests. Although the conceptual and practical underpinnings of MFM in the tropics were laid out more than a decade ago, forest management systems are still dominated by selective logging, while other forest goods and services such as non-timber forest products, hydrological regulation, and carbon sequestration are still poorly considered as potential sources of income in management practices. Based on three regional assessments of practical experiences in MFM in the Amazon basin, Congo basin, and Southeast Asia, this paper presents the main factors limiting or promoting the implementation of such multiple-use forest management systems in the tropics. This assessment allows us to propose and discuss the main research priorities actions to promote multiple-use forest management systems in tropical rainforests.

B-15 Silvicultural systems for tropical forests: challenges and progress

Organizers: Robert Nasi, *CIFOR, Indonesia, r.nasi@cgiar.org;* Sylvie Gourlet-Fleury, *CIRAD, France*, sylvie.gourlet-fleury@cirad.fr.

A toolbox for developing silvicultural systems capturing nature's way towards sustainable forest management: analyses from a forest inventory in Gabon's tropical moist forest. Geldenhuys, C.J. (*University of Stellenbosch, South Africa; cgelden@mweb.co.za*).

How do we decide which silvicultural systems to apply–using forest or species characteristics? This paper presents the concept of using relative shade tolerance of different target species as a primary driver of tropical moist forest dynamics in stand recovery stages after disturbance, as basis for developing a suitable forest management system (silviculture). Some species regenerate and establish under closed forest canopies and others require large gaps to regenerate effectively. The basic tools are an appropriately

designed forest inventory followed by data analyses to capture the underlying ecological processes that determine species behavior, to develop an ecologically, socially, and economically appropriate sustainable forest management system. Data from an inventory of tropical moist forest in southern Gabon, Africa, were analyzed to calculate species importance in different forest communities, the relationship between regeneration and mature trees of canopy species in the same stand (grain or scale of ecological processes), and stem diameter distributions (population status) of targeted species across different communities. This informed the relevance of single-tree or group felling systems for different species within economic constraints of a shorter harvesting cycle and low-impact logging, and integrating farmer slash-and-burn agriculture within timber concession management to reduce deforestation and increase mutual benefits.

Scientific basis for plant diversity recommendations in Southeast Asian production rainforests. Gustafsson, L. (*SLU, Sweden; lena.gustafsson@ekol.slu.se*), Laumonier, Y. (*CIRAD, France; yves.laumonier@cirad.fr*), Nasi, R. (*CIFRO, Indonesia; r.nasi@cgiar.org*).

Dipterocarp rainforests are the main timber source in Southeast Asia. Under proper management these logged-over forests have a much larger potential to host a rich biodiversity than do timber plantations, but rigorous scientific bases are still needed for plant diversity maintenance under logging operations. We applied a systematic review protocol to analyze the scientific literature on the ecology of vascular plants, bryophytes, lichens, and macro fungi, and identify critical factors regarding forest structure, composition, processes, and habitat variation that are important for the formulation of biodiversity guidelines in an industrial logging context. Forestry gap-phase dynamics need to be fully understood for effective conservation actions in production. The large but often overlooked variation in habitats from individual trees and forest tracts to regional scales is also of special importance. It will be crucial for future conservation biology research directed towards forestry in Southeast Asia to acknowledge such variations, the importance of site-adaptation, and the effects of larger disturbance events such as drought, storms, or landslides, if the results are to contribute to better logging performances while preserving biodiversity.

The high value of logged tropical forests: lessons from northern Borneo. Hamer, K. (*University of Leeds, UK; k.c.hamer@leeds.ac.uk*).

Timber concessions cover about 20% of all tropical forests but are often viewed as having only low residual value after logging, in both economic and other terms. As a result, tropical production forests are coming under increasing pressure for conversion to other land uses such as agriculture and agro-forestry. However, such forests could play an important role in terms of landscape-scale sustainability, particularly if they are managed appropriately post-harvesting. Here, I use an extensive data-set from a single well-studied site in northern Borneo to examine impacts of selective logging and subsequent forest regeneration on both carbon stores and biodiversity across a wide range of plant and animal taxa. I then examine in greater detail how post-harvest management affects both species and functional diversity of selected groups. Results indicate that selectively logged forests can retain surprisingly high residual value in these terms, which may then be further enhanced by post-harvest rehabilitation. These data support the notion that international policy objectives relating to net carbon emissions and biodiversity are each likely to be more attainable through proper recognition of the full value of logged tropical forests.

Limits of selective logging techniques including RIL in tropical forests to sustain timber yields and to achieve sustainable forest management in general. Sist, P. (*CIRAD, Brazil; sist@cirad.fr*), Gourlet-fleury, S., Blanc, L. (*CIRAD, France; sylvie.gourlet-fleury@cirad.fr; lilian.blanc@cirad.fr*), Mazzei, L. (*Engref, Brazil; mazzei@cirad.fr*), Priyadi, H. (*CIFRO, Indonesia; h.priyadi@cifor.org*), Ruschel, A. (*Embrapa, Brazil; ruschel@cpatu.embrapa.br*).

Since the early 1950s, numerous silvicultural systems have been experimented in the tropics, particularly in Africa and Southeast Asia. However, most of the tropical countries adopted a polycyclic silvicultural system, also called selective logging. Over the past 2 decades, sets of timber harvesting practices known as reduced-impact logging (RIL), designed to mitigate the deleterious environmental impacts of logging operations, have been implemented mainly at the experimental scale in tropical forests. However, RIL techniques have also shown strong limitations in sustaining timber yield within a 30–40 year rotation as usually recommended in forest legislation in the tropics. Based on long-term forest dynamics monitoring of the impact of selective logging in permanent sample plots implemented in three continents (Central Africa, Indonesia, and Brazilian Amazon), this paper assesses the main impact of selective logging on forest dynamics and ecology of timber species. These results allow identification of the main limitations of selective logging, including RIL, to achieve both sustainable timber yield in particular and sustainable forest management in general in tropical forests. Silvicultural paradigms common to the three continents can be found, such as the need to limit logging intensity and to define specific minimum and maximum diameter cutting.

Integrating rural livelihood needs with silvicultural management for timber harvesting in Miombo woodlands. Syampungani, S. (*Copperbelt University, Zambia; syampungani@cbu.ac.zm*), Geldenhuys, C. (*Stellenbosch University, South Africa; cgelden@mweb.co.za*).

Rural livelihoods are closely linked with the woodland resources in the Miombo ecoregion in southern Africa. Rural economics are based on slash-and-burn agriculture, charcoal production, timber harvesting and non-wood products. Each land use type has both positive and negative impacts at either the species or stand level. The challenge is to integrate these land uses into sustainable woodland management. The paper reviews various ecological studies at individual species and forest ecosystem levels to understand the implications of each land use type in integrated sustainable woodland management. Examples of how each land use affects the status of individual species or forest ecosystem structure and function across the ecoregion are presented. Timber harvesting causes economic extinction of light-demanding timber species, decreases the livelihood of conspecific replacement, and increases the risk of collapse of natural successional pathways. Slash-and-burn agriculture and charcoal production increase exposure to sunlight, reduce competition for nutrients, and improve productivity of light-demanding timber species (improved silviculture). Finally, examples are provided on how fruit production can be integrated with woodland recovery stages arising from either slash-and-burn agriculture or charcoal production. The results offer alternative options to incorporate rural livelihood needs as a silvicultural tool in woodland timber management.

Silviculture and sustainability in the Meliaceae. Ward, S. (*Mahogany for the Future, Inc., USA; seward@caribe.net*).

Forest management must achieve multiple goals for production, biodiversity conservation, and sustainability under increasing environmental degradation, and address the divergent interests of stakeholders ranging from local communities to end users. In this difficult context the high-value tropical timber species of the family Meliaceae (true mahoganies) pose striking but illustrative management issues. Timber mining, short cutting cycles, low diameter limits, insect attack, and neglect of seed trees and conditions for regeneration all pose barriers to sustaining populations and genetic diversity of these species. For example, harvest is usually too high to allow a second rotation, while the forest openings created are usually too small for regeneration of these light-demanding species. The application and effectiveness of such measures as enrichment planting, *Hypsipyla* (insect that destroys apical meristems) management, and timber tracking from forest through consumer must be assessed. Meanwhile, timber sources change (with reduced supply from natural forests and increasing from plantations) and demand as influenced by price and conservation measures fluctuates. This talk will address practice and regulations for natural forest management, gaps in research and application of research results, and changing supply and demand. Success depends on balancing multiple tradeoffs among technology, policy, and the interests of multiple stake holders.

Posters

Clump structure and diameter growth of *Hopea recopei* and *Dipterocarpus obtusifolius* growing in a young secondary forest in Kampong Chhnang, Cambodia. Ito, S. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp*), Mizoue, N. (*Kyushu University, Japan; mizoue@ffp.kyushu-u.ac.jp*), Sokh, H., Ma, V. (*FWRDI, Cambodia; sokhhengpiny@yahoo.com; vuthydalin@yahoo.com*).

Community forestry has become an important issue in Cambodian forest management. To implement community forestry effectively and sustainably, continuous income generation for local villagers is crucial, and silvicultural systems for sustainable timber production as well as restoration of degraded forests are urgently needed. As the first step to propose a silvicultural system for degraded secondary forests, this study aims to clarify the growth traits of two major tree species, *Hopea recopei* (EN in IUCN Red List of Threatened Species) and *Dipterocarpus obtusifolius* in Kampong Chhnang, central Cambodia, in terms of the growth response of stems and individuals to inter- and intra-clump competition in young coppice stands. While there was no difference in mean dbh between two species, the variation was larger for *D. obtusifolius* than *H. recopei*. This may reflect more intensive stem competition within a clump for *D. obtusifolius*. Diameter increment of stems and basal area increment of clump were much larger for *H. recopei* than *D. obtusifolius*. This difference in growth between the two is likely to come from differing shade tolerance, which also relates to branching patterns and plasticity. These results would provide useful information for a management strategy for young coppice stands.

Experiment on intensive enrichment at a logging road in a natural production forest at the logged over area. Prameswari, D., Wahjono, D., Krisnawati, H. (*Forest and Nature Conservation Research and Development Center, Indonesia; diana_eko@yahoo.com*; *nh_p3hka@yahoo.co.id*; *haruni2000@yahoo.com*).

To anticipate the decrease of log production from natural forests, a program to develop forest plantation logged-over areas is required. Several logging programs have been implemented to sustain productivity; however, results were unsatisfactory for rotation logging. This paper describes the result of an appropriate enrichment plantation experiment technique for the family Dipterocarpaceae at a logged-over area. Various meranti plants (*Shorea leprosula. S. parvifolia, S. johorensis,* and *S. fallax*) were used in this experiment, which was carried out at a logging road in a natural forest at the logged-over area in Central Kalimantan. A completely randomized design in blocks consisting of two factors (species and fertilization) was used. The result showed that for 2 years, meranti plants could grow well at the logged-over area. It is also revealed that *S.leprosula, S. parvifolia,* and *S. johorensis* showed better growth of height and diameter than *S. fallax*.

Management model for the sustainable use of Araucarian forests on the basis of stand management and site-specific silviculture. Spathelf, P. (*University of Applied Sciences Eberswalde, Germany, pspathelf@fh-eberswalde.de*), Doetzer Rosot, M. A. (*Embrapa-Florestas, Brazil, augusta_rosot@yahoo.com.br*).

In the Brazilian forestry sector. sustainable forest management (SFM) in natural forests still plays a minor role in comparison to highly productive plantation forestry. Moreover, SFM in many cases in practice was and still is depletive timber extraction with a negative impact on forest ecosystems. Legal interventions in natural forests in Brazil have to be based on management plans that include selective harvest of timber, thus mitigating damages on the remaining stand and the soil. Based on a case study in the *Araucaria*-dominated forest reserve Embrapa-Epagri in Caçador (federal state of Santa Catarina, Brazil), an integrative and site-adapted management approach is developed. The management model process comprises territorial zoning; the establishment of a GIS mapping base (relief, soils, vegetation, land-use, and infrastructure); forest growth analysis; sampling of potential risks and hazards; forest management planning on a stand basis; and the derivation of silvicultural methods according to goals, species composition, and development stage of the respective stands. The planning horizon for the measures is 10–20 years. Demonstration plots will be implemented to show the feasibility of the SFM approach for forest owners.

Site index for *Calycophyllum spruceanum* (Capirona) a timber tree specie for samll-holders in the Peruviana Amazon. Ugarte, L. (*International Potato Center, Peru; j.ugarte@cgiar.org*).

In a trial conducted in the Aguaytia river basin (Ucayali Region, Peruvian Amazon), the growth, tree health, and their relationship with soils and other site factors were evaluated in 15 experimental plantings of *Calycophyllum spruceanum* Benth. The study was carried out to identify the potential places for successful establishment of plantations in the basin. Total height and diameter at breast height (DBH), phytosanitary state and form of the trunk of all trees at 64 months were evaluated. Site index (SI), basal area, and the total volume with bark per hectare were calculated, and soil physical chemical characteristics were evaluated and compared among sites. Three productivity geographical zones (Campo Verde- Nueva Requena, Neshuya-Curimaná, and San Alejandro, were determined. Soil conditions were different among the three zones, but San Alejandro zone presented better

characteristics for tree growth. Soil evaluations showed high correlation with the SI and soil pH (0.78), aluminum saturation (–0.75) and magnesium contents (0,74) and calcium contents (0.69). Data analysis showed small correlation among topographical conditions; however plantations developed better on small slopes and with clay contents higher than 30%. The data indicated a better adaptation of the tree species at the higher level of the basin.

Impact of plantation species diversity on the growth and survival of selected tropical tree species in a mixed native plantation in Ghana, West Africa. Wagner, M. (*Northern Arizona University, USA; Mike.Wagner@nau.ed*), Bosu, P. (*Forestry Research Institute of Ghana, Ghana; Paul.Bosu@yahoo.com*), Stephens, S. (*Colorado State Forest Service, USA; Sky.Stephens@nau.edu*).

We established experimental native species plantations (monoculture, 6 species mixed, and 10 species mixed in composition) on degraded forest reserves in Ghana, West Africa. The experimental design was a complete randomized block with four replicates and three treatments. Each plantation was 40 × 40 m and included 400 trees spaced 1 × 1 m. Plantations were assessed at 6, 18, 24, and 30 months post-planting. Individual tree height, diameter, and survival were measured on 10 randomly selected individuals of each tree species. Growth was calculated for three species considered to be high-value timber species: *Khaya ivorensis* (West African mahogany), *Milicia excelsa* (Iroko), *Pericopsis elata* (Pericopsis). West African mahogany grew 20% more in mixed plantations of 10 species compared to the monoculture. Survival was not different between treatments. A similar growth pattern occurred for Iroko and Pericopsis but the effect was less pronounced. The increase in growth within a mixed plantation did not appear until 30 months after planting. These results suggest it may be possible to grow high-value species such as West African mahogany in mixed plantings and increase growth performance over monoculture plantations. This species has been particularly difficult to grow in monoculture despite having high commercial value.

B-16 Sustainable forest recreation management: a discussion on social criteria and indicators

Organizers: Tuija Sievänen, *Finnish Forest Research Institute, Finland, tuija.sievanen@metla.fi;* Ulrike Pröbstl, *University of Natural Resources and Applied Life Sciences, Austria, ulrike.proebstl@boku.ac.at.*

Experiences and implementation of social indicators in Canadian forestry. Haider, W. (*Simon Fraser University, Canada; whaider@sfu.ca*).

While the federal government of Canada was at the forefront of developing a criteria and indicator framework for Canada, its implementation is under provincial jurisdiction and therefore is approached very differently in the respective provinces. While the original set of criteria and indicators suggested that basic participation in outdoor recreation be enumerated, any implementation has so far fallen short of expectations. This presentation will elaborate on some of these reasons, such as (1) other social concerns, such as employment and community well-being, and participation by First Nations have emerged as much more important social concerns; and (2) describing the many facets of outdoor recreation around some generally valid indicators proved to be rather challenging. One further complication arises with the distinction between outdoor recreation and nature-based tourism, as both activities frequently rely on the same types of recreation activities. Thus we find a situation where outdoor recreation is considered in local and regional management processes when it is relevant, but it is generally overshadowed by other social concerns in more strategic debates and frameworks. The presentation will provide examples to that effect, mostly from British Columbia and Ontario.

Including social indicators in national forest inventories–experiences from Denmark. Jensen, F.S., Nord-Larsen, T., Johannsen, V.K., Skov-Petersen, H. (*University of Copenhagen, Denmark; fsj@life.ku.dk; tnl@life.ku.dk; vkj@life.ku.dk; hsp@life.ku.dk*).

Several international processes aim to monitor forest status, and the focus on the social (recreational) function is increasing–as well as the demand for cost-effectiveness of the monitoring efforts. The Danish National Forest Inventory (NFI) is based on a 2- × 2-km grid, with four sample plots placed in a 200- × 200-m square in each grid cell. Based on a 2006 trial inventory, 11 social indicators were identified including, such as tracks, hunting facilities, vandalism, and litter. This project includes a total of 2,269 forested clusters (constituting the primary sampling units) inventoried in 2007–2009. Excerpts of 2007 results: hunting facilities where found on 24% of the clusters; outdoor recreation-related litter/trash on 21%, and non-outdoor recreation-related dumping on 15%. The results can be related to ownership and geographical/administrative regions, for example. Traditional national forest inventories can relatively simply and cost efficiently be expanded to include a number of social indicators that are not available otherwise. The continuity of the measurements will be a valuable addition to sustainable knowledge-based management and policy decisions with regard to the social (recreational) aspects of forestry.

Capturing ecosystem services in urban forestry. Kohsaka, R (*Nagoya City University, Japan; kohsaka.seminar@gmail.com*).

We review the development of biodiversity indicators in the urban context with focus on ecosystem services including recreational functions. The developmental histories of biodiversity and urban indicators are reviewed. The driving force-pressure-state-impact-response (DPSIR) model is presented and the main critiques are summarized. The alternative presented integrates sustainable use of ecosystem services into urban biodiversity. In urban areas, the inclusion of social values from local residents and the public is increasingly regarded as a necessary, if not mandatory step. It should be noted that there is room for collaboration among all stakeholders—including policy-makers, scientists, and local users (including immigrants)—to identify relevant scales and time frames, linking local and global dimensions, and to associate sustainability indicators with drivers of change. In conclusion, it is suggested that selected approaches, including collaboration among stakeholders and integration of temporal and spatial scales,

should be integrated into the model as a means of ameliorating certain structural critiques, namely to integrate ecosystem services into urban biodiversity indicators. Capturing dependence on ecosystem services (in direct or indirect ways) within the context of indicators remains a challenge. Furthermore, linking scientific findings of ecological trends with responding policies in the urban context is critical.

Development of criteria and indicators for sustainable forest management in Austria. Pröbstl, U. (*University of Natural Resources and Applied Life Sciences, Austria; Ulrike.proebstl@boku.ac.at*).

The presentation will evaluate the applicability of the existing European Framework of Sustainable Forest Management (SFM). For this purpose we have chosen a large forested area in the Austrian Alps in the northern part of Styria. This region is forested by about 80% at average, and houses the Nature Park "Mürzer Oberland." The Austrian concept for nature parks combines extensive land use, nature protection, and nature-based tourism, and therefore is suitable to study SFM in collaboration with stakeholders, forest owners, and representatives of the nature park. An initial analysis of the proposed indictors and criteria reveals that crucial proposed indicators for recreation are not useful. It also became apparent that in practice the differentiation between the use of non-wood goods and recreational aspects is difficult. The relevance and value of close-to-nature forestry for the local tourism business is not captured by the actual set of criteria and indicators. In a second step we tried to measure the meaning of these forests for recreation and nature-based tourism by monitoring visitors to this region. The paper will present the results of the visitor monitoring, the collaborative process, and the adapted version of indicators and criteria.

Criteria and indicators of sustainable recreational forests in Korea. Shin, W.S. (*Chungbuk National University, Republic of Korea; wonsop@cbnu.ac.kr*).

The demand for outdoor recreation has been increasing dramatically since the late 1980s in Korea, because of rapid urbanizing during the past 4 decades. To combat this demand, the Korea Forest Service has developed recreational forests as one of the outdoor delivery systems. To date, more than 100 recreational forests have been developed across the country. The recreational forests provide opportunities for active outdoor recreation as well as for quiet relaxation and escape from daily urban stress. Recreational forests, as the most popular outdoor recreation system in Korea, must be concerned with efficiently managing available resources where they are most needed and where they will do most good, both for the ecological integrity of the resources and for the recreation experience of visitors. The purpose of this study was to identify criteria and indicators of sustainable recreational forest management to produce the best quality visitors' recreation experience, while also maintaining the resource base. Using delphi with a pool of experts in outdoor recreation, this study identified 7 criteria and 34 indicators. Then using important-performance analysis, the criteria and indicators were evaluated in 34 recreational forests in Korea.

Recreation indicators for monitoring the implementation of the national forest program in Finland. Sievänen, T. (*Finnish Forest Research Institute, Finland; tuija.sievanen@metla.fi*).

Finland's National Forest Program 2015 is a governmental policy program established for 2008–2015. "Enhancing forest recreation and culture" is one of six topic areas of the program. Suitable impact indicators were needed for monitoring the implementation of program actions. Several experts were invited for the process. The work was organized in working groups, and three workshops were held. As a result, five indicators were selected for the general importance of forest recreation, nine indicators for recreation demand, and nine indicators for supply of recreation resources. Only two recreation indicators were chosen for monitoring the National Forest Program. They are (1) population-level participation rate in recreation in general and in three forest-base activities, number of activity occasions per year, and time used for recreation; and (2) the number of characteristics of trails managed for recreation. This paper present the sets of discussed indicators, the criteria for the choice of suitable indicators, and recommendations for future development of statistics and databases that are essential for indicators to be used in the processes of monitoring and assessments of forest policy programs.

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Collaborative management of tourism in Gunung Rinjani National Park, Indonesia. Sukandi, T. (*Forest and Nature Conservation Research and Development Centre, Indonesia; taulana_sukandi@yahoo.com*).

Conservation International and the National Geographic Traveler recognized the Gunung Rinjani, National Park (GRNP) located on Lombok Island, Indonesia, as the 2004 World Legacy Award Winner in the category of destination stewardship. Tourism management in Gunung Rinjani has been considered as a leading role in environmentally and socially responsible tourism and in helping to protect cultural heritage. The GRNP Development Project begun in 1999 as part of New Zealand's formal assistance program in Indonesia. The objective of the project was to improve park management, foster community development, and develop responsible park tourism by encouraging ecotourism based on trekking and Sasak culture. In 2003 the Rinjani Trek Management Board was establihed to facilitate the Rinjani Trek Program, which has been collaboratively managed by the GNRP Ministry of Forestry, local government, local communities, NGOs, and donor institutions. Local communities have been involved in tourism services (boarding, guiding, and portering) and in the management of two cooperatives that organize tourism services. (Later, the cooperatives developed activities besides tourism services, such as animal husbandry.) Tourism in this national park could be sustainable because its management has involved relevant stakeholders.

Criteria and indicators for sustainable recreational use in Japan: an overview of the second country report of Japan to the Montreal Process. Tanaka, N. (*Tokai University, Japan; tanaka_nobuhiko@tokai-u.jp*), Iehara, T., Sugimura, K., Miyamoto, A., Matsuura, T. (*Forestry and Forest Products Research Institute, Japan; iehara@ffpri.affrc.go.jp; kensugi@ffpri.affrc.go.jp; asakom@ffpri.affrc.go.jp; matsuu50@ affrc.go.jp*).

In October 2009, an official document known as *State of Japan's Forests and Forest Management -2nd Country Report of Japan to the Montreal Process* was issued by the Forestry Agency, Japan. This study will give an overview on the criteria and indicators for sustainable recreational use written in this document. Criteria and indicators concerning recreation /tourism were mainly

described in the recreation and tourism indicator (6.4), such as area and share of forests for recreation and tourism, visitor numbers, and number of facilities. However, indicators deeply related to forest recreation/tourism are also found in other criteria. For instance, social aspects are found in criterion 7, such as forest cultural/social value (7.1e), public education (7.2a), infrastructure (7.2d), and new technologies and capacities (7.5c). In addition, indicators related to forest ecosystem services, i.e., supply/cultural service, are found in several criteria, such as protected area by forest ecosystem type (1.1b); mushroom, berry/nuts, edible-wild-plant picking (2e); and forest-based environmental services (6.1c, 6.2a). Therefore, we can conclude that we have to read carefully throughout the document and analyze the relationship among indicators for sustainable recreational use in Japan.

B-17 Evaluating management effectiveness of protected areas

Organizer: Vinod B. Mathur, *Wildlife Institute of India, India, vbm@wii.gov.in.*

Adapting protected area management effectiveness tools to respond to climate change. Belokurov, A. (*WWF International, Switzerland; abelokurov@wwfint.org*), Dudley N. (*Equilibrium Research, United Kingdom; nigel@equilibriumresearch.com*), Ervin J. (*UNDP, USA; jervin@sover.net*), Stolton S. (*Equilibrium Research, United Kingdom; sue@equilibriumresearch.com*).

Protected areas play a very important role in both mitigating the effects of climate change and adapting ecosystems and societies to the climate change challenge. However, only well-managed protected areas can fulfill this role. Protected area management effectiveness assessment systems are well-developed and being implemented by many countries and individual parks. These systems should be modified to better account for climate change effects by ensuring, for example, protection of carbon stocks within and around protected areas; provision of vital ecosystem services (food, water, etc.) for local communities; and sufficient resilience of biologically rich ecosystems and processes. The two most used management effectiveness tools are rapid assessment and prioritization of protected area management (RAPPAM) methodology and the management effectiveness tracking tool (METT). These tools were modified to include additional questions relevant to climate change threat. The approach developed for these tools could be relevant for adapting other management effectiveness systems and providing guidance to protected area managers. Experience gained in modifying the tools and their application in several protected areas around the world is relevant to many countries.

Management effectiveness evaluation of South Korea's protected area system. Heo, H.Y. (*Korean National Park Service, Republic of Korea; mudae4@paran.com*), Hockings, M. (*University of Queensland, Australia; m.hockings@uq.edu.au*), Shin, W. W. (*Korean National Park Service, Republic of Korea; wowshin@knps.or.kr*), Chung, H.J. (*Chungju National University, Republic of Korea; hchungmoe@hanmail.net*), Dudley, N. (*Equilibrium Research, United Kingdom; nigel@equilibriumresearch.com*), Kim, H. (*Korean National Park Service, Republic of Korea; tobeceo@paran.com*), Shadie, P. (*IUCN, Thailand; peter.shadie@iucn.org*), Vaisanen, R. (*Metsahallitus, Finland; rauno.vaisanen@metsa.fi*), Vincent, G. (*G.W. Vincent and Associates, Australia; geoff_vincent@hotmail.com*), Park, S.Y. (*Korean National Park Service, Republic of Korea; soyoung.park@knps.or.kr*).

The Convention on Biological Diversity's Programme of Work on Protected Areas calls on countries to undertake assessments of the effectiveness of management of their protected areas (PA). In 2008 and 2009, we undertook an evaluation of the protected area system in the Republic of Korea as a joint initiative between the Korean Government and the IUCN. Both international protected area experts and Korean agency staff and academics were involved in the process. The assessment was conducted at two levels: a site assessment of 39 protected areas, representing about 42% by area of the Korean PA system, and a system-level assessment conducted by an international review team incorporating field visits, interviews with staff and stakeholders, and review of relevant documentation. The evaluation identified many strengths and a number of weaknesses in management. Ten key recommendations for improving management were to develop a more regional approach to conservation, strengthen PA system planning, better integrate management across agencies within Korea, improve local community relations, enhance interaction with stakeholders, improve integration with regional government, review staff management practices, diversify the funding base, broaden the focus of internal research work, and better harmonize natural and cultural resource management.

Co-management approach and its implications for natural resource management at Lawachara National Park, Bangladesh. Islam, Md. W. (*Khulna University, Bangladesh; wasiulislam7@yahoo.com*).

Lawachara National Park (LNP) is one of the protected areas (PAs) of Bangladesh, located at the northeastern part of Bangladesh. This national park (NP) was designated a protected area in 1996, but since before 1996 the park has been deteriorating because of the direct and indirect influence of different stakeholder groups that threaten biodiversity conservation of the park. The top-down approach of the traditional forest management system was not working for Bangladesh PAs due to various causes. Community people were not included in the management strategy of the forest, so they were relaxed with respect to forest protection. As a result, a community-based approach (especially collaborative management or co-management) for the management and conservation of natural resources of the PAs and for the well-being of surrounding local communities has emerged as an important tool to overcome these problems. Consequently, PAs of Bangladesh were brought under co-management initiatives such as the Forestry Sector Project (1996–2006), Nishorgo Support Project (2004–2008), and Integrated Protected Area Co-management Project (2008–2013), with the financial assistance of foreign donors and the Forest Department as the implementing organization. This article focuses on the effectiveness of co-management at LNP through these development projects in Bangladesh.

A study on assigning IUCN categories to forested protected areas in Korea: a case study of Baekdu Daegan protected area. Kim, S.G. (*Seoul National University, Republic of Korea; seongil@snu.ac.kr*), Lee, Y.J. (*The Green Research Institute, Republic of Korea;*), Kang, M.H. (*The Green Research Institute, Republic of Korea; yeongjoo@gmail.com; kangdama@chol.com*).

There are 1,119 protected areas including 20 national parks in Korea which cover about 15,621.435 km^2 of territory. Some countries have tried to adopt a global category system, e.g. the category system of IUCN (CS-IUCN), with their protected areas.

In Korea, 227,410 km^2 of forested protected areas including 7 national parks and Baekdu Daegan Protected Areas (BDPA) were designated by the Forest Service and the Ministry of Environment in 2004. This study aimed to develop and refine the process to assign the CS-IUCN within the BDPA, which includes a core zone and buffer zone for purposes of conservation and sustainable use. There are two suggestions arising from this study. The first, more conservative, is to include categories Ia, II, IV, V and VI considering BDPA's management purposes. The second, more practical option, would be to include category of II, IV, V and VI considering the zoning system of the BDPA. In both suggested options, the national parks and core zone of BDPA would be classified as category Ia or II. Other areas would be classified as IV, V and VI according to managerial considerations.

Management effectiveness evaluation (MEE) of a protected area network in India: lessons learnt. Mathur, V.B. (*Wildlife Institute of India, India; vbm@wii.gov.in*).

Increasingly a number of countries in the developing as well as the developed world are using management effectiveness evaluation (MEE), both as a concept and as a tool, to monitor the effectiveness of the network of protected areas and to gain useful insight and trends in protected area management. The Ministry of Environment and Forests, Government of India, with technical support from the Wildlife Institute of India, initiated in 2006 an MEE of the protected area network in India. All six elements of the IUCN-WCPA-MEE framework are being used, and a series of specific criteria for each element of the framework have been developed. To date, 58 protected areas in 29 states have been evaluated by five independent expert teams. Of the 58 PAs assessed under MEE process, 9 (16%) are very good, 22 (38%) are good, 19 (33%) are satisfactory, and 8 (14%) are in the poor category. The overall MEE score is 62%. The paper discusses the strengths, weaknesses, opportunities, and constraints in the management of protected area network and stresses the need to include 'social indicators' in the evaluation process to effectively address human dimension issues in park management.

Community perception of biodiversity conservation within protected areas in Benin. Vodouhe, F. (*University of Abomey-Calavi, Benin; vodouhefifanou@yahoo.fr*), Coulibaly, O. (*International Institute of Tropical Agriculture, Benin; o.coulibaly@cgiar.org*), Adegbidi, A., Sinsin, B. (*University of Abomey-Calavi, Benin; ansadegbidi@yahoo.fr; bsinsin@gmail.com*).

This study, carried out around the Pendjari National Park (PNP), analyzed local people's views on ongoing participatory management activities and assessed their perceptions towards biodiversity conservation within the park. We interviewed 164 residents around the park and collected socio-demographic data on the awareness of conservation methods. We used stepwise-discriminant analysis to select the variables that have the greatest power for discriminating between local residents' perception to conserve biodiversity or not and to manage the park. Findings indicate that the positive behavior of local communities towards conservation of biodiversity within PNP highly correlated with the current management strategy that involves more effectively local communities, the educational level of participants, and their geographical origins. Participants' perceptions of biodiversity conservation were strongly related to locally perceived benefits. Although 89% of participants were favorable to the concept of biodiversity conservation within PNP, the decision to ban agricultural activities within the boundaries of the park has increased negative opinion on this park management option. Our results suggest that understanding local residents' perceptions and using them as a starting point to improve the park-people relationship can help park management staff to more effectively involve local communities and improve their awareness about biodiversity conservation within the park.

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Livelihoods based on illegal harvesting of indigenous fruit species, and opportunities for sustainable management in the Ivindo National Park, northeast Gabon. Christian, M.Y. (*International Cooperation Center for Agricultural Education, Japan; yobo.mikolo@g.mbox.nagoya-u.ac.jp*).

Forest and biodiversity conservation are subjects of global consern, and Gabon has made a tremendous effort towards sustainable management of forest resources by creating 13 new parks. The Ivindo National Park (INP) faces issues of illegal harvesting of forest products, especially indigenous fruit species (IFS), but government response has been weak in that regards. Furthermore, there is lack of quantitative data on the stocking levels of IFS, harvesting impacts, livelihoods contribution and economic-value, and their conservation status in the INP. A household survey carried out in eight villages surrounding the park—through participatory rural appraisal and semi-structured interviews—aimed at gathering information on:(i) socio-economic profiles of local communities and rationale for their involvement, (ii) forest use patterns and dependency levels, (iii) resource users' perceptions and awareness levels on the conservation status of IFS, and (iv) possible solutions to mitigate these threats. As a result, factors driving illegal activities include demand for food. *Coula edulis, Irvingia gabonensis, Baillonella toxisperma, Trychocypha abut* and *Dacriodes buettneri* are most threatened. Local communities tend to view government control negatively and they lack customary ownership. Results showed urgent necessity for domestication of alternative fruit species, and control of harvesting levels.

Participatory upland development in Mt. Makiling Forest Reserve, Laguna, Philippines. Dizon, J.T., Mariano, R.R.E., Balahadia, N.M., Bugayong, L., Castillo, L., Paelmo, R., Breva, R., Lapitan, P. (*University of the Philippines Los Baños, the Philippines; josefina_dizon@yahoo.com; vickymcme@yahoo.com; nickbalahadia@yahoo.com; lenlab28@gmail.com; mcme_leilani@yahoo.com; rfpaelmo@yahoo.com; rbreva_mcme@yahoo.com; portialapitan@yahoo.com*).

The Mt. Makiling Forest Reserve (MFR) is a very important natural resource not only to the University of the Philippines, which has been mandated by law to be its administrator, but also to the surrounding communities. Thus, the university's main concern is to maintain the reserve's ecological integrity so that it can continue to serve as the university's outdoor laboratory for natural and the social sciences, while maintaining its social and economic functions. However, the MFR has been beset with the occupancy problem, which has contributed to its continuous degradation. Hence, participatory upland development action research was conducted in 2006–2008, the main objective of which was to ensure MFR's productive and sustainable management through an empowered upland community. It was composed of seven integrated studies and made use of a household survey, focus group discussions, key informant interviews, farm assessments, demonstration farms, IEC, field tours, and process documentation. The

research highlights the importance of establishing rapport with the partner-community, understanding community dynamics to address conflicts, use of participatory tools and processes, tapping focal persons to facilitate project implementation and sustainability, reducing forest-dependence through alternative livelihoods, and reconciling community-based natural resources management principles with MFR policies.

Does joint forest management increase bushmeat hunting in a biodiversity hotspot? Evidence of displacement from the Kilombero Nature Reserve, Tanzania. Nielsen, M.T. (*University of Copenhagen, Denmark; nielsenmr@gmail.com*).

Developing nations are increasingly decentralizing forest management to local institutions to improve equity, efficiency, and sustainability. In Tanzania, joint forest management (JFM) is promoted in national forest reserves of high biodiversity value. However, effects are poorly documented and problems may include negative impacts on the poorest people, displacement of harvest activities, and refusal to adhere to rules where managers are distrusted. These aspects were examined in the West Killombero Scarp Forest Reserve, based on a temporal comparison spanning 7 years with JFM and a TANAPA ranger station, using bushmeat hunting as an indicator. Results reveal the number of active hunters had declined primarily because of TANAPA's patrolling, but hunting effort was displaced from hunting with rifles in grasslands to hunting with traps and dogs in forests, thereby increasing threats to endemic species. Half of hunters perceived benefits from JFM, but benefits were largely unused, inaccessible, and communal. Suspicions of embezzlement of Village Natural Resource Committee (VNRC) funds and high village development contributions were important drivers of continued hunting. Consequently, hunters preferred that TANAPA manage the forest rather than the VNRC. Recommendations for necessary adjustments before scaling up and implementation in villages surrounding the newly mapped Killombero Nature Reserve are discussed.

Stand structures of Küre Mountains National Park (Turkey) and precautions for avoiding unfavorable impacts on the local community. Sıvacıoğlu, A. (*Kastamonu University, Turkey; ahmets1973@gmail.com*), Öner, N. (*Çankırı Karatekin University, Turkey; nurioner@gmail.com*), Özdemir, S.Ö. (*Union of Village Development and Other Agricultural Aims Cooperatives, Turkey; sozcan37@yahoo.com*).

Küre Mountains National Park in Turkey is characterized by geographic formations (karstic areas, canyons, caves) and biodiversity richness. Also, this park is Turkey's only candidate to the PAN Parks Network and one of 100 "hottest points" of Europe. Temperate zone beech and fir stands, pseudo-maquis formation, mixed-forest structures in the karstic regions, and endemism are some of the valuable specialities of the park. *Fagus orientalis, Quercus petreae, Carpinus betulus, Pinus nigra, P. sylvestris, Abies bornmülleriana,* and *Castanea sativa* dominate tree species in the region. In the study, some information about forest structures was given. Meanwhile, there are settlements in the national park; consequently, some illegal activities can happen. Wood demand for fuel and handicrafts are the main basis for problems in the national park area; boxwood consumption especially contradicts conservation strategies. To avoid harmful impacts of rural communities on the national park, projects were implemented by non-governmental organizations. In these projects, changing the kind of wood materials used for handicrafts and reducing fuel-wood demand through biogas production were investigated. We also evaluated the results of the projects.

Tree species composition and stand structure of Pahang National Park, Malaysia. Suratman, M.N. (*Universiti Teknologi MARA, Malaysia; nazip@salam.uitm.edu.my*).

The forests of Pahang National Park constitute one of the world's oldest tropical rainforests. They provide fully protected habitat for long-term maintenance of biological diversity. This study was conducted to provide an assessment of species composition and to determine the level of tree species diversity in the study area. A total of five transect lines measuring 100 m × 20 m were constructed. All trees with a dbh ≥ 10 cm were measured and identified. In total, 448 individual trees with a mean dbh of 23.3 cm were recorded, belonging to 46 families, 65 genera, and 208 species. The three most dominant families are Euphorbiaceae, Myristicaceae, and Burseraceae. The three most dominant species within the five transect lines are *Elasteriospermum tapos*, *Knema patentinervia,* and *Macaranga lowii,* with 35, 13, and 12 individuals, respectively. The tree diameter distribution of national park forests confirms a reverse J-shaped diameter distribution, with stems frequencies decreasing with increase in diameter at breast height. The high value of Shannon-Weiner diversity index (4.78) suggests that forests of Pahang National Park have great community structure stability.

B-18 Identifying and monitoring old growth forests in boreal, temperate and Mediterranean environments

Organizers: Anna Barbati, Piermaria Corona *University of Tuscia, Italy, barbati.sisfor@unitus.it, piermaria.corona@unitus.it;* Thomas Spies, *U.S. Forest Service, USA, tspies@fs.fed.us.*

Are old-growth *Pilgerodendron uviferum* forests only a transitional phase in forest succession? Bannister, J., Bauhus, J. (*University of Freiburg, Germany; jan.bannister@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de*).

Pilgerodendron uviferum is a long-lived and endemic conifer of Patagonia. There exists practically no information about undisturbed old-growth forests of this species. As the intolerance of *P. uviferum* to shade, and its need for catastrophic disturbance to regenerate has variously been claimed and disclaimed by researchers in the past, this is far from certain. Therefore, this study aimed to analyse regeneration dynamics in old-growth *P. uviferum* forests on Chiloé Island, Patagonia. An inventory of trees and regeneration in old-growth swamp and upland forests was conducted. Light conditions in stands and for seedlings (% PPFD) were measured and trees were cored. Our results indicate that *P. uviferum* initially colonized the site and was able to continue regenerating on site up to the present. The results of this study show that *P. uviferum* is not a shade-intolerant species because it can regenerate under low light conditions in the understorey in old-growth forests. Our results further indicate that seedlings of this species are not very responsive to increased light. The old-growth *P. uviferum* forests do not appear to need catastrophic disturbances to regenerate. On the contrary, catastrophic fires may eliminate the species from tracts of the landscape, where no seed trees have survived.

Assessing degree of old-growthness in Mediterranean forests: experiences from Italy. Barbati, A. (*University of Tuscia, Italy; barbati.sisfor@unitus.it*), Calamini, G. (*University of Florence, Italy; gianfranco.calamini@unifi.it*), Chirici, G. (*University of Molise, Italy; gherardo.chirici@unimol.it*), Iovino, F. (*University of Calabria, Italy; francesco.iovino@unical.it*), Marchetti, M. (*University of Molise, Italy; marchettimarco@unimol.it*), Menguzzato, G. (*University of Reggio Calabria, Italy; gmenguzzato@unirc.it*), Nocentini, S. (*University of Florence, Italy; susanna.nocentini@unifi.it*), Corona, P. (*University of Tuscia, Italy; piermaria.corona@unitus.it*).

Old-growth forests are extremely rare in Europe, and even more in Mediterranean countries, due to the ancient and continuous use of woodlands throughout the continent. It is only under a favourable combination of environmental factors and protection measures that small tracts of forests have been left untouched long enough by human influence to attain a stage of biological maturity. These stands express, in various degrees, structural attributes typically found in old-growth forests; this condition, which we have defined "old-growthness" is associated with high biodiversity conservation potential. We present the results of ongoing research activities in Italy aimed at developing operational protocols to assess the degree of old-growthness in Mediterranean forests. A variety of case studies is examined, over a network of experimental sites located in national parks and remote mountain areas in Italy. The methodological approach relies: (i) on the assessment of several structural variables, collected through a standardized field protocol, including typical attributes of old-growth forest (e.g., deadwood components and decay stage); and (ii) on the selection of the best variables and related thresholds levels that can be used for a quick discrimination of stands with high-conservation value.

An old–growth beech (*Fagus sylvatica* L.) forest network in Italy: structural organization, stand productivity, and disturbance history. Di Filippo, A., Alessandrini, A., Piovesan, G. (*Università della Tuscia, Italy; difilippo@unitus.it; alessandrini@unitus.it; piovesan@unitus.it*).

We studied the pattern and process of Italian old-growth beech (*Fagus sylvatica* L.) forests through a network approach. The study ecosystems were both primary and secondary forests, growing from north to central Italy and from hills to tree-line. We characterized the structural attributes of each stand by describing its living and dead biomass organization. Dendroecology was used to reconstruct stand age structure and its disturbance history based on growth release detection on tree-ring series. By tree-ring information we reconstructed long-term dynamics of these forests, including each stand's productivity. Particular attention was focused on studying the structural features and processes involved in the transition from old-growth status following the abandonment of sylvicultural management. The older stands were characterized by a rotated-sigmoid diameter distribution and an intermediate disturbance regime. The study forests pertain to different bioclimatic units in Italy, spanning from the temperate (Alps) to the Mediterranean (Apennines) biomes and covering different elevations within the species' range. This particular bioclimatic position, and the extreme sensitivity of this area to climate change, makes it crucial to understand how these forests are responding—in terms of productivity and disturbance history changes—to the climate variations observed in recent decades.

Conserving and managing old-growth forests in Australia in a changing world. Keenan, R.J. (*University of Melbourne, Australia; rkeenan@unimelb.edu.au*), Read, S.M. (*Forestry Tasmania, Australia; steve.read@forestrytas.com.au*).

Old-growth forests in Australia are important for biodiversity conservation, recreation, carbon storage, social values, and, to a declining extent, timber production. Developing comprehensive definitions of old-growth forests that can apply across all Australian vegetation types has been challenging, and classification and assessment of old growth has largely been restricted to those areas covered by comprehensive regional assessments. These surveys identified more than 5.04 million hectares of old-growth forests, about 22 percent of the total forest area in surveyed regions, with 3.7 million hectares (72 percent) now in formal and informal conservation reserves. This paper reviews definitions of old-growth forests and the way they have been applied in different parts of Australia. We provide an analysis of the current status of old-growth forests across different types of land tenures and some examples of spatial distribution and patch sizes. Old-growth forest values can be affected by wildfire, lack of disturbance, insect pests, diseases, climate change, and forest management activities. We discuss future management options that might be applied to address these threats, focusing on issues involved with maintaining old-growth values across large forest estates with multiple tenures in a rapidly changing climate, and including forest types dependent on regular or occasional disturbance.

Restoration of old-growth forest structure in the northeastern United States: experimental evaluation of silvicultural options. Keeton, W. (*University of Vermont, USA; william.keeton@uvm.edu*).

I tested the hypothesis that silvicultural practices can be modified to accelerate rates of late-successional forest development in northern hardwood-conifer forests. An approach, termed structural complexity enhancement (SCE), is compared against uneven-aged systems modified to increase post-harvest structural retention. The study was replicated at two study areas in Vermont, U. S.A. Manipulations and controls were applied to 2-ha units and replicated four times per treatment. Structural objectives include multi-layered canopies, elevated large snag and downed coarse woody debris densities, variable horizontal density (i.e., gapiness), and re-allocation of basal area to larger diameter classes. The later objective is achieved using an unconventional marking guide based on a rotated sigmoid target diameter distribution. Accelerated growth in larger trees is also promoted through crown release. Vegetation, wildlife, soils, and economic data have been collected over 2 years pretreatment and 6 years post-treatment. There will be significant differences in stand development based on both simulation modeling and on-going monitoring. Late-successional structural characteristics will develop to a greater degree under SCE. Large tree recruitment rates were related primarily to the form of residual diameter distributions and to maximum diameter limits. Applications include old-growth restoration, riparian restoration, and low intensity commercial forest management regionally and beyond.

Old-growth forests of the Pacific Northwest, USA: diversity, monitoring, and conservation. Spies, T.A. (*U.S. Forest Service USA; tspies@fs.fed.us*).

Millions of hectares of old-growth forests exist in the Pacific Northwest despite more than 150 years of logging and wildfire. Their relative abundance provides an opportunity to understand variability in old-growth structure and processes at multiple

spatial scales and to develop and evaluate alternative conservation approaches. These forests posses significant and sometimes competing habitat and socio-economic values, which have led to management conflicts. Old growth can be defined in terms of ecological and social criteria, and it is clear that no public consensus exists for defining old growth. Nevertheless, working definitions exist and can be used as a basis for inventory, monitoring, and conservation. To assess the diversity and complexity of these forests, monitoring approaches must integrate landscape- and stand-level methods. Forest ecosystem diversity and differences in management history in the region mean that multiple approaches to conservation and restoration must be used. In wetter environments, strict forest reserves are well-suited to protecting existing old growth from logging and other human influences. In drier, fire-prone environments, active management may be needed to create forests that are resilient in the face of fire and climate change.

Long-term understory vegetation changes in northwestern European forests: a synthesis of (semi-) permanent plot studies. Verheyen, K., Baeten, L., De Frenne, P., Verstraeten, G. (*Ghent University, Belgium; kris.verheyen@ugent.be; lander.baeten@ugent.be; Pieter.defrenne@ugent.be; gorik.verstraeten@ugent.be*).

Archives of detailed vegetation records and maps, often made by early forest ecologists for phytosociological purposes, can be found all across Europe. During the past 2 decades, some of these archives have been used as baseline data to perform resurveys. The recurring objective of these resurveys is to explore patterns of long-term vegetation change and to identify key environmental drivers. We assembled and re-analysed data from 23 carefully selected resurveys of understory vegetation in ancient, mostly spontaneously developing forests to make a synthesis on a European level. More than 1,200 plot-pairs are included, and the selected studies cover large geographic (from England to Czech Republic and from Switzerland to Sweden) and environmental (from calcareous to acidic parent materials) gradients. Shifts in vegetation diversity and composition have been quantified across the resurveys, and the relative importance of local (i.e., canopy dynamics) compared to regional (changes in herbivory rates and accumulated acidifying and eutrophying atmospheric depositions) drivers in explaining these shifts was assessed. The results are important for policy and management as they quantify the vegetation dynamics over time in forests that are often used as references for conservation and restoration.

Old-growth forests, carbon, and climate change: functions and management for tall open-forests in two hotspots of temperate Australia. Wardell-Johnson, G., Dean, C. (*Curtin University, Australia; g.wardell-johnson@curtin.edu.au; Christopher.Dean@curtin.edu.au*).

We provide an Australian context to old-growth forests, and present ecological and carbon accounting prognoses under climate change for two old-growth, temperate forests. The tall open-forests (TOFs) of southwestern Australia (SWA) are within Australia's global biodiversity hotspot. Forest management in the carbon-dense old-growth TOFs of Tasmania (TAS) provide a high carbon efflux, rendering it a carbon hotspot. Under climate change, the warmer, drier climate in both areas will decrease carbon stocks directly; and indirectly through changes towards drier forest types and positive feedback. Near 2100, climate change is likely to decrease soil organic carbon (SOC) significantly, e.g., by ~30% for SWA and at least 2% for TAS. The emissions from the next 20 years of logging old-growth TOF in TAS, and conversion to harvesting cycles, will conservatively reach 66 (± 33) Mt-CO_2-e—bolstering greenhouse gas emissions. Similar emissions will arise from rainforest SOC in TAS due to climate change. Careful management of old-growth TOFs in these hotspots to reduce carbon emissions and change in biodiversity will entail adopting approaches to forest, wood product, and fire management that conserve old-growth characteristics in forest stands. Plantation forestry on long-cleared land and well-targeted prescribed burning can supplement effective carbon management.

Posters

Variable retention influence over *Nothofagus pumilio* regeneration dynamics. Martínez Pastur, G. (*CADIC CONICET, Argentina; cadicforestal@cadic.gov.ar*), Cellini, J.M. (*LISEA UNLP, Argentina; jmc@ceres.agro.unlp.edu.ar*), Lencinas, M.V. (*CADIC CONICET, Argentina; vlencinas@cadic.gov.ar*), Barrera, M. (*LISEA UNLP, Argentina; mbarrera@ceres.agro.unlp.edu.ar*), Peri, P.L. (*INTA UNPA CONICET; Argentina, pperi@correo.inta.gov.ar*).

The current silvicultural prescriptions for old-growth natural native *Nothofagus pumilio* forests are based mainly on opening the canopy to stimulate natural regeneration by modifying soil moisture and light availability at the understory level. New silvicultural practices intend to manage these forests more effectively, e.g., with aggregated and dispersed retention. The objective was to evaluate regeneration dynamics along edge-related gradients of aggregated retention, and microenvironments in dispersed retention, during the first 6 years after the harvesting. The tested hypotheses were: (i) aggregated retention influences rainfall and solar radiation interceptions, modifying the availability of these resources used by forest regeneration, where the magnitude of the influence is related to the distance from the edge and the considered aspect; and (ii) microenvironments generated by understory plant cover type, debris, and closeness of remnant trees in dispersed retention influences regeneration dynamics, where closeness of remnant trees and the increase in the understory cover negatively influences regeneration, as well as the absence or the excess of debris in the forest floor. All the studied factors influence regeneration dynamics, but regeneration was abundant in all the sites for stand recovery.

Stand structural characteristics of an old-growth *Abies koreana* stand in Mt. Jiri, Korea. Park, P.S., Kim, M.P., Park, H.K., Lee, S.K. (*Seoul National University, Republic of Korea; pspark@snu.ac.kr; moungpil@snu.ac.kr; hakki@snu.ac.kr*; *gksksofls@naver.com*).

Abies koreana is a native species in Korea showing the characteristics of subalpine coniferous species. While other subalpine species in Korea are also found in China and Russia, the distribution of *A. koreana* is limited only in high elevations in the southern part of Korea. This study was aimed to understand characteristics and stand dynamics of *A. koreana* stand. Trees (DBH > 2.5 cm) were inventoried twice in 2005 and 2009 in five 20-m × 20-m permanent plots in *A. koreana* stand in the western part of Mt. Jiri, Korea. Species composition and stand structure between 2005 and 2009 were compared. Total of 29 woody species were found and species with high importance values were *A. koreana, Quercus mongolica, Acer pseudosieboldianum, Fraxinus*

sieboldiana, and *F. chiisanensis* in both years, showing no changes in order of importance values. Shannon's diversity index was little changed, from 2.02 in 2005 to 2.06 in 2009. The stand seemed to be older than 100 years, and showed a reverse J-shaped DBH distribution. Few changes in stem density and *A. Koreana* population were found, while basal area increased by 7% for 4 years, indicating that this stand was still growing slowly.

B-19 Statistical methods in biodiversity assessment and biodiversity responses to silviculture

Organizers: Tzeng Yih Lam, Douglas A. Maguire, *Oregon State University, USA, Lam.TY@lifetime.oregonstate.edu, doug.maguire@oregonstate.edu.*

Improving tree abundance estimates from rare or aggregated populations with the EZ-Hurdle model. An, H.S., MacFarlane, D.W. (*Michigan State University, USA, anhong@msu.edu; macfar24@msu.edu*).

Reliable estimation of species abundance is essential for monitoring biodiversity. Typical tree count data will contain many missing observations of trees that are members of rare or spatially aggregated populations. Such 'zero-inflated' data contributes to high levels of variation in abundance estimates and thus a relatively large amount of time and money are required to achieve reliable estimates using standard forest inventory methods (e.g., plots). A new model, the expected zero hurdle model (EZ-Hurdle) was developed to enhance typical plot-based sampling by reducing the variation of tree abundance associated with too many zero observations. In a simulation study, tree populations were generated under three different (low) population densities, under two spatial distribution patterns, random and aggregated. Using four different circular plot sizes and a range of sampling intensities, estimates adjusted by the EZ-Hurdle model were compared to estimates derived from simple random sampling (SRS), zero-inflated Poisson models (ZIP), and traditional hurdle models (HD). The EZ-Hurdle model had the smallest standard deviation and root mean square error (RMSE) of tree abundance over all sampling intensities, plot sizes, and spatial patterns, and required a lower sampling intensity than the other methods to achieve similar levels of accuracy.

Some statistical hints on the qualification of biodiversity indicators of sustainable forest management: Bayesian parametric models, probabilistic quality, and magnitude of the effects. Gosselin, F. (*CEMAGREF, France; frederic.gosselin@cemagref.fr*).

Biodiversity indicators are now frequently used, such as inside multiple sustainable forest management frameworks or ecocertification schemes. Yet, these indicators are more based on consensus, concepts, or general ideas than on more detailed analyses associated with data. Does a given indicator reflect the variation of floristic or avifauna biodiversity? In which direction, with which magnitude? I will here present three statistical hints that I think are important to take into account in such an endeavour. (i) One of the tools needed are parametric, usually multivariate, statistical models. Furthermore, the Bayesian framework appears at present as practically more adequate than the frequentist one. (ii) Second, I suggest that probabilistic quality of the models is important, especially with messy data such as biodiversity data. I will especially present new Bayesian goodness-of-fit tools as well as new count data probability distributions. (iii) Finally, I will insist that estimation to study the magnitude of the effects is more interesting in this perspective than trying to reject point null hypotheses. Of course, this is only part of the story. I will finally discuss other points such as how to incorporate potential mechanisms in such studies.

Tropical forest management and biodiversity: status, trends, and challenges in informing sound decision-making. Guariguata, M.R. (*Center for International Forestry Research, Indonesia; m.guariguata@cgiar.org*).

Drawing from relevant examples from the literature, this presentation discusses the following issues: (i) How much information have we gained over recent years in investigating management impacts on tropical forest biodiversity? (ii) What type of information is currently lacking yet needed to guide biodiversity-friendly management systems? (iii) What are the limitations of applied statistical designs and procedures on making sound inferences in species-rich tropical forests? (iv) What is the potential role of participatory approaches for monitoring biodiversity in informing management and/or conservation decisions? (v) How realistic is it to move from assessing changes in abundance and/or species richness in "unlogged vs. logged" or "before and after logging" and work towards defining maximum levels of biodiversity loss allowed in a managed forest? And finally, (vi) How can we modify commonly applied timber censuses to accommodate multiple-use objectives in a cost-efficient manner without sacrificing scientific quality? Consideration is also given to biodiversity information needs in the context of anticipated silvicultural intensification for timber, payments for ecosystem services, and the current assumption that certified tropical forests for timber can be equated with biological sustainability.

Biodiversity assessment and responses to silvicultural practices: experiences from GEF/ITTO targeted research projects in Malaysia. Kassim, A.R., Fletcher, C.D., Musa, S., Ibrahim, S. (*Forest Research Institute Malaysia, Malaysia; rahmank@frim.gov.my; cdfletch@frim.gov.my; samsudinmusa@frim.gov.my; shamsudin@frim.gov.my*), Potts, M. (*University of California at Berkeley, USA; matthewdpotts@gmail.com*).

In 2006, a 5-year GEF/ITTO project to address the issue of maintaining diversity in timber production forest was awarded to Malaysia. The project seeks to improve the maintenance of biodiversity and other values in tropical forest landscapes managed primarily for timber. The ultimate aim is to develop planning tools that integrate ecology and economic information to create a well-managed and sustainable forestry production system that will contribute to biodiversity conservation or the sustainable use of its components. Ecologically, the project is exploring the use of statistical methods to assess biodiversity from small samples; examining the assessment of biodiversity of selected flora and faunal taxa in timber production forest before and after logging; examining the role of small protected areas (Virgin Jungle Reserves) as local refugia for biodiversity recovery after harvesting; and investigating alternative timber harvesting methods as opposed to the minimum diameter limit approach commonly practiced in the Southeast Asian region. A predictive modeling tool is also being developed to simulate the impact of harvesting and calculate the tradeoffs between timber production and biodiversity conservation. The presentation will share some experiences and highlight the challenges in designing, analyzing, and implementing the project.

Patterns of species interactions in a montane cloud forest: furthering our knowledge and understanding of key aspects of ecosystem maintenance. Ledo, A, Condés, S. (*Universidad Politécnica de Madrid, Spain; a.ledo@upm.es; sonia.condes@upm.es*), Montes, F. (*CIFOR-INIA, Spain; fmontes@inia.es*).

The present research has been developed in the frame of a diversity and structure analysis in an Andean montane cloud forest, in Peru. Today, cloud forests are under severe threat, due mainly to the pressure of human-originated disturbances. A key step towards understanding the ecosystem's organization is to analyse the existing spatial relationships among the species in the stand. To improve this analysis, a new spatial analysis technique based on the mark correlation function was developed. This new tool allows the relationship between pairs of species to be characterised according to their developmental stages at different scales, and enhances our understanding of the existing inter-specific interactions in the stand (either facilitation or competition). For example, the development of a given species may depend on the existence of another in that zone, or on the contrary, the appearance of a specific species may hinder or impede the existence of another. The application of this new tool revealed different strategies between species at different scales in the studied forest, providing evidence for the complexity of the forest structure required to sustain the ecosystem. Any guidelines for the management of these fragile ecosystems must take into account these findings.

Statistical analysis for structure and regeneration response of degraded forests towards quality improvement. Lu, Y., Liu, X., Lei, X, Meng, J. (*Chinese Academy of Forestry, China; YLu@caf.ac.cn; xdlei@caf.ac.cn; jhmengforestry@hotmail.com*).

Degraded forests are characterized by their decrease of canopy cover density and tree growing tendency, so the term of degradation is taken to mean a loss of forest structure, productivity, or regeneration. These decrease are often consequences of negative selective harvest, legal felling, fire, or human disturbance. All these factors result in the lost of former ecological integrity of a forest and lead to degradation processes or situations. With examples of 3 typical degraded forests—from the tropics of Hainan to the warm temperate zone of Beijing and the temperate forest in the northeastern city of Haerbing—this presentation introduces a study on structure and dynamics of those degraded forests. Analysis of factors and variables of successional stage, canopy type, and regeneration tendency are made and operation measures for improving such forests' quality and growth are designed based on findings of analysis. The first preparatory data after improving operation shows a clear positive response of trees and stands on promotion operation. The three principles of bio-rationalization, natural automation, and response promotion of close-to-natural forest management with the related technical framework are reified and enriched with these experiences gained from this study on degraded forest restoration in China.

Posters

Fungal communities in forest ecosystems: rich, dynamic, and difficult to detect. Chiarucci, A. (*University of Siena, Italy; alessandro.chiarucci@unisi.it*), Floriani, M. (*Trento Bresadola Group, Italy; marco.floriani@libero.it*), La Porta, N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*).

Fungi constitute one of the most species-rich groups in the biosphere, but they are scarcely known from both the taxonomic and ecologic points of view. Although fungal communities represent one the most important functional components of forests ecosystems because of their saprotrophic, mycorrhyzal, and parasitic activity, they are often not included in ecological surveys and monitoring program, mainly because of the difficulties associated to their identification. In this paper, the results of a long-term project on the temporal dynamics of fungal communities in forest ecosystems of northern Italy are reported and discussed. This project is one of the few long-term studies that take fungal components into account; it is based on four sampling areas with three plots of 225 m^2 each, which have been sampled every 2 weeks since 1993. The list of fungal species collected in this period is amazingly high, being ca. 950. The annual dynamics of fungal species richness is investigated and compared with the expectations from the hypothesis that these forests were experiencing a shift in species composition. To do this, species rarefaction curves and temporal decay of community resemblance were investigated at the plot and site scales.

Analyzing the effects of environmental factors on species diversity of understory vegetation using canonical correspondence analysis. Han, H., Jang, K.M., Chung, J.S. (*Seoul National University, Republic of Korea; pack1@snu.ac.kr; lovis7@hanmail.net; jschung@snu.ac.kr*).

The objective of this study was to investigate the species diversity of understory vegetation associated with biotic and abiotic environmental factors of forest stand in Kwangneung Experimental Forest of South Korea. Vegetation data were collected from 109 sample plots in the study area and biodiversity was measured using Shannon-Wiener diversity index. The spatial distribution of plots was analyzed using GIS in terms of forest stand conditions, soil types, landforms, and topographic wetness index (TWI). Canonical correspondence analysis (CCA) was used to analyze the relationship between species diversity of understory vegetation and environmental factors. Correlations of environmental factors with CCA axes were calculated, and p-values of the CCA axes were computed by Monte Carlo test to evaluate the significance of the axes. Biplot was also depicted in ordination space to identify visual classification of sample plots by CCA axes and major environmental factors. According to the results of this study, the species diversity of understory vegetation is influenced significantly by stand density, TWI, aspect, and soil depth. These results suggest that light and water availability are important factors to determine the species diversity of understory vegetation in forest stands.

A hierarchical Bayesian model of species abundance in floor vegetation of managed coppices and abandoned forests. Itô, H., Hino, T. (*Forestry and Forest Products Research Institute, Japan; hiroki@affrc.go.jp; tkpk@affrc.go.jp*), Sakuma, D. (*Osaka Museum of Natural History, Japan; sakuma@mus-nh.city.osaka.jp*).

Species abundance in floor vegetation was compared among three developmental stages (early, middle, and late) of managed coppices and two types of abandoned forest (broadleaved and pine). The studied coppices mainly consisted of *Quercus acutissima*, were maintained to produce charcoal, and had been cut periodically about once every 10 years. The abandoned forests appeared to have been left for at least 30 years. A hierarchical Bayesian model was constructed to estimate the probability

distributions of appearance for each species for each condition (forest type, management, stand age, and floor clearing). The results showed that species abundance was higher in the managed coppices than in the abandoned forests and higher before floor clearing (early and middle stages) than after clearing (late stages) within the coppices. A simulation using the result of the model was conducted to estimate which management plan would maintain the abundance of floor species in coppices: clearing all stands every 10 years, clearing half the stands every 5 years, clearing one-fifth of the stands every 2 years, or clearing one-tenth of the stands every year. The simulation showed that all plans except the clearing of all stands every 10 years would maintain a constant abundance of species.

A structural equation model analysis of overstory-understory relationships. Lam, T.Y. (*Oregon State University, USA; tzengyih.lam@oregonstate.edu*).

Overstory-understory relationships have been studied for decades; initially for understanding understory biomass production for foraging. Later, the interest shifted to the conservation of understory species diversity through active forest management. The relationship is multivariate and complex, but analyses thus far have been relying on the univariate response method or exploratory analysis. Structural equation modeling (SEM) is a powerful multivariate statistical tool that analyzes direct and indirect relationships among factors by imposing structure on the relationships. This requires one's understanding of the underlying processes, which could come from either empirical studies or theoretical hypotheses. An SEM is built to test direct and indirect relationships between overstory and understory. Some of the hypotheses are: (1) Does overstory tree cover have a direct effect on late-seral herb cover or an indirect effect through tall shrub and understory tree cover (light attenuation)? (2) Does tree density have a direct effect on late-seral herb cover (below ground resource competition)? And (3) Does aspect have an indirect effect on late-seral herb cover through overstory tree cover (light transmission)? Quantification of the effects will be parameter estimates very similar to those obtained from regression.

Tree species spatial structure in an upland tropical rain forest in the Amazon region, Brazil. Silva, K.E. (*Brazilian Agricultural Research Corporation, Brazil; kat.emidio@gmail.com*), Fortin, M-J. (*University of Toronto, Canadá; mariejosee.fortin@utoronto.ca*), Martins, S.V. (*University of Viçosa, Brazil; venancio@ufv.br*), Ribeiro, M.C. (*Sao Paulo University, Brazil, mcr@usp.br*), Ribeiro, C.A.A.S., Santos. N.T. (*Federal University of Viçosa, Brazil; caas.ribeiro@gmail.com; nsantos@ufv.br*), Azevedo, C. (*Brazilian Agricultural Research Corporation, Brazil; celso.azevedo@cpaa.embrapa.br*).

The roles of species-environment relationships and ecological processes in structuring tree species spatial distribution at different study area sizes were investigated in a upland Amazon tropical rainforest in Brazil. Tree relationships with soil properties were determined by using canonical correspondence analysis (CCA) to get the species response to the gradient of soil variables. Then, Ripley`s K functions (uni- and bi-variate) were used to investigate the spatial pattern of species in 33 plots ranging from 2,500 m^2 to 20,000 m^2 in size. All trees with dbh $\geq$ 10.0 cm were stem mapped in 2005 at the experimental site of Embrapa, Manaus/AM. The CCA based on nine soil variables and 68 species separates tree species in two groups occurring mainly in humid and dry sites. Soil variables and dispersion syndrome have influenced the spatial aggregation of species in different ways in the two groups at scales larger than 10,000 m^2, mainly for the species found in clay texture and less humid environments. Sample unit sizes larger than 10,000 m^2 and environmental heterogeneity should favor forest dynamic studies to better characterize and understand the spatial processes structuring tropical rainforests, contributing to biodiversity conservation and forest management in the tropics.

Typical sampling of forest ecosystems in China based on an eco-geographical zoning system. Xiang, N. (*Beijing Forestry University, China; niuxiang11@sina.com*), Bing, W. (*Chinese Academy of Forestry, China; wangbing@caf.ac.cn*).

The Chinese forest ecosystem observation network is an important platform for forest ecological long-term research. Improvement in the selection of monitoring stations within the Chinese forest ecosystem observation network was based on eco-geographical zoning. The work of the National Ecological Observatory Network and Environmental Monitoring Network for India were used as a reference. The distribution of dominant forest species and the eco-geographical zoning research results are summarized. The biodiversity hotspots and critical areas and Chinese ecological function zoning were considered.The statistic analyses included several techniques such as principal component analysis. Geographic Information System and Remote Sensing Technology were used as tools to deal with many layers.The location zones of eco-station were selected according to the overlapping part of all layers. The typical sampling of forest ecosystem in China based on eco-geographical zoning system also has been proposed. This system is designed to accomplish several goals, such as linking and/or combining many stations and repeating measurements across the network to gain greater ecological knowledge over a larger scale.

B-20 Analysing the "translation" of global discourses on forest governance to regional, national and local levels

Organizers: Karl Högl, *University of Natural Resources and Applied Life Sciences, Austria, karl.hogl@boku.ac.at*; Daniela Kleinschmit, *Swedish University of Agricultural Sciences, daniela.kleinschmit@sprod.slu.se.*

Global forest governance: less a failure than an often thought. Arts, B. (*Wageningen University, the Netherlands, Bas.Arts@wur.nl*).

International forest policy is often depicted as a failure. There exists only soft law, and the instruments that do exist are hardly implemented at national levels. In other words, one should conclude that international forest policy is characterized by "governance failure." These negative accounts mostly reason from legal, institutional, or rational policy models, because international forest law is considered 'soft' (see the *non-legally binding instrument on all types of forests*), international forest institutions are considered 'weak' (see the UNFF), and the international forest policy cycle is not closed (implementation deficit). In this

presentation, another policy perspective will be presented: discursive institutionalism. This is a new branch on the tree of neo-institutionalism and analyzes how new ideas, concepts, and narratives invoke institutional change and innovation. This approach delivers another, less pessimistic evaluation of international forest policy. It shows that new discourses such as sustainability, biodiversity, and governance have become dominant and institutionalized in the forest policy domain over the past 3 decades. This has led to behavioral change among a broad range of stakeholders and, locally, to positive impacts in the field.

Regional forest governance: potentials for forestry and political drivers in processes of regional governance. Giessen, L. (*University of Göttingen, Germany; lgiesse@uni-goettingen.de*).

Devolution or regionalisation stresses the importance of local and regional levels for addressing political issues. In combination with new modes of governance, this trend results in claims towards "regional governance" as a normative concept. It is characterised by a regionalised and inter-sectoral approach using incentives as political instruments. The aims of this paper are identifying the potentials of regional governance processes for forestry, and analysing the main political drivers therein. Case studies on German "integrated rural development policy" serves for addressing these questions. The results show that regional governance offers diverse conventional as well as innovative potentials, which may be realised by specific forestry actors only. The main political drivers are: (i) the competition among different political levels as well as among the traditional government system and governance institutions; (ii) the constraints imposed by policy sectors on the integrative nature of regional governance. Both determinants are restricting the successful implementation of regional forest governance to that of temporary pilot policy at regional levels only. The session concludes with an interactive discussion of other examples of regional forest governance, such as community forestry and model forests.

"Invasive concepts": do international forest policy approaches affect domestic policy making? Hogl, K. (*University of Natural Resources and Applied Life Sciences, Austria; karl.hogl@boku.ac.at*).

The paper will examine the role of concepts (ideas) that are prominent in international-level forest policy discourses (such as participation and policy integration), as they relate to national-level strategy processes, both in the field of forest policy as well as other policy fields. It will address the relation between the policy subsystems' receptiveness to "new" concepts and their actual manifestation as induced by international impulses (such as by international agreements). An empirical comparative analysis was conducted on the effects of legally and non-legally binding international agreements in terms of the changes induced through national strategy processes (most probably including the Austrian Biodiversity Strategy, the Austrian Forest Dialogue, and the Austrian Strategy for Sustainable Development, as well as regional strategies for protective forests management). As the empirical analyses show, international policy impulses have in fact introduced new ideas and have opened national policy arenas for new actors. However, case studies also point out that the actual effects of similar impulses for change seem to be systematically mediated by the pre-existing domestic policy subsystem configurations, resulting in substantially different strategy processes and outputs, ranging from quite substantive changes to a mere rhetorical fulfillment of international agreements.

Discursive natures: equity, benefit-sharing, and the invention of international biodiversity policy. Humphreys, D.R. (*The Open University, United Kingdom; d.r.humphreys@open.ac.uk*).

This paper argues that there is an iterative relationship between power as resources (the ownership of, and ability to mobilise, material capabilities) and power as discourses (the construction of established ways of thinking about and expressing ideas in a way that other accept as legitimate). Discourses travel among different spatial scales (ranging from the local to the global) and between different institutions. They may gain in influence and be endorsed by a wide range of actors when they are consistent with shared values and policy objectives. Discourses do not "arrive" intact in space, but are mediated through localised cultures and belief systems. The paper argues that what are often commonly thought of as global discourses are invariably expressions of ideas that originated at the local or national levels. In the case of biodiversity and forest policy these ideas include participation, equity, neoliberalism, and benefit-sharing. Indeed, while now a dominant idea, the concept of biodiversity is itself a relatively recent term that was not in common usage prior to 1985. The term is not purely descriptive; it expresses a particular normative assumption, that maintaining diversity is desirable and any loss of desirable is thus undesirable.

Posters

REDD discourse and its implications for Swedish forest policy. Holmgren, S., Kleinschmit, D. (*Swedish University of Agricultural Sciences, Sweden; sara.holmgren@sprod.slu.se; daniela.kleinschmit@sprod.slu.se*).

The link between forests and climate change imply a shift in focus from forest management perspectives to climate change and, for example, carbon trading. Reducing emissions from deforestation and forest degradation in developing countries (REDD) implies that developing countries can sell carbon credits based on reductions of emissions from deforestation and forest degradation. The aim of this paper is to discern how REDD is framed on an international level, and distinguish who is dominating the framing. Subsequently, it explores if/how the institutionalised discourse of REDD is reflected in the Swedish forest policy discourse. To interpret the results, we used a discursive-institutional approach, which relates ideas and meanings to institutional dynamics. The empirical material consists of international policy documents, Swedish media reporting on REDD, and interviews conducted with Swedish actors of the forest policy arena. The results of the international analysis are expected to clarify the struggle over the framing, and those actors/coalitions who are to be perceived as influential, as well as the difference of framing REDD on the international and national political levels.

Towards governance of science: the small steps of forest science. Real, A. (*Corporación Nacional Forestal, Chile;, alejandra.real@conaf.cl*).

Governance processes have emphasized openness and participation as fundamental principles. These are also essential for science governance. Studies have shown that openness and participation in science generally have increased in recent years. The question

is whether the same is true for forest science. Openness and participation are also fundamental aspects of deliberative discourses following Habermasian theory. Discourses that arise out of communication processes that are open and accept participation, may be considered legitimate processes. Following these premises, discourses of forest science are examined. Scientific publications on three issues that have appeared in international forest peer-reviewed journals from 1994 to 2003 are the grounds for examining the discourses of forest science and their openness and participation. Results show that regarding the inclusion of different actors (variety of countries) in its discourse, forest science is slowly catching up to science in general. However, the dominant discourses are still shaped by English-speaking industrialized countries, with a limited participation of northern European countries. For forest science to gain in openness and participation, as well as for the discourses be legitimated on a global level, forest science must decide on practices such as international collaboration that reinforce these principles.

Framing the tiger: incongruent discourses on different political levels as an obstacle to the effectiveness of international governance. Sadath, Md.N. (*Khulna University, Bangladesh; mnsadath@yahoo.com*), Kleinschmit, D. (*Swedish University of Agricultural Sciences, Sweden; Daniela.Kleinschmit@sprod.slu.se*).

International forest governance processes assume that international impulses will be translated into and be taken up at different levels (national, sub-national, and local) of forest policy arenas. Prerequisite to an unhindered translation of processes is a common understanding of governed problems on the different political levels. However, the framing of a problem might differ with the grade of concernment. The aim of this poster is to exemplify that discourses differ when it comes to different political levels. The results imply that the effectiveness of international governance processes is limited by the lack of conformity between the international discourse and the discourse of the affected political level. The case of recent tiger attacks in the Sundarbans (Bangladesh) is used as an example. From the international perspective the conservation of the "royal bengal tiger" is a global common goal. From local and national perspectives the Sundarbans is a source of economic opportunity for local people living in surroundings villages jeopardized by increasing tiger attacks. The empirical material consists of local, national, and international media reporting on recent tiger attacks.The results of the analysis will be discussed with regard to the effectiveness of international governance processes on biodiversity.

B-21 Assessing the effects of forest management on biodiversity over large landscapes: tools, trends and implications for conservation

Organizers: Ken Sugimura, *Forestry and Forest Products Research Institute, Japan, kensugi@ffpri.affrc.go.jp*; Sandra Luque, *French Institute of Agricultural and Environmental Engineering Research-CEMAGREF, France*, *sandra.luque@cemagref.fr;* David Langor, *Natural Resources Canada, Canada, david.langor@nrcan-rncan.gc.ca.*

Forest management strategies to increase structural complexity and enhance biodiversity in temperate mixed forests of Japan, Alaska, and central Europe. Deal, R.L. (*U.S. Forest Service, USA; rdeal@fs.fed.us*), Yoshida, T. (*Hokkaido University, Japan; yoto@fsc.hokudai.ac.jp*), Noguchi, M. (*Forestry and Forest Products Research Institute, Japan; mahoko@ffpri.affrc.go.jp*), Boncina, A. (*University of Ljubljana, Slovenia; andrej.boncina@bf.uni-lj.si*), Duduman, G. (*University of Suceava, Romania; gduduman@usv.ro*).

We synthesize research on tree species mixtures, selection harvesting, and management practices to increase forest structural diversity and enhance ecosystem function in temperate forest ecosystems in Alaska, northern Japan, and central Europe. We summarize management options for Alaska in older forests that have never been actively managed, and in younger forests to increase diversity of stand structures and their associated effects on biodiversity. We describe forest community dynamics in mixed confer-broadleaf forests under selection systems in northern Japan and assess their role for increasing stand complexity and sustainability of these forests. We summarize research of selection cutting in mixed forests in Slovenia and Romania and their effects on regeneration and understory plant diversity and abundance. We synthesize research in mixed temperate forests in Alaska, Japan, and central Europe and compare and contrast different forest management practices in these different forests to increase structural diversity and enhance biodiversity. Different management strategies are assessed for improving forest biodiversity; and the use of partial cutting, selection harvesting, and mixtures of different tree species are evaluated. We synthesize this research to assess the broad role that mixed hardwood-conifer forest may provide for improving biodiversity and sustainable forest management in temperate forests.

Thirty years' experience integrating biodiversity conservation in production forest landscapes: the Nordic approach. Gustafsson, L. (*Swedish University of Agricultural Sciences, Sweden; lena.gustafsson@ekol.slu.se*), Perhans, K. (*University of Queensland, Australia; k.perhans@uq.edu.au*).

A multi-scaled model for forest conservation has been applied in Sweden for 30 years, making it a pioneer example of an integrated, ecosystem approach. The model has large similarities to current practices in Norway, Finland, and the Baltic states. Trees are set aside for biodiversity purposes from individual trees at final logging to nature reserves covering thousands of hectares, with land-owner responsibility at the lowest level and with increasing state involvement at higher levels. "Key habitats," usually covering a few hectares, form an intermediate-scale level. The model is supported by ecological theory, and retention efforts at the lowest scale levels are advantageous since they stimulate land-owners' interest in conservation. Nevertheless, studies indicate that current retention levels might be too low to effectively preserve biodiversity. Development of the model will be necessary in a future with intensified forestry and global warming. Suggestions for progressive thinking include joint planning for several forest owners, consideration of cost-effectiveness, accepting opportunistic work models, adjusting retention levels to stand and landscape composition, introduction of temporary reserves, creation of "receiver habitats" for species escaping climate change, and protection of young forests.

Adaptive forest management in Europe based on a multi-criteria approach to biodiversity conservation. Hanewinkel, M. (*Forest Research Institute of Baden-Wuerttemberg, Germany; Marc.Hanewinkel@forst.bwl.de*).

The paper describes how management strategies that are adaptive to climate change for central European forests are developed based on a multi-criteria vulnerability assessment. Using the example of southwest Germany, different aspects of the vulnerability index including conservation of protected species are described. Vulnerability includes assessment of abiotic and biotic risks and is based on a biome shift model for European tree species for different IPCC scenarios. Results of this model, a GLM using pan-European level-I monitoring data and the results of regionally downscaled climate projections for temperature and precipitation are presented, together with results of an empirical storm damage model. The models show that especially cold-adapted species like Norway spruce (*Picea abies,* Karst) will lose large parts of their actual range with increasing temperature and how storm damage probability increases with height and exposure. Conservation aspects are demonstrated using a niche model for the endangered species Capercaillie (*Tetrao urogallus, L.*) in central European low mountain ranges. The paper shows how the different criteria of the vulnerability index are interconnected using a Bayesian belief network (BBN) approach, and how adaptive management strategies are developed within the framework of a large-scale integrated EU project using results of case studies in Europe.

Monitoring dynamics of biodiversity: lessons from nationwide survey in Japan. Koizumi, T., Yamaura, Y. (*Forestry and Forest Products Research Institute, Japan; koizmy@affrc.go.jp; yamaura@ affrc.go.jp*).

As the results of intensive afforestation during 1950–1970 and decrease in timber harvest since 1970, the proportion of middle and old age class forests has been increasing in Japan. We assessed the effect of this forest maturation on wildlife, using two nationwide surveys. The National Survey on the Natural Environment has been collecting the data on the distribution of wildlife every 5 years since 1973. The abundance of bird species depending on early successional forests decreased, whereas the abundance of bird species depending on mature forests increased. This phenomenon reflected forest maturation. Middle- and large-sized mammals recorded in the survey expanded their ranges. Because they use various types of forests as habitat, patchy landscapes may bring positive effects. The National Survey on the Forest Resource has been recording forest inventories on 15,700 sites every 5 years since 1999. Species diversity in understories decreased in the range of ungulates. This may be related to strong grazing/browsing impacts of extraordinarily increasing sika deer. Nationwide surveys will be an effective tool to understand the interactive relationship between forest management and wildlife.

Forest habitat quality assessment for planning conservation, and management strategies over European forest landscapes. Luque, S. (*CEMAGREF, Institute for Agricultural and Environmental Engineering Research, France; Sandra.Luque@cemagref. fr*).

Most change in the contemporary European landscape is now caused by changes in the management of semi-natural habitats. The challenge then for conservation is to manage complex landscapes in a way that retains and enhances biodiversity value. In order to improve regional planning in managed forests, habitat quality assessment is needed to design management plans to allow expansion and/or connectivity of protected areas. Forest habitats of particular importance for target species can be protected as part of adaptive management measures. The work presents methods and tools that can be used in assessing biodiversity value for both managed and protected forest areas, to help decision-making concerning valuable habitats protection and management. Several conceptual approaches have been developed in order to evaluate different habitat quality models that are used as a surrogate for forest biodiversity value at different scales. The indicators and the models developed reflect a sound scientific basis that can be implemented in other European countries that invest in national forest inventories and large databases. This effort constitutes the first attempt done at the landscape level, focusing on end users' needs, for broad-scale biodiversity monitoring and management.

Adaptive forest management for biodiversity conservation in south Patagonia. Martínez Pastur, G., Lencinas, M.V. (*CADIC CONICET, Argentina; cadicforestal@gmx.net; vlencinas@cadic.gov.ar*), Cellini, J.M. (*LISEA UNLP, Argentina; jmc@ceres.agro. unlp.edu.ar*), Peri, P.L. (*INTA UNPA CONICET, Argentina; pperi@correo.inta.gov.ar*).

Natural native forests of *Nothofagus pumilio* are the main source for the sawmill industry and are located on public and private lands. Several silvicultural methods were proposed (e.g., shelterwood cuts) including alternative methods to enhance biodiversity conservation (e.g., variable retention). Theoretical models included a remnant overstory for periods up to 20 years until natural regeneration was established. The objective was to evaluate impacts of these silvicultural methods over forest, abiotic and biotic variables (overstory, flowering and seeding, regeneration, understory plants, birds, insects, mosses, fungi, climate, and soil properties), and to determine the effectiveness of the implementation of these methods, as well as the biodiversity conservation values during the first years after the cuts. Shelterwood cuts largely affected the studied variables more than variable retention, which conserves most of the natural processes in aggregated retention. However, both methods were not correctly implemented. Large quantities of timber material were abandoned in the forest. Wind-blow of remnant trees increased over time due to stem damage during the harvesting, but regeneration was abundant for stands recovery. New harvesting strategies must be implemented to assure the stability of the remnant overstory and to sustain, both economically and ecologically, the implementation of these regeneration methods.

Evaluation of biodiversity with a multi-criteria approach and its application to conservation. Sugimura, K. (*Forestry and Forest Products Research Institute, Japan; kensugi@ffpri.affrc.go.jp*).

The number of species (species richness) in a certain taxonomic group is often used to measure biodiversity over a forested landscape. On the other hand, the presence of endangered and/or phylogenetically unique species facilitates establishment of a biological reserve. In the present study an index with a multi-criteria approach (MCA index) was developed, which involves species richness, phylogenetic uniqueness, and distribution area of a species that is supposed to represent its endangered status. Then, avian communities on 95 survey sites were evaluated and compared with each other based on this index, on species richness, and on the number of endangered species. The results indicated that the number of endangered species failed to highly evaluate the sites with largest number of species and vice versa. In contrast the MCA index evaluated both of them high.

Likewise, either species richness or the number of endangered species failed to give any significant difference between the communities in old growths and those in young growths after clear-cutting, although species richness was apparently lower in tree plantations than in natural forests. These results suggest that the MCA index is more appropriate than the others as a way to select reserves and detect effects of forest management.

Posters

A hierarchical approach for mapping priority of riparian forest restoration: toward the catchment-scale conservation of biodiversity and ecosystem services. Ito, S., Soen, N., Sato, T. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp; agf806u@student.miyazaki-u.ac.jp; agf709u@student.miyazaki-u.ac.jp*), Mitsuda, Y. (*Forestry and Forest Products Institute, Japan; mitsuda@ffpri.affrc.go.jp*).

Riparian forests are the key element of biodiversity of catchment ecosystems, as they consist of various kinds of vegetation with high biodiversity. Riparian forests also play important roles such as ecological corridors or buffering the impacts of slope events. Thus, the restoration of riparian forests degraded by production activities is urgently needed. As restoration of riparian forests in production area meets the trade-off between timber production efficiency and biodiversity conservation, strategic selection of restoration sites is crucial for feasibility of restoration. To solve this problem, this study proposes a hierarchical approach for mapping priority of restoration sites. In the first level, we evaluated the potential habitat suitability based on natural distribution of riparian trees to extract the candidate sites. Second, we evaluated the degree of degradation due to anthropogenic disturbances to assess the restoration requirement. Finally, we evaluated the restoration priority by estimating the recovery of habitat connectivity when the site is restored. This strategic selection of restoration sites would enable efficient restoration of riparian forests against different requirement of roles or functions, and help to promote balanced multiple ecosystem services for the whole catchment ecosystem by mitigating the impacts of timber production activity in the slope area.

Changes in forest resource utilization and biodiversity in a temperate *Fagus crenata* forest, Honshu, Japan. Miyamoto, A., Sano, M., Tanaka, H., Inoue, T., Makino, S. (*Forestry and Forest Products Research Institute, Japan; asakom@ffpri.affrc.go.jp; masakoto@ffpri.affrc.go.jp; hirop@ffpri.affrc.go.jp; taisei@ffpri.affrc.go.jp; makino@ffpri.affrc.go.jp*), Nakashizuka, T. (*Tohoku University, Japan; toron@mail.tains.tohoku.ac.jp*).

In the past 60 years, conifer plantations have increased in Japan, especially with extensive afforestation after World War II, and the forest landscape has changed greatly in both mountainous areas and farming communities. This dramatic change in landscape and traditional usage has likely had a significant influence on local biodiversity. In this study, to clarify the influence of changes in forest landscape on biodiversity around the Ogawa Forest Reserve (OFR) in the southern Abukuma Mountains, Honshu, Japan, we investigated forest resource utilization and forest landscapes by interviewing local residents and reviewing local historical documents. We created biodiversity maps based on reconstructed old forest landscape maps and a diversity index of insects and plants from data gathered by field survey. As a result, we found that local residents had actively used forest resources for their livelihoods. Therefore, most of the forests in this region had been heavily affected by various human impacts such as horse grazing, felling for charcoal and fuelwood, burning to maintain grasslands, and conversion of forest type from natural forest to conifer plantation after the war. Such changes in the use of traditional forest resources have greatly influenced local biodiversity.

Dynamic of a secondary forest based on ecological group distribution over a 9-year period in the domain of the Atlantic forest, in Brazil. Reis, M.G.F.; Reis, G.G.; Silva, C.T.; Ramos, D.C.; Faria, R.S.; Souza, F.C. (*Universidade Federal de Viçosa, Brazil; mgfreis@ufv.br; greis@ufv.br; crodosilva@yahoo.com.br; diegovisk10@hotmail.com; nansoares@yahoo.com.br; felippeenf@yahoo.com.br*).

The Atlantic forest in Brazil was drastically reduced mainly for wood production, agricultural crops and pasture establishment, and roads and city construction. Most of its remnant forest is composed of small fragments in different stages of succession, and their management is very important to maintain or increase biodiversity. The trees with diameter at breast height (dbh) $\geq$ 5 cm was measured in 1992 and 2001 in 10 sites with different aspect, slope, and degree of anthropogenic disturbance in a secondary forest fragment. A total of 1,950 individuals, 146 species, and 45 families were sampled in 1992, and 1,972 individuals, 150 species, and 46 families, in 2001. The species were classified as pioneer and initial and late secondary. The number of pioneer species decreased and late secondary species increased in most sites between 1992 and 2001. Initial secondary species were predominant in all sites studied. Variation in the proportion of the three groups was observed between sites; the lowland site was most fertile and the moist site was the one with the greatest number of late secondary species. Based on these results, it can be recommended that variations within the fragments should be considered in their management.

Bird species diversity and the developmental stage of conifer plantation in Japan. Sato, S. (*Shikoku Research Center, Forestry and Forest Products Research Institute; shigeho@affrc.go.jp*).

The amount of conifer plantation is extremely high on low mountain zones in Japan as a result of forest utilization by humans. Over 70 percent of forest area is covered with plantations of Japanese red cedar *Cryptomeria japonica* and hinoki cypress *Chamaecyparis obtusa* in Shikoku Island, which is one of four main islands of Japan. Forest management that considers the conservation of biodiversity is needed not only for natural forests but also for conifer plantations. To evaluate the conifer plantations for forest bird community, the author compared the species composition of forest bird community on low mountains in Shikoku Island. The research plots were set in young plantations, middle-aged plantations, and mature plantations in order to analyze the effect of the developmental stage of plantation. The number of bird species and the bird individuals were few in young plantations. The richness of bird species was higher in matured plantations than in young and middle-aged plantations. The diversity index (Shannon's H′) of birds correlated with the stand age and the crown height of the research plots. This suggests that the species richness and the composition of birds were affected by the developmental stage of conifer plantations.

Estimating biological diversity by watershed analysis tools in forested regions: a case study from Turkey. Serengil, Y., Yurtseven, İ., Çokoyoğlu, S., Uygur, B. (*Istanbul University, Turkey; yserengil@yahoo.com; ibrahimy@istanbul.edu.tr; cokoyoglu@gmail.com; buygur@yahoo.com*).

Biological diversity in a region is an outcome of biological diversity potential, which is strongly related to hydrologic diversity and watershed attributes, and also human impact level. Therefore an estimation of biological diversity can be possible by simple spatial analyses methods, which we frequently use in watershed assessments. In the Yildiz mountains region of Turkey we performed a spatial watershed assessment study by using GIS methods combined with field surveys on stream corridors. The region is going to be a candidate for biosphere reserve next year and also very important in terms of water supply to Istanbul, the largest city of Turkey. The watershed attributes we assigned to estimate biological diversity potential were; number of lentic systems (lakes, lagoons), area of lentic systems, drainage density, drainage frequency, maximum relief (max elevation-min elevation), and number of perennial streams. The highest biological diversity potential was determined in areas where human interruption was minimal. More than half the study area had a biological diversity potential from "poor (0–7)" to "fair (13–15)". Less than 10% of the study area was classified as having "very good (>400)" potential.

Biodiversity assessment in regional scale in Santa Catarina state floristic and forest inventory in southern Brazil. Vibrans, A.C. (*Universidade Regional de Blumenau, Brazil; acv@furb.br*), Uhlmann, A. (*EMBRAPA-CPAFAP, Brazil; alexandre@embrapa.cpafap.br*), Schorn, L.A., Sevegnani, L., Marcolin, M., De Gasper, A.L., Lingner, D.V., Brogni, E., Verdi, M., Bachmann, V. (*Universidade Regional de Blumenau, Brazil; lschorn@furb.br; sevegn@furb.br; marcolin@furb.br; algasper@gmail.com; deboravanessa_ef@gmail.com; e.brogni@terra.com.br; verdibio@hotmail.com; vanessabachmann@hotmail.com*).

The Floristic and Forest Inventory of Santa Catarina (95.000 km²), running since 2007, was conceived to provide information to formulate forest conservation and land use policy, by updating state-wide floristic data collected in the 1950s, as the basis for *Flora of Santa Catarina* (FIC). Therefore, integration and digitalization of the state's four existing herbaria, field inventories, assessments of the genetic structure of endangered plant populations, and study of the socio-economic importance of forest resources go hand in hand to provide a geo-referenced on-line database to be accessed by decisionmakers and the public. Until now half of 500 sampling units (4,000 m² each) located on a 10-x10-km grid have been measured. Floristic survey includes all fertile trees, shrubs, and herbs within and around sample units. Detailed assessment of vascular epiphytic plants as conservation status indicators is considered essential. High regional diversity contrasts to low diversity on the local level, showing degraded and often isolated stands. Spatial distribution of species is compared to records from the 1950s by GIS tools. Relationships between species distribution and density and climatic/edaphic gradients and human stress factors are discussed. Inventory is to be continued in a 5-year cycle.

Impacts of the reform of collective-owned forestland on biodiversity conservation in China. Zhou, J., Liu, J., Wang, Y., Li. T, (*Beijing Forestry University, China; zjh296@gmail.com; liujia1718@163.com; wangyubing@yeah.net; knat970.student@sina.com*), Li, D. (*Chinese Academy of Forestry Science, China; lidq@caf.ac.cn*).

The conflict between biodiversity conservation and economic development is a phenomenon worldwide, especially in developing countries. China is one of the countries with the richest biodiversity. In order to conserve its biodiversity and ecosystems, China has established thousands of nature reserves. The total area of nature reserves comprises more than 15% of the country's terrestrial area, and quite large portion of the reserves was collective-owned forestland. In the collective management model, individual households have not much role in forest management. In the ongoing collective-owned forestland reform, those forestlands that had been managed by the collective institution will be distributed to the households, and the households will responsible for decision making. Even though the forestland in the natural reserves is waived from the ongoing reform, the reform has impacts on natural reserve management and biodiversity conservation. This paper mainly focuses on such impacts. It first describes the current land property right property in China, and then introduces the collective-owned forest reform procedures in different regions. The behavior of households corresponding to the reform was analyzed. The paper finally gives a conclusion and raises suggestions for future policy.

B-22 Forest biodiversity—the key to healthy and resilient forests

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Posters

Biodiversity and ecology of some terrestrial orchids in deciduous dipterocarp and mixed deciduous forests of Chiang Mai and Lamphun Provinces, Thailand. Pothasin, P. (*Chiang Mai University, Thailand; nok_p_p@hotmail.com*), Wattana, S. (*Queen Sirikit Botanic Garden, Thailand; swatthana@yahoo.com*), Wangpakapattanawong, P. (*Chiang Mai University, Thailand; prasit.w@chaingmai.ac.th*).

Biodiversity and ecology of some terrestrial orchids in deciduous dipterocarp forest (DDF) and mixed deciduous forest (MDF) of Chiang Mai and Lamphun Provinces, Northern Thailand, were investigated from July 2004 to December 2005. The study aimed to determine species richness, morphology characteristics, phenology, and ecology of orchids. Three permanent quadrats, 40×40 m^2 each, were established in four study sites. Eight orchid species were found in all study sites. Four species were found in DDF, including *Habenaria dentata*, *H. hosseusii*, *H. lindleyana,* and *Pecteilis susannae*. Two species were found in MDF, including *H. lucida* and *H. malintana,* and two species were found in DDF and MDF, including *Brachycorythis henryi* and *Liparis sutepensis*. Pattern of dispersion, flowering, fruit set, and population structure were assessed. This study suggests that all six of these species should be considered as important for conservation, because there were small populations and the percentages of fruit set were very low or none, hence their numbers in nature are decreasing. Such knowledge will be very useful in managing areas, including reserved trees in the forests (which affect light intensity and shading), to maintain orchid populations in natural habitats.

Plant species biodiversity quantification and population dynamic analysis of *Scaphium macropodum* for its sustainable management and utilization in Vietnam. Quoc Huy, L. (*Forest Science Institute of Vietnam, Vietnam; lequochuy2009@gmail.com*), Marinus W. (*Utrecht University, the Netherlands; M.J.A.Werger@uu.nl*), Thanh Cong, L. (*Forest Science Institute of Vietnam, Vietnam; thanhcongle007@gmail.com*), Pieter, Z. (*Utrecht University, the Netherlands; P.A.Zuidema@uu.nl*), Rene, B. (*Tropenbos International, the Netherlands; rene.boot@tropenbos.org*).

Scaphium macropodum is a valuable multipurpose forest tree species in Vietnam utilized for tonic and medicinal beverages and for timber. Its natural distribution ranges from Bach Ma National Park (Thua Thien Hue) southwards to Cattien National Park in Dong Nai province. This species was once abundant in natural forests, and local communities significantly benefited from its valuable products. Unfortunately, owing to seriously improper management and harvesting, the species is now endangered. We quantified species diversity of the *Scaphium* plant communities and its population dynamics at three sites: Cattien, with high disturbance due to overharvesting of fruits, bamboo invasion, and forest conversion for agricultural cultivation; Bach Ma, with medium disturbance; and Dak Uy, with least disturbance. Our results showed that, across these sites, the Shannon-Weiner index (*H*) ranged from 3.68 to5.62; IVI values for *Scaphium* ranged from 13.8 to 67.9 (IVI total: 300), and rates of population development (λ) ranged from 1.014 to 1.096. The highest values of *H* were found at the medium disturbance site, where *S. macropodum* seems to thrive best. Under favourable conditions, at least 10–15 *Scaphium* plants/ha could be sustainably harvested for fruits to provide an annual income of 18–20 million VND (about 1,000$US) to local farmers.

B-23 Long-term forest monitoring and its importance for decision-makers

Organizers: Jerome Vanclay *Southern Cross University, Australia, jvanclay@scu.edu.au.*

Silvicultural studies in the virgin forests network of the Caspian region. Sagheb Talebi, Kh., Akhavan, R., Parhizkar, P. (*Research Institute of Forests and Rangelands, Iran; saghebtalebi@rifr-ac.ir; akhavan@rifr-ac.ir; parhizkar@rifr-ac.ir*).

The total area of the Caspian temperate deciduous forests is approximately 2 million ha, which are representative of forests from the Cenozoic period. Deciduous forests that were destroyed by glacial advances in Europe and northern Asia survived in Iran. Therefore, the Hyrcanian forests are among the last remnants of natural deciduous forests in the world, rich in biodiversity and containing 115 endemic plants. For nature-based sustainable management of these forests, comprehensive information on the natural forest ecosystem is required. The Research Institute of Forests and Rangelands in Iran has identified intact old-growth stands within different parts of the Caspian forests. The first four areas are distributed in the oriental beech forests from west to east covering different areas of 20, 45, 90, and 25 ha. Within each area, three sample plots, each 1 ha, have been laid out in three different development stages. An integrated research project has been carried out in the studied sites including climate, soil, flora, light regime, spatial pattern, structure, disturbances, gaps, deadwood, and silvicultural characteristics of trees and regeneration studies. It is planned to expand the investigations on oak, and mixed virgin old-growth stands and monitor them within next decades.

Importance of long-term forest monitoring for informed decision-making on forests. Vanclay, J.K. (*Southern Cross University, Australia; jvanclay@scu.edu.au*).

Permanent sample plots and long-term experiments have helped to reveal important insights into forest dynamics and environmental change, and continue to offer new insights into forest responses to climate change and other environmental impacts. A review of the literature summarises some key findings drawn from long-term studies and draws attention to the potential benefits of maintaining and collaborating on such studies. The conduct and studies of long-term forest monitoring is important, because some findings have been contrary to expectation and have stimulated new directions for research and forest management. The review also draws attention to attributes characteristic of monitoring programs that are versatile and that have offered useful insights, suggests criteria for gauging the value of monitoring programs, and suggests ways that monitoring efforts can be made more efficient and versatile. Experience indicates the benefits from collaboration and open access to data; ways to facilitate such data sharing are reviewed. Worldwide institutional and funding changes jeopardise many long-term forest monitoring plots, and the paper calls for discussion and action to ensure the continuity of high-quality monitoring efforts.

Permanent preservation plots as a tool to monitor changes in structure, diversity, and regeneration patterns of tropical wet evergreen forests: case study from western Ghats, India. Viswanath, S. (*Institute of Wood Science and Technology, Bangalore, India; sviswanath@icfre.org*), Satish, B.N., Karthik, M.L. (*College of Forestry, India; satibn@gmail.com; karthikforestry@gmail.com*).

Studies on assessing vegetation structure, diversity parameters, and regeneration status were carried out in two permanent preservation plots Malemane (Uttar Kannada district) and Bannarapade, Makuta (Coorg district) located in tropical wet evergreen forests of western Ghats in Karnataka, India, during 2008–09. The pooled data of tree species from both Makutta and Malemane showed that there was considerable temporal variation in tree density, basal area, and girth increment from 1937 to 2008. Diversity parameters such as species richness, Shannon's index, evenness index, species similarity, and species composition showed certain distinct trends in both locations. Ten dominant species based on density and basal area were identified and the change in dominance pattern over a time scale (1937 to 2008) was analyzed with respect to population structure. Constraints in regeneration class IV category (saplings) were noticed in Makutta, where anthropogenic pressures was more noticeable. A similar trend was also noticed in endemic and RET tree species in both the plots, primarily due to extraction pressures. The overall trend indicates a possible changeover in vegetation structure and composition of evergreen forests over the past 75 years that could not be ascribed to normal vegetation succession trends alone.

How to use forest monitoring data as planning tools for forest management? v. Wilpert, K. (*Forest Research Institute Baden-Wuerttemberg, Germany*; *klaus.wilpert@forst.bwl.de*), Zirlewagen, D. (*INTERRA, Bureau for Environmental Monitoring, Germany*; *d.zirlewagen@interra.biz*).

Management strategies and intensity of biomass harvest define closeness of element budgets. Actually, demand for using wood biomass as a renewable energy source leads to increasing harvesting intensities. If nutrient balances become deficient, either harvesting intensity is not sustainable or nutrient deficiencies have to be compensated in a technical way through fertilizing or wood ash recycling. In ecosystem case studies like the ICP-level-II plots, element budgets can be derived from data on water and element fluxes with high resolution. The disadvantage is that they are strongly related to these plots and their relevance for other areas is unclear. Therefore bridging the function for the transfer of element budgets is necessary. Different forest management strategies such as clear-cut systems compared to permanent-cover management, as well as the tree species variants, will be evaluated for their effect on the closeness of their element budgets. Harvesting intensities have been included through measured element pools in biomass compartments such as timber, bark, twigs, leaves, and needles. A statistical approach allows for transferring element budgets as indicator of the sustainability of forest management and harvesting intensities from case studies to the landscape level where this information is needed as planning tool for practical management decisions.

B-24 Ecology and management of mixed species stands under changing climatic conditions and environmental uncertainty

Organizers: Bogdan Strimbu, *Louisiana Tech University USA, strimbu@latech.edu*; Valeriu-Norocel Nicolescu, *Transilvania University of Brasov, Romania, nvnicolescu@unitbv.ro;* Biing Guan, *National Taiwan University China-Taipei,btguan@ntu.edu.tw.*

Towards silvicultural economics: improved bioeconomic modeling for mixed forest stands. Griess, V.C., Knoke, T. (Institute of Forest Management, Technische Universität München, Germany, mostert@forst.wzw.tum.de; knoke@ forst.wzw.tum.de).

Numerous indications suggest that mixed tree plantations are the most appropriate option for providing a broad range of goods and environmental services, as well as reduction of susceptibility to natural hazards. However, the debate continues regarding whether mixed plantations can achieve greater financial outcome than can monocultures. Quantification and modeling of the interdependence of tree species with existing growth models is only partly possible. This study implements the largely lacking effects (e.g., on stand resistance and timber quality) in bioeconomic models. Since this study is among the first, if not the first, to model the interdependence of tree species bioeconomically, we follow an analytical approach, which aims at quantifying potential economic effects of species interdependence and includes empirical data on stand resistance and improved modeling of timber quality. Important results are biologically realistic physical and financial data as well as ecological indicators. Economic optimisation forms a second part of our approach, where we attempt to combine the integration of uncertainty as a requirement of sustainability with financial optimisation. By closely linking silvicultural and ecologically oriented knowledge with economic research, this concept may generate a new quality of scientific results, which will enhance the practice of sustainable forest management.

Investigation of site conditions of *Pyrus syriaca* in Zagros Forest, Iran: a case study, Zardelan region in west Iran). Naji, H.R., Fathy, H. (*Ilam University, Iran; hrn_16hrn@yahoo.com; hfathy20@yahoo.com*).

Recognizing tree ecological conditions is an effective factor for management of natural sites. This study tries to introduce the ecological conditions of *Pyrus syriaca* in the Zardalan region in Iran. The site areas on topographical map (1:25000) were specified, then units map were prepared with consideration of special instruments, slope maps, altitude, and geographical direction; and with integration of the ground form map and canopy cover map. At least three random plots around 1,000 m² were established in each unit; some characteristics such as tree height, DBH, canopy diameter, trunk quality, and health status were studied. In the center of each plot, a micro plot (10 m²) was settled to study regeneration. In each unit several soil samples were collected to determine physical and chemical characteristics. The results show that geographical direction and altitude affect the *Pyrus* distribution, and the best ecological conditions are in northern and northwest directions, between 1,500 and 1,760 m above sea level. The obtained results by using PCA and CCA showed that there are three groups of species, and also showed that soil elements have the greatest role to establish the *Pyrus syriaca* ecological species group.

Sensitivity of temperate mixed species forests in southeast Australia to climate variability and change: the influence of regeneration and competition on stand composition. Nitschke, C.R., Arndt, S. (*University of Melbourne, Australia; craign@unimelb.edu.au*; *sarndt@unimelb.edu.au*).

The temperate forests of southeast Australia are dominated by more than 15 eucalyptus species that occur in associations of varying proportions depending on both climatic and topographic factors. The successful management of these forests hinges on successful regeneration following both harvesting and fire. Regeneration success is strongly driven by the phenology of germination in interaction with drought and frost events. In this study we used a mechanistic model to investigate the impact of climate change on the regeneration potential of 16 eucalypt species across an elevation gradient and the subsequent effect this may have on stand composition in the future. Climate change was found to influence both germination and establishment ability of all species. Stand composition was influenced by species-specific responses to climate change during regeneration. Species responses varied with elevation and site type, with species becoming increasingly affected by drought at lower elevations while at the higher elevation species were continually affected by frost. The study identified that species may exhibit high sensitivity to climate change in some locations but will have high adaptive capacity in others if they are able to out-compete species currently more adapted to drier climate and site conditions at lower elevations.

Canopy gaps and regeneration density in a mixed evergreen–deciduous *Nothofagus betuloides–N. pumilio* stand in Tierra del Fuego, Chile. Promis, A., Cruz, G. (*Universidad de Chile, Chile; alvaro.promis@gmail.com; gcruz@uchile.cl*), Reif, A. (*Waldbau-Institut, Albert-Ludwigs-Universität Freiburg, Germany; albert.reif@waldbau.uni-freiburg.de*), Caldentey, J. (*Universidad de Chile, Chile; jcaldent@uchile.cl*).

The canopy gaps present in a primary N. betuloides–N. pumilio forest on the southwest side of Tierra del Fuego (53º59′S, 69º58′W) were inventoried and characterized during summer 2006. The changes in regeneration densities were evaluated. Twelve canopy gaps (surface: 21–145 m^2) were selected for a detailed ecological analysis. All seedlings and saplings were counted and measured by species in 1-m^2 plots. Eight transects were located from the centre of the gaps to the N, NE, E, SE, S, SW, W, and NW directions, which extended to up 9 m beyond the gap edge. Plots were located at 2-m intervals along transects. Plot position was classified as occurring in canopy gap, at the gap edge, or beneath undisturbed canopy. Preliminary results showed that the density of *N. betuloides* plants in canopy gaps did not show statistical differences, compared to those found at the edge of canopy gaps and beneath the undisturbed canopy. It was shown that the density of *N. pumilio* seedlings and saplings in canopy gaps was significantly lower, compared to the canopy gap edge and beneath the undisturbed canopy. Maybe the *N. pumilio* regeneration in canopy gaps has been influenced by the new microclimatic conditions.

Estimating the uncertainty and validation of basic wood density and biomass expansion factor for *Pinus densiflora* in Korea. Pyo, J.K., Son, Y.M, Lee, K.H., Kim, R. H. (*Korea Forest Research Institute, Republic of Korea; freerider@kongju.ac.kr; treelove@forest.go.kr; kyeonghlee@forest.go.kr; rhkim@forest.go.kr*), Lee, Y.J. (*Kongju National University, Republic of Korea; leeyj@kongju.ac.kr*).

Uncertainty assessment was very important in the greenhouse gas inventory, as described in the IPCC guidelines. It is recommended to estimate the uncertainty for all estimates. The purpose of this study was to estimate the uncertainty in tree attributes—such as basic wood density—and biomass expansion factor for *Pinus densiflora* Siebold & Zucc. and *P. densiflora* for. Erecta Uyeki, and to evaluate the accuracies using the bootstrap method. Forty-two (42) representative Korean pine stands for 210 sample trees were measured for green and dry weights of each tree portion (stem, branch, and foliage). The bootstrap can be implemented by constructing a number of resamples of the observed dataset, each of which is obtained by random sampling with replacement from the original dataset. Using bootstrap simulation, a number of random sample data sets were generated and standard errors for mean were compared with increasing number of data sets to obtain the requested number of times. The results showed that the bootstrap method was comparable to the floating method, indicating that bootstrap can be an alternative approach in the uncertainty assessment.

Optimizing mixed species stand management under uncertainty. Rößiger, J., Knoke, T. *(Institute of Forest Management, Technische Universität München, Germany; joerg.roessiger@forst.wzw.tum.de; knoke@forst.wzw.tum.de).*

To properly manage a forest stand, decisions about tree species composition and about thinning or final harvest have to be made. These decisions influence the timber composition resulting from the growing processes of the forest stand. An economic optimization of timber production regarding to the optimal yield would advise only one tree species on a given site. But by integrating uncertainty of timber price volatility and risk of failure by natural hazard, diversification effects may be utilized. Various timber assortments buffer against changing market conditions or a price decline of special timber kinds that occur after calamities. Results that are achieved within one rotation length of a stand of only one tree species will be contrasted with results obtained by a simultaneous optimization, which determines the composition of different tree species and the sequence of timber harvest simultaneously. Moreover, this diversification effect opens the opportunity to covert an even-aged forest in a manifold-structured stand with multiple tree species and future options. The optimal allocation of forest area to tree species, as well as of harvesting operations to time periods, should test the potential economic benefits of a close-to-nature forestry in a more realistic way.

Forest communities on southern slopes of Ilgaz Mountain (Yenice) and some of their silvicultural properties. Sıvacıoğlu, A. (*Kastamonu University, Turkey; ahmets1973@gmail.com*), Öner, N. (*Çankırı Karatekin University, Turkey; nurioner@gmail.com*).

In this study, we aimed to determine forest communities on southern slopes of Ilgaz Mountain, which has a very high endemism rate. We evaluated 153 sample plots, defined 7 different forest communities; and crown projections of 7 sample plots and stand profiles were drawn. Ilgaz Mountain's southern slopes were chosen as the research area because of the transition area between steppe forest region and humid forest region. The vegetation of the study area was investigated from a phyto-sociological point of view, and the vegetation was classified according to the Braun-Blanquet method with respect to forest communities. Seven forest communities were determined in the research area, such as: *Daphne pontica-Abies bornmülleriana* subsp. *bornmülleriana*, *Astragalus angustiflorus-Juniperus communis* var. *saxatilis*, *Astragalus nitens-Paliurus spina-christi*, *Pinus sylvestris-P. nigra* subsp. *nigra* var. *caramanica*, *Quercus petraea-P. nigra* subsp. *nigra* var. *caramanica*, *Abies nordmanniana* subsp. *bornmülleriana-P. sylvestris* and *Nepeta racemosa-P. sylvestris*. The distribution of 170 specific and intraspecific taxa forming the flora of the research area according to floristic regions is as follows: Euro-Siberian, 20.00%; Irano-Turanian, 14.71%; Mediterranean, 4.71%; Euxin, 4.11%; and more than one floristic region, 56.47%. The number of endemic species is 18 and the rate of endemism is 10.59%.

Silviculture and management in uneven-aged production forests: a possibility to reduce risks. Zingg, A., Bürgi, A. (*Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Switzerland; andreas.zingg@wsl.ch; anton.buergi@wsl.ch*).

Uneven-aged and mixed species production forests provide many goods and services. If the stand structure is close to an equilibrium with regard to the diameter distribution, these goods and services can be generated sustainably on small areas. Stands that are mixed in regard to species and to the diameter distribution, reduce the economic risks of the long-term basis of production as well as risks of site changes resulting from, for example, climate change. This is shown by means of long-term research plots, some of which have been monitored for more than 100 years: the constant timber production as well as the effect of dry periods on increment and tree mortality. Regression models show that the increment reduction of the different tree species varies. The increment reduction in even-sized mixed stands is smaller than in even-sized pure stands. In uneven-aged mixed stands the increment reduction is even less when compared to even-aged mixed stands. Additionally the permanent regeneration in uneven-aged stands can turn out to be an advantage because there is a permanent natural selection of trees adapted to changing climatic conditions.

Posters

Litterfall production and nutrient deposition through leaf litter in northeastern Mexico. González-Rodríguez, H., Cantú-Silva, I., Ramírez-Lozano, R.G., Gómez-Meza, M.V., Domínguez-Gómez, T.G., Rodríguez Hernández, E.J.S., López Maravilla, A.G., López Hernández, J.M. (*Universidad Autónoma de Nuevo León, México; humberto@fcf.uanl.mx; icantu@fcf.uanl.mx; roqramir@gmail.com; marcovgmeza@hotmail.com*; *gustavo_dguezg@hotmail.com*; *joselyn_30@hotmail.com; anagaby_linares@hotmail.com*; *juma_loher@hotmail.com*).

Litterfall deposition and decomposition are fundamental processes in nutrient cycling of forest ecosystems. The aim of this study was to determine the litterfall production and macronutrient deposition through leaf litter in northeastern Mexico. Litterfall constituents (leaves, reproductive structures (flowers, fruits, and seeds), twigs, and miscellaneous were measured at 15-day intervals during 2 consecutive years (2006–2007 and 2007–2008), in three experimental sites: a pine (*Pinus pseudostrobus* Lindl.) forest (Bosque Escuela at 1,600 m), a *Quercus* spp. forest and the Tamaulipan thornscrub (Crucitas at 550 m), and in the Tamaulipan thornscrub (Campus at 350 m). Each site had a plot (50 m × 50 m) in which 10 litter traps (1.0 m^2 each) were used for collections. Results of this study suggest the importance of litterfall production not only in terms of nutrient cycling to the forest soil, but also to maintain fundamental ecological and ecosystems processes such as soil formation, prevent soil erosion, maintain soil fertility and substrates for plant and microbial species, increase organic matter mineralization, improve soil physical and chemical properties such as soil water availability, plant regeneration and establishment; all these are interrelated and integrated to sustain and maintain ecosystem productivity and biodiversity.

Silvicultural approach for management of vegetation in Dokdo, Republic of Korea. Hong, S.C. (*Kyungpook National University, Republic of Korea; schong@knu.ac.kr*), Park, N.C. (*Korea Forest Research Institute, Republic of Korea; pnch@forest.go.kr*), Yun, C.W. (*Kongju National University, Republic of Korea; cwyun@kongju.ac.kr*), Lee, J.H. (*National Institute Environmental Research, Republic of Korea; eco2007@korea.kr*).

Dokdo is the easternmost territory of Korea that is 87.4 km to the southeast of Ulleungdo island in Kyungpook province of Republic of Korea. It consists of mainly two small islands called Dongdo and Seodo, in area of 18.7 ha. The study was conducted to understand the current vegetation and its succession in Dokdo. The vegetation of Dokdo was classified into three communities; *Sedum oryzifolium* community (I) with the differential species of *Sedum oryzifolium* growing above the rock or over the steep slope with better sunlight condition; *Agropyron tsukushiense* var. *transiens – Echinochloa crus-galli* community (II) with the differential species of *Agropyron tsukushiense* var. *transiens – Echinochloa crus-galli* which quickly established in relatively steady site environment; *Euonymus japonica* community (III) with the differential species *of Euonymus japonica*, a native woody plant in Dokdo. Pioneer species on Dokdo included *Sedum oryzifolium, Artemissia japonica, Aster sphathulifolius* and *Cyrtomium falcatum*, and the climax species were *Euonymus japonica, Elaeagnus macrophylla* and *Lonicera insularis*. It is suggested that, when restoring the vegetation of the Dokdo, the major species should be *Euonymus japonica* and the minor species *Elaeagnus macrophylla* and *Lonicera insularis*.

Factors responsible for co-dominance of two beech species at a cool-temperate forest in central Japan: growth vs. survival in the early demographic stage. Ishizuka, W., Goto, S., Kaji, M. (*The University of Tokyo, Japan; wataru@uf.a.u-tokyo.ac.jp; gotos@uf.a.u-tokyo.ac.jp; kaji@uf.a.u-tokyo.ac.jp*).

Fagus crenata and *F. japonica* are both dominant species (co-dominant species) of a natural cool-temperate forest in Chichibu, central Japan. This forest can serve as a good model ecosystem to examine factors responsible for co-dominance. Considering that an early demographic stage is crucial to determine a success of forest regeneration, we have examined characteristics and differences between seedlings of two beech species. In an approximately 2-ha plot, all seedlings of *F. japonica* newly emerged in 2005 and of *F. crenata* emerged in 2006 were indentified and followed until December 2009. We compared the annual demography, growth, and survival of the seedlings. Spatial distributions of seedlings was also compared by a generalized linear model with independent variables of topography, light conditions, and abundance of mother trees. Except for 1-year old seedlings, different characteristics were detected between the two species. *F. crenata* had better growth but *F. japonica* showed a higher survival rate. Spatial dependencies of the two species mostly overlapped; spatial distribution of *F. japonica* was slightly influenced by topography but that of *F. crenata* was not. It was not a spatial segregation but the trade-off between growth and survival that would be responsible for a co-dominance of these species.

Contribution of sunflecks to photosynthesis in understory seedlings of six tree species at Nanjenshan Forest. Kuo, Y.L., Peng, S.H. (*National Pingtung University of Science and Technology, China-Taipei; ylkuo@mial.npust.edu.tw; p9821220@mail.npust.edu.tw*).

This study investigated dynamics of understory light and diurnal courses of photosynthesis, with emphasis on the contribution of sunflecks to daily photosynthesis, in seedlings of six hardwood species in Nanjenshan Ecological Reserve, Kenting National Park, Taiwan. Results showed that seedlings could receive more sunflecks during 10:00 to 14:00, when greater variations in sunfleck intensity (from 35 to 1,370 μmol m^{-2} s^{-1}) also occurred. On average, seedlings received 83 min accumulatively of sunflecks during the whole 450 min of the measurement period. Although this duration accounted only for 18% of the measurement period, the accumulated light intensity for seedlings receiving sunflecks reached 45% of total daylight. The accumulated photosynthetic rates of all seedlings when receiving sunflecks accounted for 35% of total photosynthesis. Daily photosynthesis of *Cinnamomum brevipedunculatum*, *Gordonia axillaris*, *Illicium arborescens*, *Wikstroemia taiwanensis*, *Rhaphiolepis indica*, and *Castanopsis cupidata* were increased 17, 39, 30, 56, 44, and 22%, respectively, by the elevated light intensity by sunflecks, indicating that sunflecks have important contribution to the daily carbon gain of these seedlings. We also found a positive correlation between daily photosynthesis and efficiency of utilizing sunflecks. That is, the more efficiently a seedling can utilize sunflecks, the more daily carbon gains it would have.

The stand structure and growth characteristics of *Quercus mongolica* fischer in Mt. Gariwang, Korea. Kwon, K.C. (*National Forestry Cooperative Federation, Republic of Korea; kkch30@yahoo.co.kr*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*).

This study was conducted to investigate the site and growth characteristics of *Quercus mongolica* stand in natural forest of Mt. Gariwang, Korea. The 79 sample plots (30 m × 30 m) were established to examine the vegetation and site characteristics. Stem analysis was performed on 6 to 7 sample trees of each site with varying altitude and aspect. *Q. mongolica* trees were dominant in the altitude of more than 800 m above sea level, especially above 1,000 m, and mainly distributed with *Acer pictum* subsp. *mono, Fraxinus rhynchophylla*, and *Cornus controversa*. Diameter growth of *Q. mongolica* showed the best growth performance in the northern part of 1,000 m. The early diameter growth ranged from 4 to 10 mm. However, trees with ages of 50 and above decreased to about 1 mm. Height growth of *Q. mongolica* increased with increasing altitude until 1,000 m, and then decreased thereafter. *Q. mongolica* showed rapid early growth of height and volume, indicating high biomass production under almost deciduous forest in Korea. The rotation age of natural *Q. mongolica* forest was estimated to about more than 60 years. Nevertheless, there is a need to consider that *Q. mongolica* easily decays its heartwood.

Changes in stand structure and decay symptoms of secondary deciduous forests after silvicultural treatment application in Mt. Gariwang, Republic of Korea. Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*), Kwon, K.C. (*National Forestry Cooperative Federation, Republic of Korea; kkch30@daum.net*), Park, J.W. (*Seoul National University, Republic of Korea; jwpark1016@gmail.com*).

The objectives of this study were to understand stand structure changes after application of different silvicultural treatments and to determine the state of hardwood stems' decay for each species in Mt. Gariwang, Gangwondo, Republic of Korea. Three different silvicultural systems, shelterwood, selection, and two-storied were applied to 5.9 ha-, 5.2 ha-, and 5.4 ha-stands, respectively. Before cutting, close stand inventory investigation was conducted in three plots (30 m × 30 m) of each treatment site. The state of decay was examined for thinned-out trees according to species and diameter classes. Before cutting, stand volume and stem density of two-storied stand (166 m^3/ha, 922 stems/ha) were highest among the silvicultural systems applied. Dead trees occupied 5% of the total trees in all stands. Decay symptoms were detected in 50%, 40%, and 38% of the thinned-out trees of selection, two-storied, and shelterwood treatments, respectively. It was found out in this study that fire and wound by root-sprout seem to cause decay. Therefore, continuous monitoring of the state of decay and application of antiseptic treatment after root-sprouts removal is necessary. Continuous monitoring and addititional thinning treatments are also important to lead each stand towards desired silvicultural systems.

Belowground niche separation and productivity in tree species mixtures. Lei, P., Bauhus Jürgen (*University of Freiburg, Germany; pifeng.lei@waldbau.uni-freiburg.de; juergen.bauhus@waldbau.uni-freiburg.de*).

Owing to the difficulties of differentiating fine roots of different species, the effects of tree species diversity on below-ground interactions are little understood. In this study, we explored a new method, near infrared reflectance spectroscopy (NIRS), to distinguish and quantify fine roots of *Picea abies, Fagus sylvatica, Quercus petraea,* and *Pseudotsuga menziesii* in mixed root samples. We investigated whether productivity increases with species richness in mixtures and whether the species-proportions of fine roots mirror the proportions of above-ground biomass. This study was conducted in one of the three BIOTREE (BIOdiversity and ecosystem processes in experimental TREE stands) sites, in Thuringia, Germany. The samples were collected with soil corers and ingrowth cores in patches with 1, 2, 3, and 4 tree species combinations. The use of NIRS permitted distinguishing and quantifying fine roots of different species independent of the species richness of the samples. At the beginning of the study, fine root biomass, length, and surface area were not affected by tree species diversity. However, root morphological plasticity and neighbour effects on below-ground competition were species-specific. Here, we will also report on productivity data based on ingrowth cores.

The basal area model studying of mixed stands of *Larix olgensis*, *Abies nephrolepis* and *Picea jazoensis* based on a nonlinear mixed model. Li, C. (*Chinese Academy of Forestry, China; lichunm@caf.ac.cn*).

Twenty mixed stands plots were selected to model stand basal area in Wangqing Forest Bureau of Jilin Province. Initially, four nonlinear basal area equations were evaluated using ordinary regression analysis to develop a local model with better precision. A nonlinear mixed model was constructed based on the local model and simulated data. Taking into account different plot effects, the convergence mixed model, in which the values of –2log likelihood, AIC and BIC are the smallest, was considered as the best model in fitting process with SAS software. Then, within-plot time series error autocorrelation of basal area data and cutting intensity which were expressed with dummy variable were taken into account in mixed model. Finally, the precision of mixed models was compared with the precision of conventional nonlinear ordinary regression analysis method based on validation data. The study showed that the precision of Schumacher form model was higher than that of the other three models. The fitted effects of mixed model approach were better than that of ordinary regression analysis, since the mixed model considered plot random effects, time series error autocorrelation and cutting intensity better than that of the ordinary regression analysis method.

Seedling carbon budgets of nine tree species at the windward forest of Nanjenshan. Peng, S.H., Kuo, Y.L. (*National Pingtung University of Science and Technology, China-Taipei; p9821220@mail.npust.edu.tw; ylkuo@mail.npust.edu.tw*).

To understand the daytime carbon gain and nighttime carbon cost of tree seedlings, we investigated understory seedlings of nine tree species in the windward forest of the Nanjenshan Ecological Reserve, Kenting National Park, Taiwan. Diurnal courses of photosynthetic rate, leaf area, and height of seedling of each species were monitored from May 2007 to April 2008. Results showed that mean diurnal photosynthetic rates of these nine species were between 1.09 and 2.28 mol CO_2 m^{-2} s^{-1}. In the aspect of carbon budget, seedlings of seven species all had positive values in daily carbon budget, while two and one seedlings of *Sapium discolor* and *Mallotus paniculatus*, respectively, showed negative values, which were suffered from snapped stems caused by natural events. Seedlings of *Castanopsis cuspidate* had the highest daily carbon budget of 88.7 mg CO_2 d^{-1}, followed by *Melastoma candidum* (84.1 mg CO_2 d^{-1}) and *Gordonia axillaries* (42.3 mg CO_2 d^{-1}). In general, net photosynthetic rates of these seedlings increased as light availability increased, especially in *Rhaphiolepis indica*. As a result, increase in net photosynthetic rate would profit their carbon gain. In addition, seedlings with larger leaf area would have more carbon gain during a day.

A measure of the composition of mixed-species stands. Strimbu, B. (*Louisiana Tech University, USA; strimbu@latech.edu*).

Mixed species stands are among the most valued terrestrial ecosystems, being less sensitive to changes induced by biotic or abiotic factors than mono-species stands. The dynamics of mixed stands is represented either by incorporating a measure of the stand's diversity (e.g., Shannon index) or by making inferences on the same stand, even that its composition has changed throughout time. Current metrics used to measure mixed-species stands either do not allow the comparison of stands with different composition but the same species, or else the comparison is performed on spatial considerations rather than from an ecosystem perspective. The objective of this research was to develop a measure that allows the comparison of stands with different mixtures of the same species as well as the tractability of the same stand throughout time. The measure converts the percentage composition into the complex space. Different stages of stand dynamics are reconverted into the real space using Lambert azimuthal projection. The measure is a true measure, describes stands with one value and converges to 100% for pure stands. Longitudinal analysis on measured and simulated stands revealed that the new measure allows the comparison of mixed-species stands similarly with pure stands.

Estimating balanced structure areas in multi-species forests on the Sierra Occidental, Mexico. Wehenkel, C. (*ISIMA-Universidad Juárez del Estado de Durango, Mexico; wehenkel@ujed.mx*), Corral-Rivas, J.J. (*FCF-Universidad Juárez del Estado de Durango, Mexico; jcorral@ujed.mx*), Hernández-Díaz, J.C., Solís-Moreno, R. (*ISIMA-Universidad Juárez del Estado de Durango, Mexico; jciroh@ujed.mx; rsolis@ujed.mx*), Cruz-Cobos, F. (*Instituto Tecnológico de El Salt, Mexico; cobos_cruz@yahoo.com.mx*).

The pine-oak forests cover 16% of the national territory, comprising 31.8 million hectares in total, and occur throughout the major mountain ranges of the Sierra Madre Oriental, the Sierra Madre Occidental, the Sierra Madre del Sur, and the Transvolcanic Belt. The balanced structure area is defined as the minimum contiguous area that includes all the tree developmental stages. It could be seen as the minimum area required for sustainable management in a multi-size selection forest. A multiple-size stand represents a balanced structure unit if the relationship between harvest and growth can be maintained, using a defined target diameter distribution and disregarding major natural disturbances. In a balanced diameter distribution a constant ratio exists between successive *DBH* classes. The objective of this study is to estimate the minimum area which exhibits a balanced structure and the corresponding number of trees, for different tree species and forest types in the Santiago Papasquiaro region, Durango, Mexico, based on 17,577 sample plots. The 95% confidence intervals for the minimum structure areas that provide a nearly balanced 3-cm *DBH*-class distribution in the DBH interval of 12 to 57 cm vary from 0.4 ha to 122 ha, depending on the tree species.

Effects of stand and inter-specific stocking on standing tree carbon stocks in forests of the eastern United States. Woodall, C.W. (*U.S. Forest Service, USA; cwoodall@fs.fed.us*), D'Amato, T. (*University of Minnesota, USA; damato@umn.edu*), Bradford, J.B. (*U.S. Forest Service, USA; jbbradford@fs.fed.us*), Finley, A.O. (*Michigan State University, USA; finleya@msu.edu*).

Given the more than 100 tree species across the eastern United States, there is a tremendous array of species compositions and stand stocking strategies for maximizing forest stand biomass and associated carbon (C) stocks. Despite the plethora of site- and species-specific stand management guidelines, there is a fundamental lack of understanding of how standing tree carbon stocks vary across tree species compositions and associated levels of species and stand stocking. Using a nationwide annual forest inventory, trends in standing tree carbon were assessed across a variety of species mixtures and stocking attributes for the 24 most common tree species in the eastern U.S. It was found that reducing inter-specific competition, such that the majority of stand stocking is in a single species, reduced maximum potential live tree above-ground (AG) C. The disparity in maximum live tree AG C between levels of total stand stocking was reduced as total stand stocking was progressively occupied by one species. Although the competitive interactions between individual species in mixed species stands can greatly complicate efforts to assess C sequestration opportunities, some basic tenets identified in this study may broadly identify species mixtures and associated stocking levels that maximize live tree AG C stocks.

Dynamics of woody debris following logging in the broad-leaved Korean pine mixed forests on Changbai Mountain. Zhou, L., Dai, L., Yu, D. (*Institute of Applied Ecology/ Chinese Academy of Sciences, China; zhouli930@iae.ac.cn; lmdai@iae.ac.cn; yudp2003@iae.ac.cn*).

Woody debris (WD) is an important component in forest ecosystems but little is known about WD dynamics in the broadleaved Korean pine mixed forests after logging at Changbai Mountain. In this research, we investigated the temporal dynamics of WD following timber harvesting (indicating specifically the harvest method used in this study) in the broadleaved Korean pine mixed forests at Changbai Mountain. The volume, biomass, size-class, and decay-class distributions of WD at different stands characterized with different logging histories were compared. The study showed that the number and volume of WD on the forest floors decreased in the initial stage, then increased rapidly after logging. At advanced stage, the number and volume of WD decreased gradually again, especially the coarse woody debris (CWD). Along with the development of forest, WD with early decay classes (1 and 2) increased in the first 2 years after logging then gradually decreased over time. However, WD with advanced decay classes (4 and 5) reversed the trend, and WD with the decay class 3 stayed relatively stable. This study suggests WD dynamics in the forests are significantly influenced by the logging history.

B-25 Frontiers in wildlife ecology and management

Organizers: C.A.M. Sylvestre Djagoun, *Université d'Abomey-Calavi, Benin, sylvestrechabi@gmail.com;* Xuemei Han, *Yale University, USA, xuemei.han@yale.edu*

Small carnivores from southern Benin: a preliminary assessment of diversity and hunting pressure. Djagoun, S. (*Université d'Abomey-Calavi, Benin; sylvestrechabi@gmail.com*), Gaubert, P. (*Muséum National d'Histoire Naturelle, France; gaubert@mnhn.fr*).

Small mammals are tempting targets for hunters, especially with the current monitoring of large game poaching which inevitably increase the pressure on less visible game. Given that, small carnivores are usually the game trade constituents. We made interviews, surveys of local markets, and occasional field observations. Some species were identified by proceeding to the nucleotide sequencing method. Nine species were identified; genets, cusimanse, and ichneumon mongoose were by far the most sighted, the prevalence of such ecologically versatile species confirming that southern Benin constitutes a disturbed "ecosystem." Ubiquitous *C. civetta* was considered the rarest species (Index of Rarity = 0.89), followed by *H. maculicollis* (0.72) and *I. albicauda* (0.69). Hunting techniques were mostly traditionally guns, accompanied by dogs, and jaw traps. Small carnivores are likely to represent a fair income source for hunters, body parts being sold to fetish markets in 47% of the cases. Mean incomes range was between US$2.5 and 5.4 per animal, except *C. civetta* (US$14.6) and heads of *H. maculicollis*, reaching US$33.7. Better characterization of small carnivoran diversity, population history, and ecology should enlighten our understanding of the Dahomey Gap as a key factor in the structuring of the West African fauna.

Deforestation and its influence on biodiversity of Caucasian black grouse (*Lyurus Mlokosizwiczi*) in Arasbaran protected area, Iran. Ghanbari, S. (*University of Tehran, Iran; Ghanbarisajad@gmail.com*), Asvad, S. R. (*Tarbiat Modares University, Iran; Reza.asvad@gmail.com*).

In the early 1990s, sustainable forest management (SFM) was introduced. Biodiversity was considered as a principle, criterion, and indicator in SFM processes. Among species indicators have been mentioned the number of dependent species in the forest area, and the number of endangered species. Therefore, to attain SFM, biodiversity must be considered. The paper examines the situation of Caucasian black grouse (*Lyurus mlokosizwiczi*) in the Arasbaran protected area located in the northwest Iran and the influence of deforestation on it. This endangered species of the Arasbaran protected area is restricted to the upper deciduous forests and the alpine meadow zones in the south-central part of the reserve at 1,800–2,100 m. This species was indentified and estimated about 250–300 birds in 1971. But, the number of this species has decreased to c.110 as a result of abundant destructive factors. The important human threatening factors are as follow: forest clearance for agriculture, ranching, horticulture, and fuel wood harvest. Some solutions to prevent forest destruction and discrimination of this bird are as follow: tourism development to improve the local economy, domesticating and conserving this species by participation of local people, and training of people through educational courses.

Managing forest stand structures to enhance conservation of the Amur tiger in Northeastern China. Han, X., Oliver, C. (*Yale University, USA; xuemei.han@yale.edu*; *chad.oliver@yale.edu*), Ge, J.P. (*Beijing Normal University, China; gejp@bnu.edu.cn*), Guo, Q.X. (*Northeastern Forestry University, China; gqx@nefu.edu.cn*), Kou, X.J., Wang, T.M., Mou, P. (*Beijing Normal University, China; xj_kou@bnu.edu.cn*; *wangtianming@bnu.edu.cn*; *ppmou@bnu.edu.cn*).

Amur tiger (*Panthera tigris altaica*) experienced a serious shrinking of its range and a significant population decline during the past century in northeastern China and the Russian Far East. Forest habitat has been considered as the primary threat to tigers' survival. However, there is a lack of analysis on the effects of forest characteristics associated with forest dynamics on tiger's habitat. We evaluated the forests in northeastern China from a dynamic perspective. We first evaluated forest development by systematically examining the historical logging and management operations as well as the natural disturbances in this region, then applied multiple metrological sivilculture methods to evaluate the current forest crowding and stand structures. Second we modeled the Amur tiger prey carrying capacity and consequent needed tiger home range under different stand structures. Third, we used satellite images to interpret forest type and stand structures. Fourth, forest growth under different management scenarios was simulated on a landscape scale with the Landscape Management System (LMS)computer model. Finally we conclude that forest stand structure is one of the major limiting factors for tiger populations. Sustainably managing forests to keep a diversified stand structure is critical to conserve Amur tigers in Northeast China.

Habitat suitability model for white-backed woodpeckers in Jeju experimental forests. Park, C.R. (*Korea Forest Research Institute, Republic of Korea; park@forest.go.kr*), Seol, A.R. (*Seoul National University, Republic of Korea; ara2007@hanmail.net*), Kim, E.M., Lee, S.B. (*Korea Forest Research Institute, Republic of Korea, kptta@naver.com; imagga2@forest.go.kr*).

From 2007 to 2009 we surveyed 26 independent variables and the nest of white-backed woodpeckers (WBWs) to develop a habitat suitability model in Jeju Experimental Forests (JEFs). We utilized the Nest Finder to identify nests at microhabitat levels and analyzed the forest vegetation map and digitized elevation map to quantify habitat variables such as forest types (FT, n = 5), forest heights (FH, n = 5), stand DBHs (DBH, n = = 3), distance to trails (DT, n = 4), edge contrast index (ECI, n = 3), topographic wetness index (TWI, n = 3), and distance to stand edge (DS, n = 4) at landscape level. We made 50- × 50-m plots in 1,700 ha in the JEFs, and conducted multinomial logistic regression using the PROC CATMOD tools with data set of 30 points of nests and 30 points of non-nests. WBWs utilized tress over 45 cm in DBH as nests, and most nests had an entrance directed to the south-western aspect. Among seven kinds of habitat variables, ECI and DT were effective variables to estimate the presence of WBWs. From this model, we can provide potential habitats of WBWs known as keystone species and suggest management scenarios of biodiversity for sustainable forest management at local level.

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Impact of forest and plantation management systems on avian communities in East Africa. Karman, M. (*FSC International Centre GmbH, Germany; m.karmann@fsc.org*), John, J.R.M. (*Seoul National University, Republic of Korea; birds@snu.ac.kr*), Borghesio, L. (*University of Illinois, USA; borghesio@gmail.com*), Cordeiro, N.J. (*Roosevelt University and The Field Museum, USA; ncordeiro@fieldmuseum.org*).

The Eastern Arc Mountains in Kenya and Tanzania are among the 34 richest biodiversity hotspots on Earth, but severely threatened as clearing and degradation of forest continues. Studies carried out in the Eastern Usambaras between 2003 and 2009 showed that habitat requirements of forest birds differed: whilst ground-foragers are clearly dependent on intact forest, canopy and mid-layer foragers which include various globally threatened species, are also frequent in successional habitats created by

disturbance, at forest edges, or even in relatively open, agricultural landscapes, if they retain at least a small amount tree cover. This suggests that some threatened bird species might benefit from certain conservation initiatives like enrichment planting with indigenous trees on formerly forested areas. In forest plantations, bird biodiversity is very limited, unless some forest patches and riparian bands are left intact. Forest management according to Forest Stewardship Council (FSC) criteria requires certified plantations to retain some natural forest patches and riparian bands creating a mix of biotopes that is not granted in other management systems. With efficient planning, land-use mosaics consisting of networks of protected areas, responsibly managed plantations, and mixed forest and agriculture, a diverse set of biotopes can be developed to conserve biodiversity hotspots.

B-26 Sustainable management and use of non-wood forest products

Organizers: Nirmal Bhattarai, *International Centre for Integrated Mountain Development-ICIMOD, Nepal, nbhattarai@icimod.org.*

Sustainable economic, social, and environmental management of medicinal and aromatic plants: experiences from South Asia. Bhattarai N., Karki, M. (*International Centre for Integrated Mountain Development, Nepal; nbhattarai@icimod.org; mkarki@icimod.org*).

The South Asian forest and biodiversity resource-dependent communities face many problems in their efforts to reduce poverty and improve their livelihoods. Plant-based traditional medicine is still the mainstay of health care. However, about 90% of the medicinal plant species used locally or in trade come from wild sources, mostly through unsustainable harvesting. The ICIMOD-based MAPPA program implemented community-participatory, pro-poor action research approaches and pilot interventions through and with local institutions in India, Nepal, Sri Lanka, and Pakistan focusing technical and institutional capacity building on *in situ* management and *ex situ* cultivation and management. The results obtained have shown impacts on adoption of good practices in production, local-level value addition, and primary processing. Local communities as well as policy makers have recognized the potential of this sub-sector to bring about socio-economic development based on the principles of sustainable conservation. Project interventions resulted in 30–40% increase in the prices of raw materials received by local producers and two-fold increase in profit in cases of processors. The paper summarizes major technical advances achieved in methodologies, as well as activities, implications, and lessons learned to indicate effectiveness of community-based conservation and management of MAP resources to maintain a long-term balance between use and conservation.

Sustainable harvest of *Actaea racemos*a, an important medicinal plant of Appalachian hardwood forests. Chamberlain, J.L. (*U.S., Forest Service, USA; jchamberlain@fs.fed.us*), Small, C. (*Radford University, USA; cjsmall@radford.edu*), Heibert, E. (*Virginia Tech, USA; ehiebert@vt.edu*).

Medicinal plants are being harvested from the forests of the Appalachian region of the United States with no knowledge of whether the practice is sustainable. More than 150 tons of black cohosh (*Actaea racemosa*) roots were harvested in 2003 and 2004 from natural populations. There is growing concern that this and other native plants are being over-harvested, leading to irreversible lose of biodiversity. The goals of this study are to provide insight into the impact of harvesting and develop inventory methods that will lead to better management of these important natural resources. Permanent research study plots in natural populations of black cohosh have been monitored and harvested since 2005, in two locations. Three harvest regimes have been undertaken to assess impacts and to estimate sustainable intensities. Measurements of above-ground plant dimensions are taken and correlated with harvested root material to provide practical inventory methods. Correlations between above- and below-ground biomass show a positive relationship that will allow for estimating volumes of the desired plant part (roots) by observing parts that are seen by the harvester. Results of this long-term study will provide useful insight to improve management of non-timber forest resources.

***Prunus africana*—the reality of moving from an endangered species to an common tree.** Ingram, V.J. (*Centre for International Forestry Research, Cameroon; v.ingram@cgiar.org*).

Prunus africana is an Afromontane tree with local uses for fuel, wood and traditional medicine. The bark is also the principal ingredient in prostatic hyperplasia pharmaceuticals in Europe and health supplements in the United States. Growing international demand over 40 years has lead to concerns of overexploitation of wild stocks, leading to its appearance on the IUCN Red List in 1998 and trade restrictions by the Convention on International Trade in Endangered Species (CITES) in 2005. Cameroon was the largest world exporter, but in 2007 commenced a self-imposed moratorium that provided a respite for the species, following 15 years of intense harvesting. Its mountain forests have degradation and deforestation rates averaging 1.6% annually, which combined with over exploitation and the export freeze have affected the livelihoods 60,000 people. In response to changes, lobbies and diverse and conflicting interests, a national management plan was participatory developed by many actors in the trade chain. This paper discusses the route from an endangered species towards domestication, analysing the planning process for conservation and sustainable management. Given the paradoxical context in which this non-timber species is found, traded and used, the risks and opportunities for successful introduction, the proposed management plan is critically reviewed.

Natural potentials of medicinal and aromatic plants on permanent forest openings in Republic of Srpska. Ljubojevic, S., Sumatic, N., Marceta, D. (*University of Banja Luka, Bosnia and Herzegovina; ljuboje@yahoo.com; sumatic@yahoo.com; dane@blic.net*).

Forests in Republic of Srpska cover more than a million hectares; around 86,000 hectares are considered permanent forest openings, which are usually considered unproductive forest stands in economic sense. However, some contain medicinal and aromatic plants, which may contribute to local healthcare and nutrition and represent important resources for rural income. This research aimed to estimate natural potentials of medicinal and aromatic plants in permanent forest openings in Republic of Srpska. Using representative method, we laid a 100-m sample plot network, with circular sampling units of 10 m^2 for low plants and 100 m^2 for shrubs and single trees. On every site we registered altitude, inclination, and exposure, and determined a wider

soil category, including soils: of lime rocks and dolomites, on silicate substrata, over serpentine bedrock, on flisch, on other parent rocks, and under permanent or prolonged water impact. We counted individuals of each species, collected their useful parts, weighed them, and then reduced their mass to air-dried condition. In this way we collected data from 198 sample plots (33 per wider soil category) in 2009. Applying standard statistical tools, we arrived at the expected biomass of medicinal and aromatic plants on the observed forest stands.

Assessment of non-timber forest functions in forest inventories. Pelz, D.R. (*University of Freiburg, Germany; pelz@biom.uni-freiburg.de*), Woo, J.C. (*Kangwon National University, Republic of Korea; jcwoo@kangwon.ac.kr*).

In the management of forests, the assessment of timber and non-timber forest functions is increasingly important as a basis for forest planning. Timber-related forest functions are assessed in traditional forest inventories through a variety of methods. Non-timber forest functions, however, are often estimated only on a partial basis in most forest inventories or are assessed in special inventories at a high cost. An approach based on external factors that are stable over time and over large areas, and on external factors that are influenced by management decisions, has been suggested. The external factors, such as slope and aspect, are assessed through a GIS on large spatial units from existing information, such as maps or GIS systems; the internal factors, such as horizontal and vertical stand structure and species diversity, are assessed from forest inventory information on a plot basis. A model is presented that allows the assessment of these forest functions on the basis of regular forest inventories and GIS information over large areas. The functions addressed are protection functions, especially erosion protection. Several applications of the approach based on forest management inventories and large-scale inventories are presented.

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Insecticidal activity of essential oils and monoterpenes against *Thecodiplosis japonensis*. Choi, M.S., Min, J.Y., Heo, C.M., Jeong, M.J., Song, H.J., Kim, H.G., Park, Y.M., Yang, J.K. (*Gyeongsang National University, Republic of Korea; mschoi@gnu.ac.kr; j-yoon0830@hanmail.net; miya0726@nate.com; jmivy121@naver.com; hyunjin617@hanmail.net; king3108@naver.com; pym89525@hanmail.net; jkyang@gnu.ac.kr*).

Essential oils are naturally occurring substances that are often responsible for a plant's distinctive scent or taste. The interest in the use of monoterpenes for insect pest and pathogen control originates from the need for pesticide products with less negative environmental and health impacts than highly effective synthetic pesticides. In this study, insecticidal activity of six coniferous essential oils (*C. obtusa, C. pisifera, T. occidentalis, P. densiflora, P. thunbergii* and *P. rigida*) and six monoterpenes (Limonene, Bornyl acetate, Decene, ρ-Cymene, Terpinyl acetate, and 2-Carene) were tested in *Thecodiplosis japonensis* with various concentrations (0.01, 0.05, 0.1, and 0.2 mg/cm^2). Among them, six terpenoids showed more than 90% mortality at 0.05 mg/cm^2 concentration within 2 hours of treatment. In addition, one coniferous essential oil (*T. occidentalis*) and one commercial monoterpene (Limonene) were more effective than other treatment. Thus two oils were treated to 0.01, 0.02, 0.03, 0.04, 0.05, and 0.1 mg/cm^2. This result showed that mortality increased with increasing concentration, and the strongest activity was observed from *T. occidentalis* essential oil at 0.1mg/cm^2 concentration within 30 min of treatment. In conclusion, plant-based essential oils might have use in pest and weed control in agriculture.

Forest pharmacy: biodiversity of medicinal plants in Bukit Tigapuluh National Park, Sumatera, Indonesia. Damayanti, E.K., Zuhud, E. A.M., Hikmat, A., Siswoyo, S.E., Permana, H. (*Bogor Agricultural University, Indonesia; e11yn.d4mayanti@gmail.com; ervizal_amzu@yahoo.com; ahikmat62@yahoo.com*).

Bukit Tigapuluh National Park (BTNP) is a "forest pharmacy" with high biodiversity, especially medicinal plants, located in tropical forest in Sumatera (Jambi and Riau Province). Total land area of BTNP is about 127,648 hectares. In the forest of BTNP lives two groups of indigenous people, the ethnics of traditional Melayu and Talang Mamak. They have rich traditional knowledge, especially about traditional medicine, which we researched by inventory using the ethno-phyto-medicine approach. The total species of medicinal plants is approximately about 317 species; life forms include: tree, vine, herb; bamboo, and shrub. The tree life form is the highest, about 119 species. Traditional uses of BTNP's medicinal plants are for treatment of 25 groups of diseases, among them malaria; disorders of the blood, circulatory, digestive, genitourinary, and immune systems; infections/infestations, inflammation, and injuries; mental, metabolic system, nervous system, and nutritional disorders; poisonings; pregnancy/birth; and disorders of the respiratory system and skin/subcutaneous cellular tissue. Medicinal plant parts used include bark, leaf, flower, fruit, root, seed, sap, shoot, stem, and whole plant. Tropical rain forest areas in Indonesia, such as the forest of BTNP, are truly the forest pharmacy for "medicine security and safety" of Indonesian people.

Mining of novel antifungal proteins from medicinal plants: towards utilization of forest genetic resources. Dasgupta M. (*Institute of Forest Genetics and Tree Breeding, India; modhumitaghosh@hotmail.com*).

Plant pathogens are a potent force in determining the survival and evolutionary dynamics of individual species and their populations. Their impact ranges from subtle to catastrophic levels, making research in breeding for disease resistance obligatory. Hence, there is a great demand for novel antifungals belonging to a wide range of structural classes, selectively acting on new targets with fewer side effects. Here we report the purification and characterization two non-race-specific, broad-spectrum antifungal proteins from *Acorus calamus* and *Withania somnifera*. The basic protein isolated from the leaves of *A. camalus* (*AcPOX*) had a molecular mass of 32 kDa with temperature stability up to 60 °C. It inhibited the hyphal extension and caused hyphal branching in several phytopathogens. Peptide sequencing revealed its similarity to bacterial induced peroxidase from *Oryza sativa* with 37% sequence coverage. Similarly, a 30kDa acidic chitin binding, non-hemagglutinating antifungal protein was purified from leaves of *W. somnifera* (*Wsl*). Peptide sequencing revealed its similarity to concanavalin-like lectin from *Canavalia ensiformis*. *Wsl* showed 10 times increased antifungal activity when compared to known antifungal lectins such as wheat germ agglutinin and concanavalin. This report adds a new dimension to the utilization of the untapped genetic resources for novel peptides.

Characteristics of Korean raisin tree (*Hovenia dulcis* var. *Koreana* Nakai) as a honey plant and physiological activity of its honey. Han, J.G., Kim, S.H., Kang, M.S. (*Korea Forest Research Institute, Republic of Korea; stationair@forest.go.kr; goldtree@forest.go.kr; andong81@naver.com*), Jun, D.H., Lee, J.T., Lee, C.E. (*Daegu Haany University, Republic of Korea;*

ulsan80@hanmail.net; jtlee@dhu.ac.kr; lce1351@dhu.ac.kr), Baik, E.S. (*Korea Forest Research Institute, Republic of Korea; 5491bkes@forest.go.kr*).

In order to examine the possibility of Korean raisin tree (*Hovenia dulcis* var. *koreana* Nakai) as a honey plant, the characteristics of flowering and nectar secretion were investigated. Flowering started a month after the flower stalk was formed. The numbers of flowers between 52 clones were from 207 to 2,388. Nectar secretion was simultaneously started with flowering and it occurred two times during two days. The amount of nectar from a flower was 4.15 ± 1.11 μ1. Estimated numbers of flowers and the amounts of secreted nectar per individual tree were 719,670 ea and 2.98 l, respectively. The amount of nectar from the Korean raisin tree was comparable to Acacia (*Robinia pseudo* L.), which has long been used as a main honey plant in Korea. Physiological activity of honey in the Korean raisin tree was analyzed by electron donating ability and tyrosinase inhibition effects. Anti-oxidant activity using the DPPH method showed was 61% at 10% distilled water solution, which was higher than the corresponding value of Acacia (24%). Tyrosinase inhibition effects of the honey also showed anti-oxidant activity.

Local knowledge of Sumba people on utilization of natural dye: a study of ethnobothany of *Indigofera* species. Herawati, T., Adalina, Y. (*Forestry Research and Development Agency, Indonesia; tuti_hera_wati@yahoo.com; yelin_adalina@yahoo.com*).

This paper is attended to explain local knowledge of People in Sumba Island, Indonesia, in utilizing *Indigofera* as natural dye. Lifestyle demands of today's society lead to the use of environmentally friendly colouring materials. The study used an ethno-botanical approach to learn how Sumba people use natural dyes, which they have done for a long time as a cultural heritage from their ancestors. The leaf of *Indigofera* spp. is a main material to be used as blue colouring for their traditional woven fabric, which is called as tenun ikat. The colouring process of *Indigofera* takes about a month through the phase of leaf soaking, squeezing, precipitating of the solution, making a paste, and applying to the fabric. For the people of Sumba, tenun ikat is very valuable because of its traditional uses. In addition to its high cultural and traditional values, the woven fabric that is coloured by *Indigofera* also has a high economic value, with the price of a piece of woven cloth in the size of 2 m × 4 m more than US $500.

Factors affecting *Acer mono* sap exudation: Ham-Yang region in Korea. Kang, H.Y., Choi, W.S., Park, M.J. (*Korea Forest Research Institute, Republic of Korea; hykang@forest.go.kr; wonsil.choi.2009@gmail.com; lionpmj@snu.ac.kr*), Choi, I.G. (*Seoul National University, Republic of Korea; cingyu@snu.ac.kr*), Lee, H.J. (*Korea Forest Research Institute, Republic of Korea; leehj@forest.go.kr*).

Xylem sap water from the *Acer mono* tree, which in Korea has been traditionally used as a kind of health drink being beneficial to bones, can be eco-friendly produced in nationwide forest of Korea and be evaluated as important income resources for agroforestry farmers. This study was carried out to investigate the optimum condition for sap exudation of *Acer mono* Max. trees in a site of Mt. Jiri, Hamyang-gun, Korea. Amount of sap exudation, air temperature, relative air humidity, tree diameter at breast height(DBH), and sugar content in sap were monitored during the early springtime, and correlation analysis of several factors was carried out to explain date-to-date and tree-to-tree variations in sap exudation. The correlation, linearly-associated between DBH and sap amount, was strengthened as daily amount of sap increased, but there was no significant tree-to-tree variation in time and period for sap exudation. The maximum air temperature was only significant($p < 0.05$) factor for amount of sap in correlation analysis to explain date-to-date variation in sap exudation. Sucrose content in sap was in the range of 1.5 and 1.7% during exudation days, but sharply reduced to 0.6% level at the end of exudation period.

Physiological characteristics and growth performances of *Allium victorialis* var. *platyphyllum* growing under three different light intensity regimes in forest-floor cultivation. Kim, G.N. (*Chungnam National University, Republic of Korea; tintin2580@hanmail.net*), Cho, M.S. (*Korea Forest Research Institute, Republic of Korea; gungdong@hanmail.net*), Kwon, K.W. (*Chungnam National University, Republic of Korea; kiwon@cnu.ac.kr*).

This study investigated photosynthetic characteristics, chlorophyll fluorescence, chlorophyll contents, and growth performances of *Allium victorialis* var. *platyphyllum* growing under three different light intensity regimes (53–64%, 30–42%, 5–8% of full sun) in forest-floor cultivation in Buyeo. *A. victorialis* var. *platyphyllum* showed good photosynthetic capacity in June. Particularly, it showed the highest (9.6 μmol $CO_2 \cdot m^{-2} \cdot s^{-1}$) in 30–42% of full sun. Light compensation point and apparent quantum yield tend to be same as photosynthetic capacity. So did chlorophyll fluorescence in June. But the lowest with a significant difference was in 5–8% of full sun. Total chlorophyll contents was the highest (19.03 $mg \cdot g^{-1}$) in 5–8% of full sun and it increased as the shading level decreased. *A. victorialis* var. *platyphyllum* leaf area was the highest (96.14 cm^2) with significant difference, and the number of leaves was the highest in 30–42% of full sun. The leaf thickness decreased as shading level increased. Total biomass was the lowest (1.22 g) in 5–8% of full sun. And the rate of T/R was outstanding in 30–42% of full sun. When light environment of *A. victorialis* var. *platyphyllum* is 30–42% of full sun in an environment such as forest-floor cultivation, physiology and growth may be proper.

Effects of number and size of boring on sap collection of *Acer mono*. Kwon, S.D., Goo, S.Y., Park, S.B. (*Korea Forest Research Institute, Republic of Korea; kwonsd@forest.go.kr; synine@korea.com; parksb@forest.go.kr*), Moon, H.S. (*Gyeongsang National University, Republic of Korea;hamon@gnu.kr*).

A total of 3,588 kl of sap is collected from *Acer mono*, *Betula platyphylla* var. *japonica*, *B. schmidtii*, *B. costata*, *Phyllostachys* spp., providing collectors with an estimated yearly income of $11,000,000 in South Korea, according to the Korea Forest Service. Among these species, *A. mono* account for 97 percent of all sap collection, and the production and demand for sap of *A. mono* are continuously increasing. There are many methods for collecting sap, and that of *A. mono* is collected by stem boring. Taking growth of *A. mono* into consideration, boring size and numbers need to be restricted. Boring sizes of 16 mm have been used in collection of sap, but this has been found to damage tree growth due to the slow healing of boring wound. This study was carried out to establish an effective method of sap collection from *A. mono* by studying the optimum number of borings (1, 3, 5, and 10) in relation to the healing rates of bore wounds and diameter growth. We also studied the healing rates of borings, as well as evaluating the optimum number of borings through analysis the amounts of sap collected by boring size of 8, 10 and 12 mm.

Is sustainable cultivation of *Medeola virginiana* under maple tree cover possible? Lamontagne, M., Wortman, G., Fournier, R. (*Moncton University, Canada; manuel.lamontagne@umce.ca; egw4792@umoncton.ca; richard.fournier@umce.ca*).

Medeola virginiana is a wild edible plant that occurs naturally in the sugar maple stands of New Brunswick, Canada. Its rhizome has a fine and sophisticated flavour. The study aims at developing a sustainable cultivation method that has no negative impact on the production of maple syrup. In summer 2006, a trial was established to identify the micro-environment favouring the growth and propagation of the rhizome under maple trees. For this purpose, three diameter categories of root-stock were used and five treatments applied in order to modify the soil temperature, soil drainage, and quantity of light received (black mulch, soil scarification, plowing with a board of a height of 15 to 20 cm, shade house, and reference plant). Compared with the reference plant, the treatments have improved the survival rate of the plants by 21% ($p = 0.000$) but they have not modified the biomass of the rhizomes ($p = 0.472$). The plowing treatment with board produced 21% more clones than the reference plant ($p = 0.0454$). The large root-stocks produced 22% more clones than the small and medium ones ($p = 0.001$).

Research about the weather characteristics and growth of a mountain ginseng cultural site. Lee, D.S. (*Kyungpook National University, Republic of Korea; Leejo@knu.ac.kr*), Lee, K.W., Woo, S.Y. (*Seoul National University, Republic of Korea*).

We investigated geographical condition, soil characteristics, and forest condition characteristics, with forest shade rate adjusted by 80%. We used Hobo to measure temperature and soil temperature changes. The geographical condition characteristics of the research site are similar to those that appear variously in all research sites, and the soil characteristics of the research site also express the characteristics of South Korea's typical forest soil. Air temperature is over 5 degrees at April budding time, and soil temperature begins to rise rapidly at April, so that it is different from the temperature of the air. The leaf of a mountain ginseng buds and comes out when the temperature of the soil rises to 8 degrees. Leaves begin to fall off if the temperature of the soil reaches over 18 degrees. Mountain ginseng cultivation is influenced by forest type, seedling ages, and seeding budding rates. In the case of a seedling planting, early budding rate is high but budding rate is reduced rapidly and the plant dies naturally in 3 years. In the case of seeding, the rate of early budding is lower than the seedling planting, but the rate to die naturally is lower.

A study of biological activity of extractives from the bark of *Phellodendron amurense*. Lee, H.J., Lee, S.K., Park, C.W. (*Korea Forest Research Institute, Republic of Korea; leehj99@forest.go.kr; lsk24@hanmail.net; pcwpcw@forest.go.kr*).

Phellodendron amurense has long been used as oriental medicine and folk remedies. In this study, extractives from the bark of *P. amurense* were evaluated as a functional cosmetic material through various biological activity tests. The bark extractives were obtained in the stepwise extraction process of water solubles, n-hexane insolubles, and ethyl acetate solubles. For the characterization of the extracted compounds, TLC, NMR, and mass spectrometry were performed. Biological activity tests were conducted with the crude fractions, and the isolated compounds were evaluated for antioxidant activity, cytotoxicity, whitening activity, and anti-cancer activity. Limonin was isolated from the ethyl acetate soluble fraction; and ferulic acid, protocatechuic acid, vanillic acid, and berberine were isolated from the water soluble fraction. In antioxidative activity test using DPPH, the fractionated extractives and isolated compounds showed higher positive activity than BHT as control, and in *in-vitro* tests using MTT assay, they did not show cytotoxicity. Also it is considered that they can be a potential geriatric cosmetic material that is effective against dark spot and pigmentation on the elderly's skin, since they showed toxicity against the B16F10 cell, a skin cancer cell.

Flow regime and yield, chemical composition, and microbiological features of common birch sap (*Betula pendula* Roth). Ljubojevic, S., Marceta D. (*University of Banja Luka, Bosnia and Herzegovina; ljuboje@yahoo.com; dane@blic.net*).

Exploitation of the sap of living trees, known as tapping, is as old as human civilization. Fresh birch sap is nowadays used as refreshing and healing drink and an important component of some cosmetics products. During four seasons, common birch trees were tapped in the northern part of Republic of Srpska, in Bosnia and Herzegovina. In that period quantities of exuded sap, air humidity, and temperature were measured and phenological changes observed. Certain factors such as diameter at breast height, branchiness, density of crown canopy, inclination, and orientation—which are thought to have certain impacts on sap flow regime and seasonal yield—were also determined. In parallel, samples of common birch sap were analyzed in view of their chemical and microbiological composition. Apart from water, the most common sap constituents were sugars, followed by organic acids, tannin matters, and ash. Layer chromatography established presence of glucose, fructose, and sucrose already known to be present in the birch sap, as well as two new sugars: arabinose and galactose. No microorganisms were found either in fresh or 1-year-old sap. Test results on *Salmonella* bacteria, sulfitereducing *Clostridia*, *Proteus* bacteria, *Escherichia Coll*, coagulase positive *Staphylococci*, moulds, and yeast were negative.

Assessment of the populations state and the sexual reproduction potentials of *Boswellia dalzielii* Hutch., a high value medicinal tree in Burkina Faso. Ouedraogo, A., Thiombiano, A. (*University of Ouagadougou, Burkina Faso; o_amade@yahoo.fr; adjima_thiombiano@yahoo.fr*).

Boswellia dalzielii is a tree mainly exploited by people for medicinal purposes in Burkina Faso. The harvesting, which involves striping its bark, causes damage to the individuals and is a real threat for the species. This study aimed to make a diagnosis of natural populations and their regeneration state through quantitative inventories and analysis of demographic structures of natural populations. Its reproduction by seeds was also tested through germination and breeding trials. The results showed aging populations and unpredictable natural regeneration. Trees generally had stem diameters of 20–40 cm, while the saplings were rarely greater than 0.5 m in height. The proportion of debarked individuals in natural stands was between 50 and 80%. The results from reproduction trials showed an average rate of germination (30–35%) which was attributable to the high proportion of infertile seeds. The growth rate of seedlings was low (0.2 cm/day). The saplings survived transplantation well, passing through the dry season by developing a ligneous tuber that resists water stress, but their growth remained low. These results arouse in interest in exploring other ways of multiplication, notably through vegetative means, which could help to preserve the species.

Anatomy of inoculated Korean mistletoe. Park, B.S., Hwang, K.H., Chong, S.H. (*Korea Forest Research Institute, Republic of Korea; bspark@forest.go.kr; m54290@hotmail.com; nayte@forest.go.kr*).

As concerns about health and well-being grow, demands for natural functional foods, medicines, and medical components derived from extractives of natural plants have been increasing rapidly. To survey the potential of artificial cultivations, an anatomical

analysis of mistletoe penetrated into host plants was conducted. Japanese apricot (*Prunus mume*) and mulberry (*Morus bombysis*) were used as host plants, and Korean mistletoe (*Viscum album* var. *coloratum*) was inoculated into 2-year-old branches of the host plants in spring. Mistletoe cells in Japanese apricot survived and grew in good condition with significant portions. However, only a few mistletoe on mulberry survived until the next spring, and they died the following summer because of the natural defense substances of mulberry. Inoculated mistletoes in Japanese apricot grew actively at the host plant's branches, and cell divisions occurred well at the cambium zone. Then the ramified endophytes grew together or individually, and they grew as a stem or many stems. Surviving mistletoes take water and nutrition for their living from their host plant, so it is reasonable that the medical components of them could be derived from those of their host plants.

Conservation of a threatened achlorophyllous orchid, *Gastrodia elata*, using *in-vitro* symbiotic mycorrhizal associations. Park, E.J., Kim, S.T., Ahn, J.K., Lee, W.Y. (*Korea Forest Research Institute, Republic of Korea; pahkej@forest.go.kr; kimst94@hotmail.com; jkahn@forest.go.kr; wylee20@forest.go.kr*).

Gastrodia elata has been designated as a rare and threatened species by both the Korea Forest Service and the International Union for Conservation of Nature (IUCN), mainly because of unsustainable collection of wild plants for medicinal purposes. In this study, symbiotic germination and subsequent vegetative growth by using *in-vitro* mycorrhizal associations were utilized for the production of *G. elata* immature tubers. We first hand-pollinated and then germinated seeds on a medium containing fallen *Quercus* leaves infected with *Mycena* spp. Seed-derived protocorms were developed within 2 months and transferred to a PSH medium containing peptone, sucrose, and hyponex powder. The PSH medium stimulated rhizomorph attraction and protocorm thickening, upon response to subsequent infection with *Armillaria* spp. Within 6 to 7 months of *in-vitro* culture, we were able to produce immature rhizomes that can be directly used for a plant reintroduction program as well as commercial field production. We therefore suggest that this system is an efficient way not only to overcome the rapid loss of native habitat but also for the mass and rapid production of the immature tubers of *G. elata*.

Is it feasible to grow Chaga mushroom, Inonotus obliquus, on a living Betula tree? Park, H., Lee, B.H., Ka, K.H., Ryu, S.R. (*Korea Forest Research Institute, Republic of Korea; hyunpark@korea.kr; bonghun90@naver.com; kasymbio@korea.kr; 25ryul@naver.com*).

Chaga mushroom, Inonotus obliquus, has been widely used as a folk medicine in northern Europe and recently in far-east Asian countries. Because the chemical structure of melanin in naturally occurring sterile conk of the fungus is different than that synthesized compared by cultured fungus, the demand for natural sclerotium is expected to increase, although we can culture the fungus in vitro. In this study, we tried to culture fruiting bodies of the fungus by artificial inoculation on Betula platyphylla var. japonica, a species commonly planted in Korea. We identified the same fungus from the inoculated spot about 14 months later, indicated that the inoculation was successful. Although we expected that more than 10 years would be needed to get a conk from an infection, we observed a small sclerotium about 30 months after the inoculation with diameters ranging from 3 to 5 cm. The conk showed almost the same feature of that collected from natural habitat in Korea, while the diameter was much smaller than that of naturally occurring one. We expect that harvesting is possible within 5 years, but need to confirm the growth rates of the sclerotium to decide suitable time for getting more economic value.

Diversity of natural resources in traditional cosmetics in Togo: an example of forest use by communities. Pereki, H., Batawila, K., Wala, K. (*Laboratoire de Botanique et Ecologie Végétale, Toko; perekih@yahoo.fr; batawila@tg.refer.org; kpwala75@yahoo.fr*), Gbeassor, K. (*Laboratoire de physiologie nimale et de pharmacologie, Togo; gbeassor@tg.refer.org*), Akpagana, K. (*Laboratoire de Botanique et Ecologie Végétale, Togo; koffi2100@yahoo.fr*).

In many countries of Africa, some studies have shown the place of natural resources, in particular their use as cosmetics. In Togo, little work has been carried out on this thematic. Data related to their diversity, intensity of their use, and their management by local populations are rare. This study is making an exhaustive inventory of natural resources used as traditional cosmetic resources by indigenous people. The study is based on an ethnobotanic approach, using the TRAMIL model, in 38 ethnic groups of Togo. In total, 172 species with potential use in cosmetics and skin care products are identified. These resources belong to 167 genera and 59 plant families, and are used for 26 desired effects. Families Poaceae, Euphorbiaceae, Asteraceae, Combretaceae, and Fabaceae had the highest numbers for anti-wrinkle and highlighting traditional lotions. The nomenclature and taxonomic position of plants were determined in accordance with Aubreville and Akoegninou et al. and revised by APG II. This study demonstrates how many traditional societies show respect for nature and use plants, minerals, ingredients, and other resources of biodiversity in cosmetic lotions and skin care products for anti-wrinkling and giving softness to the skin.

Propagation and conservation of medicinal plants through in vitro culture and their sustainable use. Sinha, P. (*Bangladesh Council of Scientific and Industrial Research, Bangladesh; pinakiju@yahoo.com*), Sayeed Hassan, A.K.M., Roy S.K. (*Jahangirnagar University, Bangladesh; lshkmroy@yahoo.com*).

Exploitation of medicinal plants must be accompanied by mass propagation. Protocols have been developed for mass propagation of three endangered medicinal plants, *Rauvolfia serpentina, Gloriosa superba,* and *Smilax zeylanica* through *in-vitro* shoot tip culture. For shoot induction and multiplication, B5 and MS basal media supplemented by auxins and cytokinins were required, in which 82–95% cultures regenerated shoots with 3.9–6.1 shoots per culture. For further development of the medium, casein hydrolysate (50–200 mg/l) and coconut water (5–20%) were added individually or simultaneously to the medium for all three species. *In-vitro* raised shoots rooted on half-strength MS medium with auxins. The survival rate of regenerants of *G. superba* was 62%, whereas that of other two species were 85–90%. In the case of *G. superba,* when rooted shoots were subcultured in an MS medium with 8% sucrose, 8–10 microtubers were induced per culture. Microtubers were harvested from the culture and stored at 25 °C for 1 year. About 85% of microtubers germinated *in-vivo* and morphological parameters of regenerated plantlets were found to be normal. The techniques described here may be a promising method for propagation as well as for sustainable use and conservation of these three medicinal plants.

Impact of dragon blood *(Daemonorop draco)* exploitation as a medicinal plant on the sustainability in the nature in Jambi province, Indonesia. Tarmuzi, Z. (*Ministry of Forestry Republic of Indonesia, Indonesia; Zuraidaus21@gmail.com*).

This study was conducted in Jambi Province in 2008. Dragon blood (*Daemonorop draco*), is a rattan palm native to Malaysia, and Indonesia. In Indonesia, it is called jernang. This species has ecological, sociological, and economical value. It is used as pigment to color matter for varnishes, and also is used for medicinal purposes. Local people around the forest in Jambi Province use this plant as medicine for many kinds of disease. It has high and competitive price in international trade. Unfortunately, the existence of this species in nature in threatened because of over-exploitation, and forest fire, which in 1997 in Jambi destroyed most of the Jernang area. Also, most people around the forest exploit this species in nature without any effort to cultivate it. As a result, it tends to be endangered species. According to the description above, because this species is threatened in Indonesia's forest, it is necessary to make regulations or take efforts to make this species sustainable in nature.

Conservation and sustainable use of medicinal plants in Garhwal Himalaya, Uttarakhand, India. Uniyal B., Bhatt V., Shiva V. (*NAVDANYA, India; bhagwatiuniyal@rediffmail.com; navdanya@sancharnet.in*).

Among all the Himalayan states of India, Uttarakhand is well known for its floral and faunal diversity including traditional knowledge of medicinal plants. Uttaranchal is known as a green state with its natural forests and alpine pastures. Rural areas communities depend on forests for fuel, fodder, and non-timber forest product (NTFP) collection. They have small scale traditional agriculture system and other strong traditions for protecting biodiversity of the region. Medicinal and aromatic plants are integral parts of the rural communities, in which their centuries-old indigenous knowledge has and continues to be used for curing diseases utilizing these plant resources. The indigenous knowledge of medicinal plants in this region has not been documented by any institution in the area. The study aim was to provide information for conservation planning of medicinal plants for long term sustainable options in different rural areas of Garhwal Himalaya. About 122 medicinal plant species were documented, which are generally used by the local people for various purposes. A planning process has been identified with institutions for conservation and cultivation of natural resource for long tern sustainable use.

Ecological niche modeling and dynamics of *Pentadesma butyracea* populations in Benin. Vodouhe, F., Avocèvou-Ayisso, C., Sinsin, B. (*Université d'Abomey-Calavi, Benin; vodouhefifanou@yahoo.fr; c.avocevou@gmail.com; bsinsin@gmail.com*).

Pentadesma butyracea Sabine (Clusiaceae) is a multi-purpose tree that provides non-timber forest products. In particular, fruit almonds can be transformed into butter for cooking and cosmetics. Unfortunately it is threatened in Benin where its natural stands occur mostly in endangered ecosystems of riparian forests, stretching along the rivers in areas. Accurate modeling of geographic distributions of species is crucial to various applications in ecology and conservation. Applying niche-based models (Maximum of entropy instance MAXENT), we predicted the potential distribution of *P. butyracea*. Field assessments of populations of *P. butyracea* were used to parameterize a matrix model, which was used to predict the impact of different harvesting regimes on population dynamics of the species. We found that there is a strong influence of precipitation of coldest and warmest quarters in *P. butyracea* geographical distribution that interacts with temperature changes over the year. The links between these determinant variables and climate change highlighted the species sensitivity to global warming. Values of the dominant latent root (λ) were 0.9444 and 1.0025 respectively for high and low fruits harvesting populations. High fruit harvesting populations are thus in decline while low fruits harvesting populations are stable.

Assessing the effect of material-storage duration and distillation methods on the yield and active content of the resulting Masoy essential oil. Winarni, I., Roliadi, H. (*Forest Products Research and Development Center, Indonesia; inawinarni@yahoo.com; p3thh@yahoo.com*).

The masoy (*Cryptocarya massoia*) tree is one of the plants that produce essential oil in Indonesia. Currently, the utilization of masoy is not yet optimal, because it directly traded by local people in bark shape without being initially processed into essential oil; also masoy stems without bark are left on site to decay or are used just as firewood after the bark material is removed. Therefore, the investigation focused on the effect of storage duration of masoy bark and stems with boiling and steaming distillation methods on the essential oil yield and its active content. The highest oil yield was acquired from the steaming-distillation method: 1.5% (bark) and 1.27% (stem), respectively; the corresponding values from the boiling-distillation method were 1.3% (bark) and 0.63% (stem). Analysis results of active items revealed that the oil distilled from masoy stem and bark contains three major compounds: lactone-1 (C-10), lactone-2 (C-12), and benzoic benzyl. The largest content of those three consecutive active compounds was derived from the stem-distilled oil, at 7 days stem storage duration, being 77.34%, 17.56%, and 2.01% respectively; corresponding values for the bark-distilled oil were at 14 days bark storage-duration, being 67.98%, 19.96%, and 2.23% respectively.

Analysis of physico-chemical properties of dragon's blood and Ipoh bark yielded from traditional processing by the Anak Dalam tribe, Jambi province. Winarni, I., Waluyo, T.K., Roliadi, H. (*Forest Product Research and Development Center, Indonesia; inawinarni@yahoo.com; tikowaluyo@yahoo.com; p3thh@yahoo.com*).

Dragon's blood and ipoh bark signify endemic non-timber forest products commodities indigenous to Jambi Province. Dragon's blood typifies the resin secreted from rattan (*Daemonorops draco*) fruit as obtained from the extraction method. Ipoh bark is merely bark-sheet obtained from *Antiaris* spp trees. Unfortunately, local people only sell them as just raw material without processing. Therefore, research has been carried out regarding the observation on dragon's blood extraction techniques and ipoh bark processing as traditionally done by Anak Dalam tribe. Research results revealed that the traditional extraction techniques adopted the dry method with the yield at 7.42 ± 0.99%, while the corresponding value using methanol solvent reached 9.50 ± 0.67%. Physico-chemical properties of dragon's blood afforded moisture content 4.4%, dirt content 16%, ash content 2.8%, and melting point 105 °C. Meanwhile, physical analysis results revealed its tensile strength 59–299 N, tear strength 10–34 N, stretch 16–37%, absorption duration 6–76 second, and absorption capacity 384–577%. In brief, dragon's blood extraction using methanol solvent seems more effective than using traditional methods. Other ways to improve the qualities of dragon's blood is by drying prior to extraction. Meanwhile, based on physical analysis results, ipoh bark is more appropriately used for handcraft items, particularly bags.

Processing technology for added-value improvement of low-quality dammar (*Shorea javanica*) from Lampung, Indonesia. Winarni, I., Zulnely, Z., Roliadi, H. (*Forest Product and Development Center, Indonesia; inawinarni@yahoo.com; p3thh@yahoo.com; p3thh@yahoo.com*).

Dammar is one of the essential NTFP commodities offering notable roles in domestic industries as well as for exports (1,186 US$ in 2008 and 476,000 US$ in 2009). Unfortunately, the dammar is sold in raw-material shape (Rp 6,000–12,000), and the technology adopted by the community is still traditional. Consequently, this lowers its selling-price in the market. One of the ways to achieve dammar's added value is to improve purification technology and product diversification. So far, dammar purification is done using solvents (sold with prices 3–4 times higher). However, currently the market demands purification techniques without solvent uses, because they are more environmentally friendly. Therefore, we studied purification techniques using heating and filtering (200 mesh) methods and varnish production for small-scale manufacture. Physico-chemical analysis revealed the yield at 60%, color 58.89%, ash content 0.1%, and softening point 98.75%. Research resulted in varnish from low-quality dammar with the formulated mixture of dammar solution (66%), synthetic alkyd (24%), kerosene (0.3%), and dry cobalt (0.3%). Concurrently, the total production cost of manufacturing 50 kg of varnish reached about Rp 609,400, or Rp 12,188/kg, while the varnish price in the market ranged around Rp 20,000 – 40,000/kg.

The production of mushroom salt using mushroom extracts and the features of functional quality of the product. Yang, E. J., Oh, D.S., Yoo, S.B., Wi, A.J., Park, W.S. (*Forest Resources Research Institute, Republic of Korea; ej-yang@korea.kr*).

This study produced mushroom salt by adding the nutrients and medicinal components of the mushroom to solar salt; and then we analyzed the quality features and functions of the mushroom salt. We measured minerals contained in mushroom salt—*Lentinus edodes* mushroom salt (LEMS5-25), *Pleurotus ostreatus* mushroom salt (POMS5-25), and *Auricularia polytricha* mushroom salt (APMS5-25). According to the results, LEMS25 contained 746.11 mg/100 g of K^+ and 146.43 mg/100 g of Ca^+; POMS25 contained 915.86 mg/100 g of K^+ and 130.64 mg/100 g of Ca^+; and APMS25 contained 502.68 mg/100 g of K^+ and 142.64 mg/100 g of Ca^+. The three substances held K^+ about 1.4–2.5 times more than solar salt, whose K^+ content reached 381.37 mg/100 g, and held Ca^+ about 4–4.5 times as much as solar salt, which contained 32.04 mg/100 g of Ca^+. According to the result of a measurement of DPPH radical scavenging activity, both solar salt and refined salt scored 0%, while LEMS15 gained 92.43 ± 0.05%, LEMS20 94.05 ± 0.01%, LEMS25 93.78 ± 0.01%, POMS15 90.61 ± 0.05%, POMS20 91.76 ± 0.01%, and POMS25 94.08 ± 0.01%. These substances turned out to have more antioxidant than mushroom extracts, whose antioxidant content stood at 85.22 ± 0.02–88.47 ± 0.04%.

Resource development for a short-term forest income using the lower of the warm-temperate forest-cultivation planting for *Allium victorialis* var. *platyphyllum* and investigation of its functional ingredients. You, H.C., Oh, C.J., Park, J.S. (*Jeonnam Resources Research Institute, Republic of Korea; hckor7810@korea.kr; ohcj3441@korea.kr; yesrok@korea.kr*).

This study was carried out to investigate the possibility of producing and analyzing individuals produced after planting *Allium victorialis* var. *platyphyllum,* which grows naturally in Ullung Island and alpine regions of Korea. In addition, we examined the possibilities of its edible or medicinal use. We planted the bulbs of the triennial *A. victorialis* var. *platyphyllum* at 200 m, 300 m, 400 m above sea level and in the Wando Arboretum. As a result, we found out this species can be grown well at all regions regardless of the altitude. But growth above sea level had the following results: at higher altitudes the leaves came out later; it grew by the last 10 days of August. Therefore, it is able to control the harvest time by planting at different altitude regions. After analysis on the functional components, it was found out that *A. victorialis* var. *platyphyllum* substantially contains kaempferol 3-o-glucopyranoside, ferulic acid, quercetin, kaempferol, etc: more in the leaves than in the bulbs. As a result of analysis on the functional components of the *A. victorialis* var. *platyphyllum* grown at the Wando Arboretum, we found that the kaempferol content was more than 20-fold in comparison with that of Ullung Island.

B-27 Innovative approaches to forest ecosystem restoration

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Secondary forests, slash-and-burn agriculture, and invasive alien plants: developing a basis for forest rehabilitation towards biodiversity recovery and socio-economic benefits. Geldenhuys, C.J. (*University of Stellenbosch, South Africa; cgelden@mweb.co.za*), Mala, W. (*University of Yaounde, Cameroon; williammala@yahoo.fr*), Syampungani, S. (*Copperbelt University, Zambia; syampungani@cbu.ac.zm*).

Secondary forests, slash-and-burn agriculture, and invasive alien stands create many concerns but they cover vast areas of tropical land, affect many people's lives, and are useful in integrated multiple resource use and biodiversity recovery. How can we manage such areas to rehabilitate forest biodiversity and use value at relatively low cost? All forest ecosystems are naturally composed of development stages from very early pioneer stages to mature 'old-growth' forest. Species of such systems find their optimum development somewhere along that gradient. The three broad land use systems of concern are associated with forest degradation but represent early recovery stages of natural forest. They are dominated by light-demanding, fast-growing tree species, either native or introduced to a specific area. The system recovery processes typically follow an early succession process and can be managed. Examples are used of forest recovery after slash-and-burn agriculture in Congo Basin tropical moist forest and in southern African deciduous Miombo woodland, and alien tree stands adjacent to warm temperate forest in South Africa. Principles are developed to guide pro-active management of such systems towards forest biodiversity and stand structure recovery, incorporating sustainable resource uses benefitting different stakeholders, including forest farmers and timber concessionaires.

Reversing biodiversity loss and land degradation across agricultural landscapes in southern Nigeria. Isikhuemen, E.M. (*Ministry of Environment and Public Utilities, Nigeria; ekeobamatt@hotmail.com*).

A study was conducted in a degraded landscape located at latitude $6^0\ 3^1\ 1^{11}$N and longitude $5^0\ 37^{1}14^{11}$E. The 1.2-ha plot was devoid of herbal and grass vegetation while all the relic trees and shrubs were retained. Four indigenous timber species seedlings

were raised in the nursery and later planted at 3-m × 3-m. Cuttings of 3 cassava varieties—Tropical Manihot Series 30572, 30555 and 4(2) 1425—were introduced as inter-plantings and maintained on a two successive rotations of 12–15 months each. At 30 months after planting, 21 families, 33 species, and 1,312 individuals were inventoried. Among the introduced taxa, 1,160 seedlings representing 6 species and 5 families were recorded. An average height of 225 cm was obtained by 258 seedlings, while 14 grew to 400 cm in height. At 12 months after planting mortality was significant ($P < 0.05$) among the introduced taxa. With appropriate eco-friendly cropping mixtures and agroforestry practices, degraded forest land can recover from deflected succession.

Regional study on early-stage vegetation recovery processes at abandoned plantation clearcut sites. Nagashima, K., Yoshida, S. (*Kyushu University, Japan*: *njunior@ffp.kyushu-u.ac.jp; syoshida@ffp.kyushu-u.ac.jp*).

The number of forestry sites that are abandoned after clearcutting is increasing in Japan, and it is feared that if the vegetation recovers unsuccessfully, there would be a reduction in the capacity of forests to influence soil, water, and biodiversity conservation. Understanding the general vegetation recovery processes at these sites is essential to evaluate whether the vegetation will successfully recover. This is the first regional-scale study that investigates a large number of abandoned plantation clearcut sites distributed across Kyushu Island to understand the general early-stage vegetation recovery process. Four types of vegetation—grass (G), few pioneer trees (FPT), non-pioneer trees (NP), and pioneer trees (P)—were observed as a result of the vegetation survey. The decision tree analysis detected deer browsing as the main factor inhibiting tree species recovery, and as the degree of deer browsing became serious, longer time was needed for tree species to recover. The slope form, existence of adjacent natural broadleaved forest, and area of abandoned sites were detected as factors that differentiate the vegetation types with tree species. The former indicated the differences in understory tree distribution prior to clearcutting and the latter two indicated the importance of seed dispersal in the regeneration processes.

Contemporary forest restoration. Stanturf, J.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us*), Madsen, P. (*University of Copenhagen, Denmark; pam@life.ku.de*), Lamb, D. (*Queensland University, Australia; d.lamb@uq.edu.au*).

Although restoration ecology has traditionally aimed to re-create some putative more 'natural' ecological state, forest landscape restoration (FLR) has emerged over the last decade as an approach aimed more at restoring natural functions, while focusing on meeting human needs. Restoration ecology, as a scientific discipline, developed from practitioners' efforts to restore degraded land, with interest from applied ecologists attracted by the potential for restoration projects to apply and/or test developing theories on ecosystem development. Since then, FLR has emerged as a practical approach to forest restoration particularly in developing countries, where an approach is required that is both aimed at landscape-scale and focused on meeting human needs. Yet despite increased investigation into both the biological and social aspects of forest landscape restoration, there has so far been little success in systematically integrating these two complementary strands or in addressing the challenges of global change. Here we present an overview of contemporary forest landscape restoration as practiced internationally, drawing on presentations from practitioners and researchers at recent IUFRO conferences and from the literature, and suggest ways to more effectively integrate social and natural science approaches within a resiliency science framework.

Tree species effect on herb layer succession in post-agricultural forests. Thomaes, A., De Keersmaeker, L. (*Research Institute for Nature and Forest* (*INBO*)*, Belgium; Arno.Thomaes@inbo.be; Luc.Dekeersmaeker@inbo.be*), De Schrijver, A. (*Ghent University, Belgium, An.Deschrijver@Ugent.be*), Vandekerkhove, K. (*Research Institute for Nature and Forest* (*INBO*)*, Belgium, kris.vandekerkhove@inbo.be*), Verheyen, K. (*Ghent University, Belgium, Kris.verheyen@Ugent.be*).

In Western Europe and north-eastern America, ancient forests have diminished dramatically. Restoration of natural forest plant communities in post-agricultural forests is limited due to unsuccessful colonization of ancient woodland plant species. We hypothesize that, on acidification-sensitive soils, the prospects for colonisation of ancient woodland species are partly determined by the planted tree species. We present a vegetation study in a chronosequence of first generation oak (*Quercus robur*) and poplar (*Populus* × *euramericana*) forests and a introduction experiment of ancient woodland species in a common garden comparing 8 tree species, both in post-agricultural forests. Our chronosequence study revealed a declining soil-pH by age under *Quercus* compared to a stable soil pH under *Populus*. The herbal vegetation showed little tree species-specific differences, however, more ancient forest plants seem present under *Populus* than under *Quercus*. In the common-garden, pH-H_20 in the topsoil varied from 3.8 under *Alnus glutinosa* to 5.6 under *Populus*. The introduction revealed that seedlings and adult plants have a better recruitment under tree species with better litter quality and higher topsoil pH. We conclude that management, by tree species selection, clearly affects restoration of natural forest plant communities and that litter quality seems to be a driving force for restoration.

Posters

Assessing utilization of lesser-known tree species in secondary semi-deciduous tropical forest in Colombia: a contribution to ecosystem rehabilitation and sustainable management. Paredes, A.; Nutto, L.; Becker, G. (*University of Freiburg, Institute of Forest Utilization and Work Science, Germany; angela.paredes@fobawi.uni-freiburg.de; leif.nutto@fobawi.uni-freiburg.de; institut@fobawi.uni-freiburg.de*).

Colombia's forests constitute one of the most biodiverse ecosystems in the world and have enormous potential for sustainable forest utilization. However, the country presents high rates of deforestation and forest transformation. There is need to find out management strategies that allow the forest to recover and maintain their production of goods and services. The semi-deciduous tropical forest appears to be one of the most threatened ecosystems in Colombia. Besides forest transformation through slash and burning practices and conversion to other land uses, this forest type is highly intruded upon for selected harvesting of a few commercial species, leaving the relicts without economic importance for the proprietors. In this framework, this research seeks to increase forest value through sustainable management of lesser known species (LKS). An evaluation of the forest's status will be a first step in assessing and identifying economically potential wood species. Further on, an evaluation of the marketing options and of possible added value wood products for the LKS species will be carried out. The results of this research are planned to be disseminated by help of local organizations and are expected to create a strong impact in regional forest management and the wood industry.

Seedling morphology and leaf trait variability of species preferred for mixed-species reforestations in Leyte. Sales-Come, R. (*Visayas State University, the Philippines; rfs_lsu@yahoo.com*), Hoelscher, D. (*Georg-August Universitaet-Goettingen, Germany; dhoelsc@gwdg.de*).

A scheme to reforest degraded sites called "rainforestation" was developed in the Philippines, favouring native species and supplemented with fruit trees. Establishment of these stands relies on the quality of seedlings produced in nearby nurseries. It is important to assess the ecophysiology of potted seedlings, maximal stomatal conductance (g_{smax}) in particular, in addition to the usual evaluation of seedling morphology. Objectives were to (1) determine the species-specific leaf traits of selected seedlings grown in various nurseries; (2) search for relationships between g_{smax} and other tree seedling variables; and (3) find out whether leaf traits group the species studied. Species-specific g_{smax} differed nine-fold (72 to 643 mmol m^{-2} s^{-1}). For studied leaf traits, only leaf length-width ratio showed a simple linear correlation with g_{smax}. The use of principal component analysis combining leaf traits provided an explanation of 72 percent variability by the first two axes. All native species were associated with low g_{smax}, and low leaf length-width ratio. *Artocarpus heterophylla* and *Samanea saman* showed high g_{smax} and with round leaves. These associations of seedling species with leaf traits as variables indicate that species have different leaf investment strategies, which may imply whole plant performance when planted in the field.

Bamboo resources in restoration of mined sites in Ghana: what are the potentials of some native bamboo species? Tekpetey S.L. (*Kwame Nkrumah University Science and Technology, Ghana, niilartey@gmail.com*), Danso, I. (*Oil Palm Research Institute, Ghana*).

Bamboo resources are under-utilized in most developing countries, although there are about 1,500 documented uses worldwide. In the discourse on climate change, new adaptation and mitigation of options are being explored. The IPCC and AIACC reports have concluded the inevitability of climatic stress and threats, which will intensify in coming years. A number of adjustments are required. The use of renewable natural resources such as bamboo cannot be over-emphasized in most nations. Little information exists on the exploration of bamboo species for use on marginal and degraded land in Ghana and other developing countries. In this paper, the potentials of five exotic species and two bamboo species on mined soil in Ghana were explored. The shorter gestation period, soil binding quality, and higher carbon sequestration abilities of bamboo species were ranked through literature review, field observation, and some preliminary studies. The study concludes with a clarion call for further research and awareness creation on the use of bamboo species for food security, environmental stability, and a "greener future" campaign around the world.

B-28 Contemporary challenges in forest ecosystem management and silviculture

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The legacy of forest management in tropical plantations: analyzing its influence with ecosystem models. Blanco, J.A. (*University of British Columbia, Canada; juan.blanco@ubc.ca*), González, E. (*Universidad de Pinar del Río, Cuba; eduardo@af.upr.edu.cu.*).

The legacies from previous human actions can be a key factor in forest ecosystems, both during the period of active management and later on during the natural recovery of the sites after management ends. Ecological models are a useful tool to compare alternative management regimes. In this paper, the long-term influence of forest management on tree growth is explored by using the ecosystem-level forest management model FORECAST, calibrated for a *Pinus caribaea* plantation in western Cuba. Three different management types were explored (for biomass, pulp, and timber), differing in rotation lengths and intensity of biomass removal, among other features. Our results showed that managing for biomass could produce a fast depletion of soil nutrients in the first rotations, later reducing tree growth after management ends. Managing for pulp may need extra inputs such as fertilizers to keep constant tree growth after the first rotations. As for timber, its longer rotation lengths may allow the ecosystem to sustain stable tree growth rates for longer periods and quickly recover after management ends. In conclusion, management legacies can be a key factor on tree growth, with the long-term sustainability of forest management depending on the particular objectives and ecosystem characteristics.

Seed production of the Andean oak *Quercus humboldtii* in two Andean forests of the Colombian eastern cordillera. González-Melo, A., Parrado-Rosselli, A. (*Universidad Distrital, Colombia; andresao77@hotmail.com*; *aaparrador@udistrital.edu.co*).

Knowledge of mechanisms of tree species reproduction under natural situations, including fruit and seed production patterns, is important for management strategies. Considering the influence of abiotic factors such as soil characteristics, humidity, and rainfall on fruiting phenology we studied fruit production patterns of the only Andean oak species (*Quercus humboldtii:* Fagaceae) in two forest sites of the Colombian Eastern Cordillera, under contrasting environmental conditions (Cachalú and Patios). At both sites we monitored monthly fruit production of 15 trees in Cachalú and 11 in Patios using fruit/seed traps placed under the tree crowns. In general, trees in Cachalú produced more fruits than in Patios, and mean fruit mass (wet and dry weight) also was significantly higher in Cachalú. At both sites, oak fruiting peaked from April to May, when the highest rainfall occurs. We found positive correlations between fruit production of the same month and one month prior. High phosphorus (P) and potassium (K) were the main variables for explaining the high production. In contrast, high aluminum (Al) contents explained the low production that was found in Patios. This information may have potential application in management and restoration strategies of this important timber species.

The effects of ground cover vegetation on natural regeneration of wild pistachio (*Pistacia attlantica*) in a forest area: case study of Wild Pistachio Research Forest, Fars Province, Iran. Negahdarsaber, M. (*Center of agriculture and natural resources, Iran; saber@farsagres.ir*).

To study the relationships between ground cover vegetation—including shrubs, bushes, and natural regeneration of wild pistachio (*Pistacia attlantica*)—a research project was carried out for 5 years in 4 hectares in an enclosed area in Wild Pistachio Research Forest in Fars Province. The regression between number of shrubs such as *Amigdalus scoparia*, *A. lycioides,* and *A. ebornea* and the number of seedlings due to natural regeneration of wild pistachio is as follows: $y = 5.8207x^{0.6499}$ ($R^2 = 75.5\%$).The relation of number of bushes and natural seedling regeneration was low ($R^2 = 35.87\%$). Statistical analysis using T-test showed that enclosing an area had no significant difference compared with control for natural establishment of wild pistachio regeneration ($\alpha = 0.05\%$). Therefore, the best method for improving the natural regeneration of wild pistachio is enriching wild almond species by planting them in wild pistachio forests.

Effects of a regeneration felling on wind speed in a *Nothofagus pumilio* forest on southern Patagonia, Chile. Promis, A., Caldentey, J., Cruz, G. (*Universidad de Chile, Chile; alvaro.promis@gmail.com; jcaldent@uchile.cl; gcruz@uchile.cl*).

Nothofagus pumilio forests in southern Patagonia in Chile are managed by using a shelterwood system, designed to promote natural regeneration after logging. In this research the effects of a regeneration felling under a shelterwood system on the wind speed during 7 years (March 1997 to March 2004) was analyzed. Two weather stations measured the wind speed among other microclimatic variables in the Monte Alto estate (52º05′S, 71º45′W; 460 m above sea level). The wind speed measured in a primary even-aged forest (890 trees ha^{-1} and 80 m^2 ha^{-1}), without intervention, was compared to those recorded in a managed forest (213 trees ha^{-1} and 36 m^2 ha^{-1}), where a regeneration felling was applied. The hourly mean wind speed recorded in the primary forest was 0.86 m s^{-1} (range of between 0.05 and 4.00 m s^{-1}). Whereas in the managed forest the hourly mean wind speed was 1.8 m s^{-1} (range between 0.22 and 6.98 m s^{-1}). The hourly maximum wind speed in the managed forest was in average 2.38 times higher than in the unmanaged forest. Therefore, in the managed *N. pumilio* forest with regeneration felling, the wind speed condition was changed with respect to a primary forest condition.

Posters

Coppice management effects on conservation of *Buchholzia coriacea.* Akinyele, A. (*University of Ibadan, Nigeria; akinyelejo@yahoo.co.uk*).

The effect of traditional coppice management was investigated on seedlings of *Buchholzia coriacea*, a threatened medicinal tree species of West Africa. Six-, 8- and 10-month-old seedlings were decapitated at 10, 15 and 20 cm from collar diameter. The aim was to discover the appropriate age and height at which regrowth occurs in decapitated seedlings. Height of the coppice, number of coppices, and number of leaves were assessed fortnightly for a growing season. Using ANOVA, significant differences were observed regarding the influence of age on regrowth. Eight-month-old seedlings had the highest coppice height. The effect of age on number of coppices produced did not differ significantly between 6- and 8-month-old seedlings. Seedlings decapitated at 10 cm from the collar diameter produced the highest coppice height at 4.8 cm; the coppice height decreased with the height of decapitation. Also, as the age of seedlings decreases, the height of the coppice increases. The number of coppices increases simultaneously with the height of decapitation. As height of decapitation decreases, the number of leaves produced increases. This result implies that regrowth is dependent on the height and age at which the seedling is decapitated.

Nutrient deposition through litter secondary components in vegetation communities, northeastern Mexico. Cantú-Silva, I., González-Rodríguez, H. (*UANL, Mexico; icantu@fcf.uanl.mx; humberto@fcf.uanl.mx*), Kubota, T. (*Kyushu University, Japan; kubot@ffp.kyushu-u.ac.jp*), Gómez-Meza, M. (*UANL, Mexico; marcovgmeza@hotmail.com*), Sánchez-Castillo, L. (*Kyushu University, Japan; lau-sc@hotmail.com*), Domínguez-Gómez, T. (*UANL, Mexico; gustavo_dguezg@hotmail.com*).

The study objective was to determine macronutrient (Ca, K, Mg, P) and micronutrient (Cu, Fe, Mn, Zn) deposition through secondary litter components in different vegetation communities in northeastern Mexico. Litter secondary constituents were measured at 15-day intervals, December 21, 2006 to December 20, 2007, in four experimental sites with different vegetation types. Each site had a plot (50 m × 50 m) in which 10 litter traps (1.0 m^2 each) were used for collections. Micronutrient deposition represented 93–99% of the total annual deposition. Macronutrients deposition order was as follows: Ca > Mg > K > P, while the micronutrients deposition was: Fe > Mn > Zn > Cu. On the other hand, Ca, K and P were returned mainly by reproductive structures in all experimental sites, except in Bosque Escuela where P was returned equally by all secondary components; while Mg was deposited principally by branches (Crucitas and Bosque Escuela) and reproductive structures (Campus and Cascajoso). In relation to micronutrients Cu, Fe, Mn and Zn were returned in Cascajoso y Campus by reproductive structures, in Crucitas by branches and in Bosque Escuela by the component bark.

The effect of light intensity on growth of a 3-year old *Shorea leprosula* plantation with a line cutting-replanting system in south Kalimantan, Indonesia. Faridah, E., Wibisono, M.G., Adriyanti, D.T. (*University of Gadjah Mada; enyfaridah@ugm.ac.id; mgwibisono@ugm.ac.id; dwityaningsih@yahoo.com*).

As a rehabilitation program, a *Shorea leprosula* plantation was established in PT. INHUTANI II with a cutting and replanting line system. The study aims to identify effect of light intensity (LI) on *S. leprosula* growth in six measurement plots (A, B, C, D, E, and F) (0.2 ha each) with gradual shadings using naturally associated plants. Measurement was conducted on plant height and diameter (100% sampling intensity), LI, biomass, humidity, temperature, and species inventory of shading trees. Results showed that while temperatures did not differ among plots (30.6–33.8 °C), plot A with the highest LI (62.83%) had the highest height and diameter of *S. leprosula* plants (2.76 m and 3.03 cm), while the lowest plant height and diameter (1.27 m and 2.28 cm) was found in plot F, which also had lowest LI (46.42%). Plot A had also highest biomass content (1030.36 kg/ha) and lowest humidity (64.5%). Diversity index of shading trees from all six plots ranged from 0.9274 to 0.5511, dominated by dipterocarp, but other species also found included *Dellinia eximio*, *Macaranga*, *Nimonius*, *Aleurites*, and bamboo. In conclusion, 3-year old *S. leprosula* already need a high light opening for successful growth. Thinning of shading trees can facilitate light requirements.

The structure and composition of restricted access and unrestricted access in temperate Himalayan forests along an altitudinal gradient. Gairola, S., Sharma, C.M., Ghildiyal, S.K., Suyal, S. (*HNB Garhwal University, India; sumeetgairola@gmail.com; sharmacmin@gmail.com; skghildiyal@gmail.com; sarveshsuyal@gmail.com*).

The present study was undertaken to understand the structure of various temperate forests as influenced by the magnitude of disturbance along an altitudinal gradient (1,500–3,000 m above sea level) of Garhwal Himalaya. Two study areas, Mandal-Chopta (restricted access; RA) and Chaurangikhal (unrestricted access; URA), having similar physiographic and edapho-climatic conditions were selected for the study. Two kinds of disturbances—natural (cloud burst, windfall, earthquake, landslide, lightening and wild fires) and anthropogenic (stem cutting, grazing, lopping, fodder and fuelwood extraction, fire, extraction of non-timber forest products, etc)—were identified as altering the forest structure in the study areas. The study revealed that in the RA forest, natural disturbances were more prominent in altering the structure of the forest whereas in URA forest anthropogenic disturbances were more prominent. At higher elevations (>2,500 m) natural disturbances were more prominent, whereas at lower elevations (1,500–200 m) anthropogenic disturbances were so. Among natural disturbances, windfall and landslides were more pronounced, whereas among anthropogenic disturbances, stem cutting, lopping, and grazing were more disturbing factors. The RA forest had higher species richness, diversity, growing stock, stem density, and total basal cover values as compared to URA forest at all the elevations.

Abundance and diversity of regenerated trees on skid trails after selection harvesting in conifer–hardwood mixed forests in Hokkaido, northern island of Japan, in relation to ground disturbance, canopy opening, and dwarf bamboo coverage. Kuramoto, S., Sasaki S., Iida, S., Ishibashi, S. (*Hokkaido Research Center, Forestry and Forest Products Research Institute, Japan; shkura@ ffpri.affrc.go.jp; shozos@ ffpri.affrc.go.jp; iida34@ffpri.affrc.go.jp; sa9267@ ffpri.affrc.go.jp*).

Successful regeneration after harvesting is important for sustainable management and biodiversity conservation in conifer-hardwood mixed forests in Hokkaido, northern island of Japan, where selection harvesting is commonly practiced. However, it has been reported that regeneration post selection harvesting is generally poor with dwarf bamboo, possibly because of major competing vegetation. We investigated tree regeneration on skid trails, which are sites primarily disturbed by selection harvesting, with regard to ground disturbance by logging machine traffic and canopy gap formation by cutting, since these two aspects of disturbance are expected to affect tree regeneration via dwarf bamboo growth control. The regeneration density on skid trails increased with ground disturbance and was the lowest in canopy gaps with low ground disturbance. The number of regenerated species was also higher with high than with low ground disturbance and the lowest in canopy gaps with low ground disturbance. Dwarf bamboo coverage increased as ground disturbance intensity decreased and was higher in gaps than under a closed-canopy with low and medium ground disturbance. These findings suggest that ground disturbance as well as the extent of canopy closure were important factors for ensuring the post-harvesting regeneration accompanied by removing and suppressing dwarf bamboo growth.

How do *Robinia pseudoacacia* riparian forests regenerate after clear-cutting? Emergence of current sprouts. Kurokochi, H., Teramoto, M., Komatsu, R., Hogetsu, T. (*The University of Tokyo, Japan; aconitum-k@fr.a.u-tokyo.ac.jp; mthope@fr.a.u-tokyo.ac.jp; komatsu@fr.a.u-tokyo.ac.jp; ho@fr.a.u-tokyo.ac.jp*).

How to manage *Robinia pseudoacacia*, an exotic tree that vigorously invades riparian forests in Japan, may be of much note. Cutting a *R. pseudoacacia* tree could facilitate seed germination in seed-banks by changing forest floor environments, and simultaneously new ramet generations on stumps and horizontal roots. Thus, after clear-cutting, *R. pseudoacacia* forests may regenerate both sexually and asexually in certain balance. In this study, we investigated the balance by using microsatellite markers, that is, codominant and highly polymorphic DNA markers. All trees in two sites in riparian *R. pseudoacacia* forests were cut in 2008, and the next year, newly formed sprouts were positioned and genetically analyzed with four microsatellite markers. Although some stumps regenerated no sprouts because those sprouts were bored by insects or rotten, new sprouts grew on the other stumps and soil, and were broadly distributed in the sites. Genetic analysis showed that several ramets in each genet identified among the sprouts clustered and rarely mingled with those in other genets. Because sexual reproduction should result in genets with only one ramet, this indicates that the sprouts regenerated after clear-cutting only by asexual reproduction on stumps and horizontal roots, genets of which had clustered before clear-cutting.

Survival analysis of direct seeding regenerated Taiwan red and yellow cypress at Chi-lan-shan Area in northeastern Taiwan. Lin, S.T. (*National Ilan University, China-Taipei; stlin@niu.edu.tw*), Chiu, C.M., Chung, C.H., Lin, C.Y. (*Taiwan Forestry Research Institute, China-Taipei; cmchiu@tfri.gov.tw; uld9801@ms13.hinet.net; cylin@tfri.gov.tw*), Lin, C.L. (*Forest Conservation Administration/Veterans Affairs Commission, China-Taipei; lon580329@yahoo.com.tw*).

For promoting native cypress regeneration in conifer plantations, this study explored the survival of direct seeding regenerated Taiwan red cypress (*Chamaecyparis formosensis*) and Taiwan yellow cypress (*C. obtusa* var. *formosana*) seedlings in Japanese cedar forest gaps created by row thinning at Chi-lan-shan in northeastern Taiwan. Results shown that the seed germination rate and survival rate of emerging seeds after 10 months were 7.9% and 4.3% for Taiwan red cypress and 4.2% and 7.4% for Taiwan yellow cypress respectively. However, no significant differences were shown for germination and survival rate of two species and site preparation treatments. The survival rate of seedlings of Taiwan red cypress was higher than that of Taiwan yellow cypress as assessed by survival analysis. Moreover, the seedlings of Taiwan yellow cypress died gradually while Taiwan red cypress died largely simultaneously. The hazard rate of mortality of Taiwan yellow cypress seedlings occurring without ground preparation treatment would be lower than that with ground preparation treatment. Hazard rate of mortality in the succulent seedling stage between the two species were different, which implies a distinction in seedling adaptation type of Taiwan red and yellow cypress.

Changes of herbaceous vegetation in Kunugi (*Quercus acutissima*) forests after clear-cutting for bed logs for Shiitake mushroom. Okonogi, H., Fukuda, K. (*University of Tokyo, Japan; okono0403@gmail.com; fukuda@k.u-tokyo.ac.jp*).

In rural districts in Japan, various forests were used for agricultural and forestry purposes. Diversity of these forests had been maintained by routine management for a long time. However, many of them are abandoned and devastated after the economic

growth in 1960s. *Quercus acutissima* forests have been clear-cut in 15–20 year cycles for bed logs for Shiitake mushrooms. Clear-cutting is the most significant disturbance in forest management and is supposed to have a role to maintain herbaceous species diversity. To clarify the role of clear-cutting in the maintenance of plant diversity, we compared before and after clear-cutting. Vegetation and environmental data were collected in October 2008 (before clear-cut) and October 2009 (after clear-cut). After clear-cutting, sky openness and surface soil water content increased. Annual forbs increased from 2 to 8 species, and evergreen trees and shrubs decreased from 2 to 0 and from 6 to1 species, respectively. Relative dominance of *Pleioblastus chino* decreased and that of *Miscanthus sinensis* increased after clear-cutting. Some grassland plants appeared after clear-cutting. It is suggested that clear-cutting in *Q. acutissima* forest is important to conserve grassland plants from the monopoly of *P. chino*.

Effects of pruning and spacing on epicormic branch development of silver fir (*Abies alba* Mill) in southwest Germany. Pyttel, P., Benneter, A., Bauhus, J. (*Albert-Ludwigs-University Freiburg, Germany; patrick.pyttel@waldbau.uni-freiburg.de; ad.be@gmx.com; jürgen.bauhus@waldbau.uni-freiburg.de*).

Epicormic shoots are one factor reducing timber quality and value of silver fir (*Abies alba* Mill). No previous study has documented epicormic branch frequency and persistence in relation to artificial pruning and stand density of this species. In the present work, we inventoried epicormic sprouts of 966 pruned and unpruned trees, growing in twelve 33- to 45-year-old stands thinned to two different densities (250 and 500 stems/ha). Sprout dimensions and positions were determined for 120 sample trees. Diameter, age, and number of living sprouts was highest for pruned trees growing at a density of 250 stems/ha. Dead and small sprouts (< 3 mm) were more prevalent on unpruned trees. Frequency of living sprouts was significantly higher in south-facing bole sections than in the other cardinal directions. Highest photosynthetic active radiation (PAR) measurements were taken directly above larger and older sprouts underlining a strong relationship between light availability and sprout persistence. We conclude that pruning and thinning of silver fir did not increase the total amount of epicormic sprouts, but increased the number of persistent and therefore larger epicormic branches owing to alterations of the light environment.

Effects of thinning treatments on dasometric parameters of Iberoatlantic oak forests and birch groves in northeastern Spain. Silva-Pando, F.J., Rozados Lorenzo, M.J., Ónica, C. Polanco, Nuria, G.B., Cristina, L.S., Margarita, A.S. (*CIF-Lourizán, Pontevedra, Spain; jsilva.cifal@siam-cma.org; mjrozados@siam-cma.org; malonso.cifal@siam-cma.org*).

Between 1998 and 2003, six thinning plots were established in regular natural stands of *Quercus robur* and *Betula celtiberica* on six places in Galicia between an altitude of 400 and 1,400m. All except one plot stemmed from natural regeneration and a medium/high site quality. The treatments comprised the elimination of 15, 35, and 45% (for birch) and 55% (for oak) of the basimetric area and a control treatment (0%). Corresponding measurements before and after thinning were carried out at mean periodic intervals of 3 years. The evolution of various crop parameters is presented. The treatments have different effects on the plots and are more visible on the plots of young oaks, whereas they are less visible on plots of older oaks but are appreciable in all cases. We measured a diameter increment of up to 6 mm/year^{-1} and a height increment of 40 cm/year^{-1}, with these increments being higher on oak plots and on plots with a higher thinning weight.

Domesticated forest ecosystems: design and analysis. Tewari, V.P., Joshi, S.C. (*Institute of Wood Science and Technology, India; vptewari@yahoo.com; dir_iwst@icfre.org*), Gadow, K.V. (*Georg-August-University, Germany; kgadow@gwdg.de*).

People harvest trees to utilize the wood and non-timber products; they change the species composition to attain some desirable structure and adapt rotation ages to improve the runoff from water catchments. Global surveys of human impact indicate that virtually all terrestrial ecosystems have already been "domesticated," that is, modified by harvest events, plantings, fertilization, irrigation, and other human-induced disturbances. However, domestication activities are not always sustainable; they are often destructive, resulting from food shortages, a lack of foresight, or pure greed. The dynamics of a terrestrial ecosystem is determined to a considerable extent by the impact of human activity and to a much lesser extent by natural processes. For this reason we believe that research on the processes and functions of natural systems, which hardly exist any more, needs to be complemented by studies focusing on ecosystems design and engineering. It may be useful if such studies are based on theories which include both human impact and ecosystem response. One such theory is the "multiple path" concept, which deals with the adaptive design of a domesticated forest ecosystem. The approach differs substantially from the traditional view of sustainable forest management. The concept is presented with application examples from India.

General Posters: Biodiversity Conservation and Sustainable Use of Forest Resources

Effect of methyl jasmonate on the root growth and the eleutheroside accumulation in adventitious root culture of *Eleutherococcus senticosus.* Ahn, J.K., Lee, W.Y., Park, E.-J. (*Korea Forest Research Institute, Republic of Korea; AHNJK@ forest.go.kr; wylee20@ forest.go.kr; pahkej@forest.go.kr*).

This study was carried out to investigate the dose-dependent effect of methyl jasmonate (MeJ) on both the growth of adventitious roots and the accumulation of various eleutherosides in adventitious root culture of *Eleutherococcus senticosus* bioreactor culture. MeJ significantly inhibited biomass production, while it stimulated the production of eleutheroside B, E and E1. The highest levels of eleutheroside B and E (476.3 μg/g DW and 676.0 μg/g DW) were obtained by 0.5 mg/L MeJ and eleutheroside E_1 was accumulated at the highest level by 0.01 mg/L MeJ. The highest content of total eleutheroside was 2468.6 μg per liter culture by adding 0.01 mg/L MeJ. In addition, when the adventitious roots were cultured with 0.01 mg/L MeJ, the highest levels of eleutheroside B, E and E_1 were obtained at the 6th, 8th and 4th day, respectively. In conclusion, these results showed that the addition of MeJ increased the levels of eleutherosides including B, E, and E1, in a dose-dependent manner, suggesting that this method may provide a basic understanding in the production of eleutherosides in the adventitious root culture of *Eleutherococcus senticosus*.

Variation among provenances of *Fraxinus rhynchophylla* in seed size and germination response to various temperatures. Choi, C.H. (*Chonbuk National University, Republic of Korea; freewillow@hanmail.net*), Kang, K.S. (*Korea Forest Research Institute, Republic of Korea; kangks@forest.go.kr*), Seo, B.S. (*Chonbuk National University, Republic of Korea; byungsoo@chonbuk.ac.kr*), Baik, E.S. (*Korea Forest Research Institute, Republic of Korea; 5491bkes@forest.go.kr*).

The difference among provenances in seed characteristics and germination properties was observed among eight provenances of *Fraxinus rhynchophylla*. Seed length ranged from 12.5 to 16.8 mm; seed width varied from 2.6 to 4.2mm. Seeds collected from northern origins had high seed moisture and 1,000-seed weight, which exhibited the highest coefficient of variation (*CV*) among seed characteristics. There were significant differences ($p < 0.01$) among provenances for all germination properties in response to various temperatures: germination percentage, mean germination time, germination rate, and germination performance index. In high temperature regimes, germination of seeds from high annual mean temperature was higher than that of seeds from low annual mean temperature. Germination performance index showed a similar trend to germination rate. Base (T_b), maximum (T_m), and optimum temperatures (T_o) were evaluated by regression models using germination percentage and germination rate, respectively. The low annual mean temperature-provenances showed low T_b, T_m and T_o, while the high annual mean temperature-provenances showed high T_b, T_m and T_o. Among the cardinal temperatures, T_b had the highest *CV* while T_m had the lowest. We expect that observed patterns of variation would have important implications for seed transferring of the species in Korea.

Growth performance and provenance by site interaction of *Pinus strobus* in Korea. Choi, H.S., Ryu, K.O., Kim, I.S., Cho, D.H. (*Korea Forest Research Institute, Republic of Korea; forgene@forest.go.kr; koryu95@forest.go.kr; kimis02@forest.go.kr; cowandboy@nate.com*).

Two sets of *P. strobus* (1972, 1986 planted respectively) were used to analyze growth performance with provenances and sites, among ages, and provenance by site interaction in Korea. Volume growth of *P. strobus* at age 39 was best in Chuncheon site, and North Carolina provenance proved to be superior in every site. Height growth was positively correlated with annual precipitation, foggy days, and sand contents in soil while diameter(DBH) growth was positively correlated with longitude, altitude, and clay in soil. Variance components analysis revealed that there is provenance by site interaction in diameter but no interaction in height growth. Regression and AMMI model were used to analyze provenance by interaction. The interaction term explained 2.0–2.5% in height and 18.9–24.6% in diameter of total variation with the two models respectively. CSP*i* method ranked North Carolina provenance as the best provenance with good adaptability and performance. 27-year-old *P. strobus* with six provenances from the United States were evaluated for growth performance. Growth of southern provenances was superior to that of northern provenances. Annual height growth still increased, but diameter gradually decreased at age 27. The growth performance and patterns revealed that the North Carolina provenance was best in Korea environments.

Reproductive biology of an endangered shrub (pondberry, *Lindera melissifolia*). Devall, M.S., Schiff, N.M. (*U.S. Forest Service, USA; mdevall@fs.fed.us; nschiff@fs.fed.us*), Skojac, S.A. (*USA*).

Pondberry is a rhizomatous, clonal shrub that occurs in seasonally flooded wetlands and on the wet edges of sinks, ponds, and depressions in the southeastern United States. The distribution and abundance of pondberry have been affected by habitat destruction and alteration, and it was listed as endangered by the U.S. Fish and Wildlife Service in 1986. Pondberry usually occurs in colonies of numerous stems with few branches. The species is dioecious, with small yellow flowers that bloom in early spring. The fruit is a drupe about 1 cm long that ripens in late summer. We have monitored flowering, insect visitation, and fruiting at several locations in Mississippi and Arkansas since 1998. During flowering, stems at each location were tagged, flowers were observed, and the gender was noted. Flower clusters on male and female plants and the number of flowers per cluster were counted. Fruits were monitored until ripening occurred. Male pondberry flowers open a few days before female flowers. A male stem may produce up to 400 flowers, and a female stem may produce up to 300 flowers and 100 fruits. The plants are susceptible to late freezes, which may preclude fruit production for that year.

Evaluation of field performance of *Pongamia pinnata* (L.) Pierre. clones by morphometric analysis. Divakara, B.N., Krishnamurthy, R. (*Indian Council of Forestry Research and Education, India*; *bndsira@gmail.com, dir_ifp@icfre.org*).

Pongamia pinnata (L.) Pierre. clonal evaluation trial was conducted using 24 promising candidate plus trees (CPTs) collected from various zones of Jharkhand, India. The experiment was conducted at the Forest Research Centre, Institute of Forest Productivity Mandar, Ranchi during 2005–08. The trial aimed to identify outstanding clones with better field establishment and performance for mass multiplication and field development of *P. pinnata*. Six clones (CPT-5, CPT-22, CPT-6, CPT-1, CPT-23, CPT-18) showed better performance for morphometric trait height. However, overall better growth performance as indicated by volume index was expressed by CPT-18, CPT-2, CPT-6, CPT-23, CPT-22, and CPT-5. These clones not only performed better but also had better adaptability to the study site and hence, are applicable for future planting in Jharkhand through mass clonal propagation. On the basis of broad sense heritability and genetic advance percentage of mean estimates traits, number of branches and volume index were found to be genetically controlled and could be considered reliable for selection for further improvement. All the traits in this study expressed positive and significant correlation among each other at both genotypic and phenotypic levels. Therefore, improvement of one character may cause simultaneous changes in other characters.

Estimation of heritability and genetic gains on volume growth of open-pollinated progeny of *Pinus densiflora*. Han, S.U., Oh, C.Y., Cheon, B.H., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; sanguhan@forest.go.kr; chang05@forest.go.kr; cbhmk1302@forest.go.kr; jskim20@forest.go.kr*).

Progeny test plantations were established with 49 open-pollinated families of *Pinus densiflora* in six sites in 1987, using seedlings grown from seeds collected from plus trees to improve genetic quality of the native species. Height (H) and DBH (D) were measured when the trees were 24 years old, and volume was calculated ($H \times D^2$). Growth performance was relatively good in Chuncheon and Wanju sites, but relatively poor in Taean and Gongju sites. In the analyses of variance within each site, differences were significant in families and replications for growth performance in some sites, but highly significant differences were found in family × replication interaction. The analysis of variance with all data from six sites showed that there were highly

significant differences in families and sites, but no difference was found in family × site interaction. Therefore, family growth pattern was similar among sites. Family heritability for height, DBH, and volume analyzed with combined data of all sites was relatively high: 0.941, 0.521, and 0.578, respectively. We estimated that genetic gains from 25 superior families for height, DBH, and volume were 5.3%, 1.4%, and 4.6%, respectively.

Indication of association between EST loci and ecotypes of Japanese red pines. Hong, Y.P., Ahn, J.Y., Kim, Y.M., Yang, B.H., Hur, S.D. (*Korea Forest Research Institute, Republic of Korea; yphong@forest.go.kr; gee330@daum.net; ymalfm@naver.com; time1124@forest.go.kr; protenaf@forest.go.kr.*).

There are five ecotypes of Japanese red pine in Korea, which are distinguished by their unique tree forms. To identify key functional DNA markers responsible for resulting tree forms of each ecotype, EST primers of coding candidate genes related to growth of needles or xylem tissues were investigated. Cleaved amplified polymorphic sequences, caused by either indel or point mutations, were observed, which allocated in eight EST loci. On the basis of allele frequencies in eight EST loci, a pretty low level of genetic differentiation was observed among populations (Fst = 0.0184). In spite of mimic population differentiation, four loci revealed a high level of fixation indices. In two of the four EST loci, a pretty high frequency of heterozygotes (with the absence of one of the expected homozygotes) was observed, which resulted in a pretty high level of negative fixation indices in both ecotypes of mid-southern flatland and Weebong, representing medium height growth. It is unclear whether the high frequencies of heterozygotes in two EST loci observed in this study are really responsible for genetic control of determining tree form for each ecotype. Another unproved possibility may be potential strong natural selection against one of the two homozygotes in both loci.

Selection of walnut cultivars with high quality and high-yielding. Hwang, S.I., Park, Y.K., Lee, M.H. *Korea Forest Research Institute, Republic of Korea; hwangsi@forest.go.kr; ykpark@forest.go.kr; mhlee99@forest.go.kr*).

The goals of this research were to evaluate the yielding and fruit characteristics of walnut selected from different regions in Korea. Different varieties of walnut grown in Korea were investigated with regard to fruit weights, fruit length, and yield. The walnut belongs to the family Juglandaceae and is one of the most important nut crops grown in temperate regions. Walnuts, the seeds of *Juglans sinensis,* are a highly nutritious food. They are also used as a traditional remedy for treating cough, stomach ache, and cancer in Asia. The present investigations were undertaken during 1998–2009 in five walnut-growing areas. We observed a wide range of variation in walnut characters from different locations. From these varieties, we have been regularly investigating the fruiting characteristics—which are the average of fruit length (FL) and width (FW) and weight of fruit (WF)—and individual yields (IY) during 10 years to select good quality walnut trees. Among these varieties, the 'Ui-Tan 1' showed the largest values with an average of 44.8 mm (FL), 41.0 mm (FW), and 19.7g (WF), respectively.

Mutation induction in Sugi cedar by ion beam irradiation and tissue culture of non-pollen trees. Ishii, K., Hosoi, Y., Taniguchi, T. (*Forestry and Forest Products Research Institute, Japan; katsuaki@ffpri.affrc.go.jp; yh2884@ffpri.affrc.go.jp; s4332@affrc.go.jp*), Hase, Y., Tanaka, A. (*JAEA, Japan; hase@jaea.go.jp; atanaka@taka,jaeri.jo.jp*).

Sugi cedar (*Cryptomeria japonica*) is the most important plantation conifer tree in Japan. Mutants such as male-sterility to solve the problem of pollinosis and prevent gene flow from transgenic trees are promising. The combination of ion beam irradiation and tissue culture was beneficial for high frequent mutation induction. We tried to induce the mutants by irradiation of in vitro cultured buds of Sugi cedar with $^{4}He^{2+}$ and $^{12}C^{6+}$ heavy ion beams. Fresh buds were irradiated with 50 MeV $^{4}He^{2+}$ or 320 MeV $^{12}C^{6+}$ ion beams delivered from the AVF cyclotron at TIARA in JAEA-Takasaki. After irradiation the buds were subcultured to the new media for assessing the survival rate and detecting mutation. There were plastid mutations such as albino and partial light-green leaves in Sugi cedar. Regenerated Sugi cedar trees were grown in the greenhouse and treated with gibberellic acid (GA) at 100 ppm in July to induce the formation of male flowers. So far, we observed scarce male flower and non-flower plantlets and plastid mutants of Sugi cedar by ion beam irradiation. Further confirmation experiments of mutation of Sugi cedar are necessary. Tissue culture of non-pollen Sugi cedar trees found in the field stands is also presented.

Effects of plant growth regulators on hardwood cutting in *Acer tegmentosum* Maxim. Jang, K.H., Song, J.H., Hur, S.D., Lee, J.C. (*Korea Forest Research Institute, Republic of Korea; jang123@forest.go.kr; sjh8312@forest.go.kr; protenaf@forest.go.kr; jaeclee99@forest.go.kr*).

Acer tegmentosum Maxim. has been used a source of traditional medicines for the treatment of hepatic disorders in Korea. This study was carried out to select plant growth regulators that are effective for macro-propagation of hardwood cuttings of *A. tegmintosum*. Rooting responses of hardwood cuttings in March were examined for the kinds and concentrations of plant growth regulators. Cuttings collected from 1-year shoots were taken from the upper part of the crown and about 8 cm in length with a basal diameter of 8–15 mm. Basal ends of the cuttings were soaked for 5 minutes in the given hormone solution to depth of 3 cm. Each treatment was repeated on three batches of 30 cuttings in the greenhouse. The rooting of the cutting was assessed after 3 months. Analysis of variance (ANOVA) was applied after the angular transformation of rooting percentage. Percentage of rooting showed significant differences only among kinds of plant growth regulators. The treatment with plant growth regulators showed an increase (about 10%) in rooting percentage as compared to the control (non-treated cutting). Especially, the application of NAA 1,000 mg/ℓ was more effective in callus formation and rooting of cuttings (31.7%) than the control (11.7%).

Development of propagation method from *Allium victorialis* var. *platyphyllum*. Jeong, M.J., Song, H.J. (*Gyeongsang National University, Republic of Korea; jmivy121@naver.com; hyunjin617@hanmail.net*), Doh, E.S., Chang, J.P. (*Joongbu University, Republic of Korea; esdoh@joongbu.ac.kr; jpchang@joongbu.ac.kr*), Yang, J.K. (*Gyeongsang National University, Republic of Korea; jkyang@gnu.ac.kr*), Yun, C.W. (*Kongju National University, Republic of Korea; cwyun@kongju.ac.kr*), Choi, M.S. (*Gyeongsang National University, Republic of Korea; mschoi@gnu.ac.kr*).

An efficient method *for in-vitro* propagation and growth of the *Allium victorialis* var. *platyphyllum* (Liliaceae) was established. Bulbs of *A. victorialis* collected from Ullung Island (Naribunji, Taewharyong, Sungin Peak, and Jungmaewhagol) in Korea were obtained and the bulb surface sterilized. The growth pattern of plantlets on various culture media was undertaken. Effects of

cytokinin on growth of *A. victorialis* were tested in MS solid medium containing several cytokinins (2ip, kinetin and BAP) of various concentration (0.1, 1.0, and 5.0 mg/L). Shoot elongation was examined with several carbohydrate concentrations (1, 3, 5, 7, and 9%) and levels of nitrogen source (NH_4NO_3 and KNO_3) in order to optimal culture condition. The studies revealed that the most efficient cytokinin was 1.0 mg/L 2ip for growth, followed by 1.0 mg/L BAP and 1.0 mg/l Kinetin. Plantlets grown in the medium with half of both NH_4NO_3 and KNO_3 developed and were healthy in appearance. Regeneration of *in-vitro* bulblets was better in Taewharyong than other regions in culture. Dominant *A. Victorialis* (74cm) of Sungin Peak was selected and secured. An *in-vitro* culture system for shoot proliferation and growth of *A. victorialis* was established.

Effects of plant growth regulators on the *in-vitro* culture of *Lagerstroemia indica* for. *alba* (W.A. Nicholson) Rehder. Jung, W.S., Park, J.I. (*Chungbuk National University, Republic of Korea; deux486i@hanmail.net; jipark@chungbuk.ac.kr*).

This study was conducted to establish a micro-propagation method for *Lagerstroemia indica* for. *alba* to find out the most effective media for shoot multiplication and rooting of shoots, several concentrations of plant growth regulators were tested. For shoot multiplication, axillary buds were cultured on WPM supplemented with adjusted different concentrations of BAP (6-benzylaminopurine) and TDZ (thidiazuron) for 4 weeks. The most effective condition for shoot multiplication from axillary buds appeared to be WPM supplemented with 0.1mg/L TDZ (3.4 ± 0.5 shoots) and 0.1 mg/L BAP (3.2 ± 0.4 shoots). When both auxin and cytokinin were treated in WPM, shoot development did not produce better results than did the single treatment with 0.1 mg/L TDZ, 0.1mg/L BAP. To find out the optimal hormonal concentration for rooting, the axillary buds were cultured on WPM that involves different levels of IBA (indole butric acid) and NAA (a-naphthalene acetic acid) for 4weeks. The most effective treatment for rooting of *L. indica* for. *alba* was culturing the buds on WPM containing either 1.0 mg/L IBA (4.5 ± 0.8 roots) and 1.0 mg/L NAA (3.7 ± 0.6 roots). All the regenerated plantlets successfully survived in a pot in high humidity condition under plastic film cover in culture room.

Successful vegetative propagation techniques for the threatened *Dendropanax morbifera* L_{EV}. and *Machilus thunbergii* S. et Z. Kim, C.Y. (*Chonnam National University, Republic of Korea; silvic@naver.com*), Kim, J.O. (*Korea Forest Service, Republic of Korea; fore0208@forest.go.kr*), Oh, K.I. (*Chonnam National University, Republic of Korea; kioh@chonnam.ac.kr*), Jang, S.K. (*Korea Forest Conservation Association, Republic of Korea; jsk0424@naver.com*), Kim, Y. (*Chonnam National University, Republic of Korea; iamahan@naver.com*).

Dendropanax morbifera and *Machilus thunbergii,* resourceful species distributed in the southern part of the Korean Peninsula, are promising as primary planting species to restore degraded warm-temperate forest. This study was conducted to develop the most effective greenwood cutting propagation technique; we investigated conditions such as cutting time, ortet age, and an applied plant growth regulator. We found the most successful method to cut *D. morbifera* is to extract cutting stocks in mid-July from 17-year-old ortets, followed by IBA20 mg/L PGR. For *M. thunbergii*, the successful vegetative propagation method is to extract cutting stocks in late June from trees less than 10 years old, followed by IBA40 mg/L or NAA20 mg/L. However, when treated with PGR, both showed higher rooting rates compared to the control. Results suggest that cutting of both species is related to the juvenility factor and PGR treatment. To restore degraded forests, species that grow fast, adapt to forest environments, and have resource value are needed. *D. morbifera* is comparatively useful as lacquer and aromatic agent; *M. thunbergii* is useful for medicinals and timber. Planting of cutting saplings using these cutting methods with selected superior genotypes is more profitable than seedlings, owing to their narrow gene pool.

Provenance by site interaction of *Quercus acutissima* in Korea. Kim, I.S., Kwon, H.Y., Ryu, K.O., Choi, H.S. (*Korea Forest Research Institute, Republic of Korea; kimis02@korea.kr; kwonhy@korea.kr; koryu95@korea.kr; forgene@korea.kr*).

Quercus acutissima is one of the economically important tree species in Korea. Most seeds for reforestation have been supplied from seed production plantations in each province. However, the geographic variation and growth characteristics of the provenances of *Q. acutissima* are not well-known. This study was conducted to investigate provenance by site interaction of *Q. acutissima*. Seventeen provenances, systematically collected from the whole range of distribution, were evaluated for stability and adaptability for height growth at three test sites. Data were obtained from measurements at age 12 and analyzed using a linear regression model. There was significant provenance by site interaction effect ($p < 0.001$). Most of provenances were significantly different from the unity ($b = 1.0$). Adaptability of provenances to test sites were estimated with mean height growth and regression slope. Hwasoon, Youngam, and Yeonki provenances are sensitive to environmental change and well-adapted to preferable environments. Gangwha, Heungsung, Whasung, Namyang, Keumreung, Cheongyang, and Wonju are less sensitive to environmental change. Particularly, Keumreung showed higher adaptability to a poor environment. The implication of GxE interaction is discussed in view of seed transfer and delineation of seed zone.

Micro- and macro-propagation techniques for *Simarouba glauca.* Kumaran, K., Geethanjali, S., Nesamani, K., Manivasakan, S., Govinda Rao, M. (*Tamil Nadu Agricultural University, India; drkkmail@yahoo.com; geethanjalik@gmail.com; knesa2005@gmail.com; smanivasakan@yahoo.com.in; deanformtp@tnau.ac.in*).

Simarouba glauca, a native to El Salvador, belongs to the family Simarubaceae. The kernels yield on decortication 55% to 65% oil, which is suitable for human consumption without hydrogenation or blending with other fats. The species can adapt to a wide range of temperatures from 30° to 45 °C and grows well upto1,000 m MSL in all types of well-drained soil with pH 5.5–8.0. The species is botanically polygamodioecious, with more than 60% andromonoecious, which is a bottleneck for commercial cultivation of the species for oil production. Hence an attempt was made to standardize the macro- and micro-propagation techniques to produce more female trees. Among the macro-propagation techniques, epicotyl grafting followed by cleft grafting emerged as the best methods for propagation of *Simaruba*. Regarding micro-propagation studies, 0.1 percent $HgCl_2$ was effective for surface sterilization of explants. Shoot tip explants and MS basal medium were found to be suitable for micro-propagation of *Simaruba*. MS + BAP 2.5 mg l^{-1} + Kinetin 3.0 mg l^{-1} was the best treatment for shoot bud organogenesis. MS + IBA 1.0 mg l^{-1} performed well with respect to rhizogenesis.

Clonal propagation of *Pongamia pinnata* through stem cuttings. Kumaran, K., Kala, S., Manivasakan, S., Govinda Rao, M. (*Tamil Nadu Agricultural University, India; drkkmail@gmail.com; kalaforestry@gmail.com; smanivasakan@yahoo.com.in; deanformtp@tnau.ac.in*).

The study describes the scope of clonal propagation of *Pongamia pinnata*, a potential source of biodiesel, by stem cuttings collected from matured trees. Improved techniques of vegetative propagation through stem cuttings were developed for *P. pinnata* at Forest College and Research Institute, Mettupalayam, India. It is an indigenous and important agroforestry tree species in most parts of India. This study investigated the effects of IBA on rooting of stem cuttings in this species. Percentage rooting and primary root numbers differed significantly between treated and untreated cuttings. Treatment of cuttings with 3,000 ppm IBA maximized rooting (89.0%), along with increased survival (84.0%) and primary root number (18.7). Rooting success and root number were better in 15-cm × 2.5-cm diameter cuttings. Cuttings planted in sand: soil: VAM (2:1:1) rooted better, with more roots ensuring better survival. Survival and growth of the clonal plants were best when using improved techniques like size of the cuttings with proper IBA concentration and also combined with suitable rooting media. The results of this study suggest that it is possible to develop clones of superior trees of *P. pinnata* for use in agroforestry or large-scale biofuel plantations.

Evaluation of rare plant in Korea by IUCN category. Lee, B.C. (*Korea National Arboretum, Republic of Korea; lbbc@forest.go.kr*), Kim, J.S. (*National Institute of Biological Resources, Republic of Korea; foko@korea.kr*), Lee, J.H. (*National Institute of Environment Research, Republic of Korea; eco2007@korea.kr*), Suh, G.U., Chung, J.M. (*Korea National Arboretum, Republic of Korea; seed@forest.go.kr; rhuso@forest.go.kr*).

The Korean National Arboretum conducted nationwide field research, sample surveys, and literature studies in order to collect data on Korean native plants. A total of 571 rare species of flora were categorized into EW, CR, EN, VU, LC, and DD according to the criteria of endangered species suggested by IUCN. The results of grade evaluation of rare plants displays 4 species as EW (extinct in the wild), 144 species as CR (critically endangered), 122 species as EN (endangered), and 119 species as VU (vulnerable), totalling 389 species that are included in IUCN conservation categories. However, an additional 70 species and 111 species are LC (least concerned) and DD (data deficient), respectively. Species for each category were 53 Pterophyta, 7 Gymnospermae, 242 Magnoliopsida, and 87 Monocotyledoneae. Especially, in monocotyledoneae, the number of plants in Orchidaceae is over 50%, and among monocotyledoneae Orchidaceae such as *Cypripedium japinicum* and *Neofinetia falcate*, 26 species are critically endangered. Therefore, identification of conservation measures and proliferation method for plants in Orchidaceae is evaluated to be the foundation of conservation policy for rare plants.

Identification of *Castanea* spp. cultivars using leaf morphological characteristics. Lee, U. (*Korea Forest Research Institute, Republic of Korea; rich26@korea.kr*), Kwon, S.H. (*Hannam University, Republic of Korea; wolfpack@hnu.ac.kr*), Lee, K.Y., Hwang, S.I. (*Korea Forest Research Institute, Republic of Korea; treegene@korea.kr; hwangsi@forest.go.kr*).

A total of 29 cultivars were used to establish a leaf classification system of cultivars in the growth period. To create an identification key based on breeding origins and species, all quantitative/qualitative characteristics of the leaf were statistically significant except leafing time. Using these characteristics, 22 cultivars (75.9%) could be identified. For the logic model, we used a total of seven qualitative characteristics, except for two characteristics. Using these characteristics, the 22 cultivars formed into three different groups that could be used as an identification key. From the discriminant function rule using measurable data, three morphological characteristics except for leafing time were significantly different at 5% and selected discriminant variables to classify cultivars. Fisher's linear discriminant function rule was inappropriate as it had a misidentification rate of 77.6%. We also applied the non-parametric discriminant function rule of K-nearest neighbor (K = 5), but still the misidentification rate was higher than we expected (67.8%). The result of discriminant function rule showed that an effective classification system of cultivars is difficult to establish using leaf characteristics. Finally, we conclude that cultivar classification using leaf characteristics, if the number of cultivars is reduced, will increase discrimination and enable the identification key to be most effective.

Identification of *Castanea* spp. cultivars using multivariate analysis. Lee, U. (*Korea Forest Research Institute, Republic of Korea; rich26@korea.kr*), Kwon, S.H. (*Hannam University, Republic of Korea; wolfpack@hnu.ac.kr*), Baik, E.S. (*Korea Forest Research Institute, Republic of Korea; 5491bkes@forest.go.kr*), Lim, H.I. (*Seoul National University, Republic of Korea; storm01@snu.ac.kr*).

A total of 29 cultivars were used to establish a classification system of chestnut cultivars using morphological characteristics. Ten quantitative characteristics were used to discriminate chestnut cultivars using multivariate analysis and to establish a cultivar classification system in the period of fruiting. From the multivariate analysis, 4 morphological characteristics out of 16 characteristics in flower and fruiting were significantly different, so these were selected as discriminant variables. From the discriminant function rule, Fisher's linear method produced a high misidentification rate (67.5%). We also applied a non-parametric method, K-nearest neighbor (K = 5), but the misidentification rate was still higher than we expected (52.8%). Although, like leafing time, flowering time out of 10 quantitative characteristics relative to flower and fruiting showed indistinctive trends among breeding species and cultivars, four cultivars were significantly different on each characteristic, so that it was easier to classify cultivars. To establish a classification systems of chestnut cultivars, the logic model using classification variables such as flower and fruiting characteristics is more efficient than the discrimination model, and conducting traditional classification is more effective at the same time.

Production of acteoside in hairy root culture of *Paulownia fortunei* Hemsl. Liao, Y.K., Hsu, C.F., Ku, K.L. (*National Chiayi University, China-Taipei; ykliao@mail.ncyu.edu.tw; s0935114@mail.ncyu.edu.tw; klku@mail.ncyu.edu.tw*).

In this study, *in-vitro* grown Paulownia (*Paulownia fortunei* Hemsl.) inoculated by *Agrobacterium rhizogenes* was obtained to produce hairy roots for acteoside (As) production. Hairy root lines 7-6, 23-1, and 55-1 were first cultured for high-yield screening. Among them, line 55-1 incubated on MS liquid medium (50 mL/flask) for 35 days achieved the highest yield (13.12 mg/flask). Subsequent examinations using 55-1 as explants demonstrated that both MS and 1/2 MS media provided equal support for a better ($p < 0.05$) As production. Upon monitoring the growth dynamics and As accumulation in the root tissues, both measurements showed a lag stage in about the 28th day in culture. Medium supplemented with 6% (w/v) sucrose also achieved the best yield, and As content was reduced at lower sucrose levels. Methyl jasmonate(MeJA; 50–500 ppm), as prepared

by 95% ethanol and added in the 21st day of incubation, actually reduced the As production as compared with the control non-treated hairy roots at day 7 after application. This elicitor as used in this study with the presented method did not perform any benefit for a higher yield of As.

Effect of the root cut treatment of *Ailanthus altissima.* Nagai, M., Takeuchi, F., Suzuki, K., Sakurai, S., Joumura, M. (*Nihon University, Japan; nagai.m.742@gmail.com; f.takeuchi230@gmail.com; acorn810@yahoo.co.jp; ssakurai@brs.nihon-u.ac.jp; Joumura.mayuko@nihon-u.ac.jp*).

Ailanthus altissima propagates itself by root sucker. Our hypotheses was that the characteristics of the root sucker are a preparation for disturbance. If the hypothesis is true, after we cut lateral roots of mother tree below ground, *Ailanthus* may be able to grow by use of saving nutrient in the remainder of the root. We investigated the effect of the root-cut treatment of *Ailanthus*. We choose 20 shoots and set a 30-cm^2 quadrat around each ramet on 30 July 2009. In half the quadrats we cut the roots by a hand saw along each quadrat. The other quadrats were as a control treatment. After the treatment, we measured shoot length and the number of stems in each quadrat about every 10 days. When the shoots dropped all leaves, we observed whether they stopped growth. When annual shoot changed to brown in color, we recorded "dead." The root-cut shoots had a little growth and the number of the stems increased. Conversely, most of the control shoots had a big growth and the number of stems had very little change. The root-cut ramets began to die in September, but the control ramets did not die even in December.

Intra-clonal and inter-clonal tree growth variations of genets of *Hevea brasiliensis*. Naji, H.R, Sahri, M.H., Nobuchi, T., Bakar, E.S. (*Universiti Putra Malaysia, Malaysia; hrn_16hrn@yahoo.com; Hamami5253@gmail.com; tadeshi@putra.upmedu.my; edisuhaimi@putra.upm.edu.my.*

Silvicultural practices are efforts to improve tree growth and wood quality. This study was carried out to evaluate the effect of two clones, RRIM 2020 and RRIM 2025, and four planting densities(500, 1,000, 1,500, and 2,000 trees/ha) in each clone on tree growth of a 9-year-old plantation in Malaysia. Diameter above ground level (DAG), diameter at breast height (DBH), and height of bole (HOB) were measured. DAG showed highest values (27.98 and 24.62 cm) at the first planting density and lowest values (23.27 and 18.84 cm) at the third planting density. The highest DBH was at the first planting density (20.27 and 19.96 cm); the lowest value for clone one was at the third planting density (17.42 cm) and for clone two was at the fourth density (15.57 cm). The highest HOB value for clone one was at the third planting density (1,023 cm) and for clone two, the fourth planting density (1,026 cm); the lowest value for clone one was the first planting density (467 cm) and for clone two was the second planting density (738 cm). It is concluded that the ideal planting density should be managed at 500 trees/ha.

Seasonal mating system in a seedling seed orchard of *Pinus merkusii*, a Southeast Asia pine species. Nurtjahjaningsih, I.L.G., Saito, Y., Uchiyama, K. (*University of Tokyo, Japan*), Ide, Y. (*University of Tokyo, Japan; yoko@es.a.u-tokyo.ac.jp; kuchi@es.a.u-tokyo.ac.jp; ide@es.a.u-tokyo.ac.jp*).

Since flowering phenology influences genetic diversity and genetic values of seed crops through mating patterns, this study was conducted to investigate effects of a year-round flowering of *Pinus merkusii* on seasonal variations of mating system in a seedling seed orchard (SSO) using five microsatellite markers. The study was carried out at three flowering seasons, in the SSO of *P. merkusii* located in Jember, East Java, Indonesia. Although abundance of female and male flowers varied among seasons, rate of outcrossing was high and similar among three seasons (t_m = 0.941–0.962). However, disproportional flowering resulted in high H_E value (0.402) in the seed crop. This was supposed to be caused by increased substantial fertilization from distant pollen. The other disproportional flowering resulted in low H_E value (0.361) in the seed crop, which may be caused by restriction of pollen dispersal. Proportional flowerings represented relatively high H_E value (0.397). An ideal mating that increased mating among neighbouring trees and panmictic equilibrium may occur under this condition. We concluded that seasonal fluctuation of *P. merkusii* severely affects genetic diversity of seed crops through various mating systems corresponding to the abundance and the proportion of female and male flowers in the SSO.

The differences of photosynthetic mechanisms between superior and inferior families of *Pinus densiflora* according to shading and nutrient treatments under drought conditions. Oh, C.Y., Han, S.U., Woo, K.S., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; chang05@forest.go.kr; sanguhan@forest.go.kr; woo9431@forest.go.kr; jskim20@forest.go.kr*).

We compared photosynthetic activities of superior and inferior families of open-pollinated *Pinus densiflora* progenies to find their reaction mechanisms to shading and nutrient treatments under drought conditions. We selected superior and inferior families from progeny test; KW85 is superior and KW40 is inferior. Drought was induced by irrigation period control, three times a week for control and one time a week for drought. Nutrient treatments were induced by fertilizer application, 2:2:1 and 3:8:1 of N:P:K fertilizer compositions. Shading treatment was induced by applying 70% shading net. Drought treatment induced decrease in photosynthetic rate and carboxylation efficiency. Photosynthetic rate and apparent quantum yield were increased by shading treatment and also by high nutrient condition. The superior family, KW85, showed higher photosynthetic rate and apparent quantum yield than the inferior family. Chlorophyll fluorescence showed significant difference among family, fertilizer treatment, and shading and its interaction. There were significant differences between fertilization × shading in yield; fertilization, shading, family × fertilization, and fertilization × shading in ETR; and family, fertilization, and family × fertilization in NPQ. Shading and applying nutrient treatments affected physiological activity of *P. densiflora* and helped increase its tolerance to drought.

Biodiversity research for resource-rich mountainous landscapes: link to sustainable livelihood surrounding proposed mining in southern Philippines. Pampolina, N.M. (*University of the Philippines Los Baños, Philippines; nelmpampolina@yahoo.com*), Sebua, J.C. (*Sagittarius Mining Incorporated, Philippines; josesubaua@yahoo.com*), Estrada, E.S. (*Municipal Environment Officer, Philippines; eileenestrada@yahoo.com*), Freay, R.T. (*B'laan Tribal Chieftain, Philippines; renaldofrey@yahoo.com*).

Participatory biodiversity research within 20,000 hectares of mountainous southern Philippines was conducted (2004–2008) to investigate potential resources to sustain livelihoods of B'laan communities endangered by proposed mining operations. Leveling-off with stakeholders was initiated to approximate logistics for 10 transects (1–2 kilometers each) with 50 plots for trees (100 m^2), intermediate (9 m^2), undergrowth (1 m^2), and wildlife along 700–1,600 m elevation bisecting grassland, farm, secondary

growth, and primary forest. Quadrat sampling was used to assess plants and macrofungi; ocular and sweep methods for wildlife; and wet-sieving-decanting for endomycorrhizae. GIS methods and socio-economic surveys followed standard procedures. Biodiversity indices were analyzed using Estimate-S. Biodiversity was low in disturbed sites, moderate in forest (103 species of trees, 42 intermediate, 112 undergrowth, 50 epiphytes). Wildlife comprised 6 mammals, 5 amphibians, 6 reptiles, 35 birds, and numerous arthropods. Decomposers consisted of 77 macrofungi and several mycorrhizae. Overall, biodiversity resources are a potential source of propagules for rehabilitation, food, medicine, ecotourism, biofertilizers, bioenergy, and other services that can sustain community income if proposed mining is confined to degraded areas while managing a secured ecobelt as wildlife sanctuary. The whole ecosystem can sequester 500–800 tons carbon per hectare as a community CDM project.

'Chensa': a new dwarf variety of *Hibiscus syriacus* L. suitable for indoor growing. Park, H.S., Kwon, H.Y. (*Korea Forest Research Institute, Republic of Korea; parkh@forest.go.kr; kwonhy@forest.go.kr*).

The objective of this study was to develop a new variety ('Chensa') of *Hibiscus syriacus* L. by crossing 'Andong', which makes beautiful flowers, with 'Pyungkasan', which is used as a potted plant. Morphological characteristics of 'Chensa' were funnel shape in open type of corolla and simple flower type. The diameter of flower was 46.5 mm, which is very small compared with that of the mother tree, 'Andong'. The petal was folded and the diameter of eye zone was 12.6 mm. Leaf type is an oval shape, and the length and width of leaf were long (39.4 mm) and narrow (20.0 mm), respectively. Ratio of width of leaf to width of leaf shoulder (1.71) was similar to that of mother tree (1.67). Leaf thickness, glossiness level, and shape of the leaf base were medium, medium, and rounded, respectively. Quantity of bloom was medium under normal conditions, and changes in the numbers of flowers depending on seasons were small. In addition to being a short shrubby tree, it has very short internodes and compact branching. According to all these characteristics, the new variety 'Chensa' could be useful as a potted plant for growing indoors and as a small garden tree.

Cryopreservation of *Populus alba* × *P. glandulosa* seeds. Park, J.I. (*Chungbuk National University, Republic of Korea; jipark@chungbuk.ac.kr*).

The longevity of poplar seeds under natural conditions has been reported as from 2 weeks to months, varying with species, season, and local environmental conditions. The longevity of poplar seed is known to be much shorter than other species. To develop a long-term preservation method of poplar seed, the possibility of application of cryopreservation for these seeds was examined. Seeds collected from a tree were kept 1 hour, 10 days, and 30 days respectively at room temperature, 4 °C in a refrigerator, and −196 °C in liquid nitrogen respectively. The germination ability was detected at 25 °C on moistened filter paper in a petri dish in an incubator. When the seeds were kept at room temperature, the germinability dropped rapidly within 1 month to 25% and reached to 0% within 3 months. At 4 °C it decreased more slowly, much less than room temperature. Within 5 months the germinability decreased to 67%. However, when kept in liquid nitrogen, the germinability of seeds was maintained at over 94% during 5 months. This implies that cryopreservation could be used for long-term preservation of poplar seeds and that its seeds can be used more widely for various purposes.

Breeding of new kiwifruit cultivars: hybrids *Actinidia* × 'Matua' and 'Hayward' × *A. arguta*. Park, Y.K., Hwang, S.I. (*Korea Forest Research Institute, Republic of Korea; ykpark@forest.go.kr; hwangsi@forest.go.kr*), Lee, M.H. (*KFRI, Republic of Korea; mhlee99@forest.go.kr*).

To make new cultivars with the largest and highest yielding fruit and cold tolerance characteristics, we crossed *Actinidia arguta* with 'Matua', and 'Hayward' with *A. arguta*. The new hybrid cultivars ('Hayward' × *A. arguta*) were 'Dae-Myung', 'Hwang-Oak', and 'Ja-Wang'; and the other new hybrid cultivars (*A. arguta* × 'Matua') were 'SM 1-7' and 'SM 2-13'. *A. arguta*, called hardy kiwifruit, has an edible smooth skin and contains high amounts of vitamin C. *A. deliciosa* are known as kiwifruit and originated in Southwest China. The cultivar 'Hayward' occupies most of the world's kiwifruit cultivated surface and is the cultivar commercially produced in Korea. However, kiwifruit-producing areas are limited to warm climate regions, so it can be cultivated only in the southern parts of Korea. In our research, several hybrids have been developed to enhance cold tolerance by crossing 'Hayward' with domestic species. These new three varieties ('Dae-Myung', 'Hwang-Oak', and 'Ja-Wang') were selected from seeds obtained from the cross breeding. The weights of these fruits are 103.9 g, 70.6 g and 103.1 g, respectively. The fruit weight of 'Dea-Myung' was 11.24% higher than that of 'Hayward'. Since these varieties have cold tolerance characteristics, they can be planted in central and southern Korea.

Microscopic morphological features in evergreen plants of Jeju Island: an optical contrasting study. Pelc, R. (*Institute of Physiology/Academy of Sciences, Czech Republic; radek.pelc@seh.oxon.org*), Son, S.G., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; sonsak@foa.go.kr; daram@forest.go.kr*).

Jeju Island off the southern coast of the Korean Peninsula features 1,818 species of vascular plants, 46 of them endemic. Here we examined microscopic morphology of its evergreen plants, on leaf replicas in an acrylate-based transparent resin. A 'microscopic herbarium' thus formed includes structures such as rosette-like trichomes, ca 200 μm in diameter, that form a silvery (i.e., light-scattering) coat at the underside of leaves of glabrous eleagnus (*Eleagnus glabra* Thunb., Eleagnaceae). By embedding these non-absorbing (so-called phase) objects in refractive-index-calibrated fluids, their optical thickness could be controlled. This made it possible to use a range of complementary microscopic optical contrasting modalities such as relief contrast, Hoffman modulation contrast, Nomarski differential interference contrast (DIC), and phase contrast. As some of them (e.g., apodized phase contrast) are relatively new to microscopy, their thorough testing on naturally occurring microstructures featuring a wide range of optical thicknesses and spatial frequencies is essential, and may be useful for disseminating knowledge about plants of the fragile insular ecosystem of Hallasan National Park, a UNESCO Natural Heritage site.

Introduction of exotic tree species and provenance tests in Korea. Ryu, K.O. (*Korea Forest Research Institute, Republic of Korea; koryu95@forest.go.kr*), Choi, H.S. (*Korea Forest Research Institute, Republic of Korea; forgene@forest.go.kr*), Kim, I.S. (*Korea Forest Research Institute, Republic of Korea; kimis02@forest.go.kr*), Cho, D.H. (*Korea Forest Research Institute, Republic of Korea; cowandboy@nate.com*).

Adaptation tests of exotic species have been carried out for 415 tree species from 38 countries during the 1958 to 1995 in Korea. Because of the absence of advance information on exotic species and hasty introduction, 300 species were rejected at nursery stages because of differences of environments and climatic conditions. Ninety-two species were rejected for bad adaptation and poor growth compared to native species at young ages. Several species—*Populus euramericana* (I-214 and I-476 from Italy, V-211 from Belgium); *Alnus inokumai* (form Japan); *Pinus* species (*P. taeda*, *P. virginiana,* and *P. strobus* from USA)—were selected as economic tree species and have been planted on about 787,000 hectares in Korea. Recently, *Liriodendron tulipifera*, *Quercus palustris*, *Q. rubra*, and *Betula pendula* proved to have good adaptation and were expected to be promising in Korean environments; and 12 species have been tested continuously (*Picea abies*, *Prunus serotina,* etc.). Future plans for exotic species breeding in Korea are to select the superior provenances by species and to make and expand seed production stands of economic species. Introduction of new species and adaptation tests will be carried out for securing species resources and responding to climatic changes.

Effective clone number and cone production in a clonal seed orchard of Anatolian black pine (*Pinus nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe) in Kastamonu, Turkey. Sivacioğlu, A. (*Kastamonu University, Turkey; ahmets1973@gmail.com*), Öner, N. (*Çankırı Karatekin University, Turkey; nurioner@gmail.com*), Şevik, H. (*Kastamonu University, Turkey; hakansevik@yahoo.com*).

In this study the effective number of clones (*Nc*) was estimated for an Anatolian black pine clonal seed orchard in Turkey, for 2008, based on the variation of the ramet numbers among the clones. Also, the cone numbers of the all ramets were investigated. The orchard was established at Hanönü (Kastamonu) Turkey in 1993 by using 2,039 grafts of 30 clones. The effective number of clones (*Nc*) in the seed orchard was estimated using the coefficient of variation (*CV %*) for the number of ramets representing all clones in the orchard. The *Nc* value is calculated as $Nc = N/(CV^2+1)$.To compare the census number (*N*) and the effective number (*Nc*) of clones in the seed orchards, their relationship, $Nr = Nc/N$ was used. The mean effective clone number was 27.9. Thus, the census number of clones in a seed orchard is generally rather informative, but the effective clone number is more informative. The use of effective clone number may be more important in future seed orchards and genetically thinned seed orchards. In 2008, 170,000 cones were produced in total in the orchard. The contribution of the clones to cone production varied 0.83–5.46%.

Wanagama forest's biodiversity: plant species in the uncultivated area. Syahbudin, A. (*Ehime University, Japan; syahbudin_atus@yahoo.com*), Adriyanti, D.T. (*Universitas Gadjah Mada, Indonesia; dwityaningsih@yahoo.com*), Wiyono (*Universitas Gadjah Mada, Indonesia; wiyono@ugm.ac.id*), Osozawa, K., Ninomiya, I. (*Ehime University, Japan; ososago5503@agr.ehime-u.ac.jp; mack@dpc.ehime-u.ac.jp*).

Wanagama Forest, located in Yogyakarta Province, Indonesia, was cleared in 1926. It was then rehabilitated with teak (*Tectona grandis*) in 1927 and 1948, but these trees have not been successful yet. In 1960 and 1964, Universitas Gadjah Mada (UGM) started to cultivate mulberry (*Morus alba*) in 10 hectares, as well as fast-growing and fast-harvesting species. Terracing was used and season also calculated. In 1967, rehabilitation continued with tree species within 79.9 hectares and became 599.9 hectares in 1983. Recently, uncultivated areas of Wanagama forest still exist and are interesting for exploring because of limited data. A study was conducted between June and November 2008 to investigate the plant composition in this uncultivated area. Nine plots of 5 m × 40 m were randomly made. All vegetation in the plots was counted, sampled, documented, and then identified in UGM. There were 83 species and 35 families recorded. *Cyperus rotundus* is the most dominant species. Cyperaceae is the most dominant family, followed respectively by Fabaceae and Poaceae. Fabaceae has big potential for rehabilitation to hasten succession in Wanagama forest.

Production of F_1 interspecific hybrids of eucalypts: paving the way for sustainable yield. Velmi, P. (*Forest Research Institute, Dehradun, India; parveen_velmi@yahoo.co.in*).

At 7 years age, superiority of F_1 hybrids of *E. torelliana* × *E. citriodora* was estimated over the parents [*E. citriodora* (178.15%) and *E. torelliana* (65.88%)] and mid-parent (106.24%) for productivity. Keeping this in view, a breeding arboretum of eucalypts was established in open-pollinated mating design for production of inter and intra-specific hybrids. The species of same sub-genus were planted side by side at 3-m × 3-m spacing to create more chances of natural crossing and to make it easy for controlled crossing. *E. pellita* is frost resistant and moderately resistant to stem cankers *Cryphonectria cubensis* and has fast growth. *E. urophylla* has higher productivity and adaptability but is susceptible to *C. cubensis*. Both the species are used for pulp and paper, and infestation of gall insect has not been reported so far. The reproductive biology of these species has been studied for controlled hybridization. F_1 hybrids of *E. pellita x E. urophylla* have been produced and planted in the field. A high degree of heterosis is reported from the nursery stage itself for height and collar diameter. Success also was achieved for macro-propagation through rooting of cuttings for mass clonal multiplication.

Development of the containerized seedlings planting machine. Yamada, T., Endo, T., Sasaki, S. (*Forestry and Forest Products Research Institute Hokkaido Research Center, Japan; kenchan@ffpri.affrc.go.jp; shozos@affrc.go.jp*).

Recently non-forested lands after logging have increased in Japan because of economic factors, such that sustainable forest management will be prevented. It is expected that reduction of early silvicultural costs leads to an increase of reforestation area. We tried to mechanize plantation as a method to improve silvicultural operations. We developed a prototype for a containerized seedlings planting machine as the attachment for a mini-excavator. It consists of two hydraulic augers, a hydraulic planting tube, and a pneumatic seedlings supply system. Scarification by augers is expected to reduce weeding operation after planting by prevention of reproduction of weeds. All planting processes are automated by the programmable logic controller. All the operator has to do is boom operation, seedlings supply, and turning on the start switch. However, although planting was done successfully and weeds have not been able to reproduce around planted seedlings, examination of the planting machine showed need for some improvement. Thus we developed a new planting machine, which cancels the defects of the prototype machine. While the improved machine has the same fundamental construction as the prototype machine, a larger excavator was selected as the prime mover and a turret container was mounted for the seedlings supply system.

Theme C: Forest Environmental Services

C-01 Stand structure: a key issue in managing forests for timber, wildlife, water, and NTFP resources

Organizers: Valerie LeMay *University of British Columbia, Canada, Valerie.LeMay@ubc.ca*;
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Spatial patterns in untouched beech (*Fagus orientalis* Lipsky)-dominated stands within forest development stages in the Caspian region of Iran. Akhavan, R., Sagheb-Talebi, K. (*Research Institute of Forests and Rangelands, Iran, akhavan@rifr-ac.ir; saghebtalebi@rifr-ac.ir*).

To understand many problems in woodland ecology and management, detailed spatial tree data are a necessary perquisite. Furthermore, determination of tree spatial patterns in each stage would show the dynamics of stands over time and can provide valuable information on the underlying processes, especially in the case of uneven-aged forests. For this purpose, three 1-hectare (100 m × 100 m) plots were closely selected at three development stages (initial, optimal, and decay) in an untouched, unmanaged, and uneven-aged beech (*Fagus orientalis* Lipsky)-dominated forest in the middel of the Caspian region of Iran. Diameter of all trees with dbh greater than 7.5 cm, together with their coordinates, using the azimuth-distance method, were recorded and fully mapped. Spatial point pattern analyses by Riply's L function showed that while the number of stems decreases from initial stage toward decay stage, the spatial patterns of trees in initial, optimal, and decay stages are highly aggregated, random, and slightly aggregated, respectively. It is believed that for any insight into natural processes, forest managers need to gather such an information from untouched stands as a key reference for any close-to-nature activity in under-managed forests and for sustainable management of forest ecosystems, as well.

Stand structure versus carbon fixation under different management systems. Barbeito, I., Serrano, F., Montes, F. (*CIFOR-INIA, Spain; barbeito@inia.es; serrano.fernando@inia.es; fmontes@inia.es*), Gea, G. (*Swiss Federal Research Institute WSL, Switzerland; guigeiz@gmail.com*), Bachiller, A., Cañellas, I. (*CIFOR-INIA, Spain; bachille@inia.es; canellas@inia.es*).

Society is becoming more aware of the role that forests can play as carbon sinks in mitigating the effects of climatic change. The likelihood of conflicts among resource managers, particularly in regards to managing forests for carbon fixation versus managing forests for biodiversity conservation, are increasingly probable. The objective of this study was to compare group shelterwood and uniform shelterwood systems in the management of Scots pine (*Pinus sylvestris* L.) within the Central Mountain Range of Spain, in terms of growing stock increment and structural diversity. This location is close to the southernmost distribution of this species and thus constitutes an ecosystem particularly sensitive to the effects of climate change. Based on a chronosequence approach and using periodic remeasurement sample plot data from stands managed under each system, tree growth patterns and stand structural changes were analyzed over time. Although the results indicated that the growing stock increment was similar under both management systems, the average carbon stock increased with rotation length. The group shelterwood system enhanced the performance of natural regeneration and increased structural heterogeneity. Overall the results suggested that the dual objectives of biodiversity conservation and carbon storage are compatible when managing Scots pine.

The community structure of *Pinus densiflora* forest in the preservation area around the Wangpicheon basin of South Korea. Byun, J. (*Kyungpook National University, Republic of Korea; kajo1125@nate.com*), Jung, S. (*Korea Forest Research Institute, Republic of Korea; scjung20@msn.com*), Joo, S. (*Kyungpook National University, Republic of Korea; shjoo@knu.ac.kr*), Koo, K., Sou, H. (*Korea Research Institute, Republic of Korea; kyosang@forest.go.kr; hongducksou@hotmail.com*), Hur, T. (*Kyungpook National University, Republic of Korea; htaechul@hanmail.net*).

The preservation area around the Wangpicheon basin in South Korea has been largely retained in its natural state by minimizing human interventions. The area is highly valued for its ecological significance throughout society. The purpose of this study was to provide prerequisite information in terms of community structure and species diversity for the conservation and management of the *Pinus densiflora* forests within the area. Analytically, cluster analysis was applied to 23 dominant species within the tree, sub-tree, and shrub layers within 73 sample plots, from which 7 community associations were delineated. Species diversity indices were subsequently used to determine the degree of variability among the main tree species and to infer interspecific competitive relationships. The results suggested that *P. densiflora* was able to compete successfully among the main competitors, *Quercus mongolica* and *Q. variabilis*, within the studied communities.

Long-term changes in rainfall runoff response with afforestation in a coniferous forest catchment. Choi, H.T., Jeong, Y.H., Ahn, Y.S., Kim, K.H. (*Korea Forest Research Institute, Republic of Korea; choih@forest.go.kr; green@forest.go.kr; ysahn@forest.go.kr; kkyha@forest.go.kr*).

Afforested areas constitute more than 30% of all forest land of Korea. Since significant changes in land cover may affect the water cycle of a watershed, it is expect that newly afforested areas undergo significant changes in the water cycle as these new forests develop. For our analysis, about 30 years of rainfall-runoff data observed in the paired forest catchments near Seoul, i.e. one a planted coniferous forest catchment (GCFC) (planted in 1976) and the other a natural deciduous forest catchment (GDFC) (over 80 years old). GDFC was used as a reference to make a baseline to assess the effects of forest growing on the rainfall runoff responses in the coniferous catchment. Our results show that the average annual runoff rate of the GCFC during the last decade (forest age class 3) is 54%, and this rate is 11% higher than during the previous decade. However, during same periods, there were no significant changes in the annual runoff rates of the GDFC. The coefficients of hydrograph regression curve was reduced in value by more than 30% by forest growing in the GCFC, which reflect increasing of low streamflow levels during the dry season.

Dendrometrical structure of one fragment of the semi-deciduous seasonal forest in Brazil. Imaña, E.J. (*University of Brasilia, Brazil; jose.imana@gmail.com*).

A 10-ha semi-deciduous seasonal forest fragment (15°45′54″ S and 49°04′03″ W) found in the bioregion of the Savannah EcoMuseum localized in Goiás, Brazil, was studied. For the phytosociological survey, 10 sample plots of 20 × 20 m were systematically located. All living trees of 5 cm DBH and above were measured within the plot boundaries. There were 742 individuals belonging to 83 species, 67 genera, and 38 families. The richest families in terms of the number of species were Fabaceae, Rubiaceae, Myrtaceae, Apocynaceae, and Chrysobalanaceae, which contributed 48% of total species. The species with the highest importance value indices were *Tapirira guianensis* Aubl., *Protium heptaphyllum* (Aubl.) March, *Callisthene major* Mart., *Amaioua guianensis* Aubl., and *Anadenanthera macrocarpa* (Benth.) Brenan. The Shannon diversity index was 3.80 nats/individual and the Pielou equality index was 0.86. For the total population and for 25 species, 549 sampled trees had DBH values lower than 30cm. This indicates that this forest has a high potential for natural succession. Two DBH distributions were observed: the typical reversed "J", described frequently in the literature, and a nearly Gaussian distribution.

Effects of cutting intensity on regeneration of natural spruce-fir conifer and broadleaved mixed forest in Changbai Mountain. Kang, X.G., Gong, Z.W., Zhang, Q. (*Beijing Forestry University, China; xingangk@163.com; gozewe@126.com; zhangq@bjfu.edu.cn*).

For natural forests, the quantity, quality, and structure of forest regeneration varies with the cutting intensity and with the spatial pattern of the harvested trees. This study was carried out in mixed spruce-fir conifer and broadleaved forest on Changbai Mountain, Jingouling Forest Farm, in northeast China. In the 36.5 hectare forest area, a 3.4-km × 20-m sample strip was established. In this strip, there were 76 sampled forest gaps, which were classified into 10 types according the gap size. The numbers of regenerated seedlings were measured in each gap and also under forest canopies (i.e., as understory trees). This survey showed that the number of regenerated seedings was highest for forest gaps of 20 to 40 m^2, and lowest for gaps larger than 300 m^2. More regeneration occurred in forest gaps than under a forest canopy. Also, for fir (*Abies nephrolepis* Maxim) seedings less than 20 years old, diameter and height growth in forest gaps was faster than under forest canopies. However, there were no significant differences in diameter and height growth in forest gaps versus under forest canopies for spruce (*Picea koraiensis* Nakai) and Korean pine (*Pinus koraiensis* Sieb.et Zucc).

Forest bark structure: an indicator of forest biodiversity and health. MacFarlane, D.W. (*Michigan State University, USA.; macfar24@msu.edu*), Luo, A. (*Xishuangbanan National Nature Reserve Management Bureau, China; roger_aidong@yahoo.com.cn.*

A number of case studies have examined the important contribution of tree bark structure to the success and diversity of bark-using organisms, but methods to quantify bark structure as a component of total forest structure are lacking. Tree bark structure has also been linked to tree vigor; thus, metrics defining forest bark structure should also help to quantify forest health and inform forest ecosystem management practices. A new metric, a bark fissure index (BFI), was developed and applied to hardwood tree populations, comprising15 different tree species common to northeastern North American forests, to examine allometric relationships among tree size, species, and bark structure. A study of the behavior of *Sitta carolinensis,* a bark-using bird species, revealed a strong correlation between BFI and bird tree-species preference. Both models and data from several sources were applied to examine species contributions to forest bark structure, revealing that species contribute unequally and predictably to forest bark structure. Variations in bark structure not explained by species composition and forest size structure are most likely explained by differences in stand age and vigor.

Stand structure classification to facilitate modelling and mapping of forest succession. Moss, I. (*Tesera Systems Inc., Canada; forestree@shaw.ca*).

A new clustering algorithm was developed to separate stands into structure classes. The clustering method maximally differentiates stands using a new measure of similarity based on empirical cumulative diameter distributions. The overall goal was to develop a high-level standardized system of classification to facilitate more consistent, precise, reliable, and verifiable communications across disciplines. This system was also designed to connect tree, stand, and forest-level dynamics. The resulting stand structure classes can be used for a number of applications, such as growth modelling, habitat assessment, and relating stand structure to fuel loading and non-timber forest products (NTFPs). In this paper, the use of the stand structure classification system to characterize stand succession over time and to summarize the extent of each class over a landscape is discussed. The clustering algorithm was applied to 421 plots established in a wide variety of stand conditions in the central interior of British Columbia, Canada, resulting in a 17-class stand structure classification system. The change in stand structure classes over time was also studied within the context of delineating forest succession pathways.

Diversity of non-timber products of the Sal (*Shorea robusta* C.F. Gaertn) forests of Bangladesh. Rahman, M. (*Office of the Deputy Commissioner, Bangladesh; mizan_peroj@yahoo.com*), Vacik, H. (*University of Natural Resources and Applied Life Sciences, Austria; harald.vacik@boku.ac.at*).

Non-timber forest products (NTFPs) encompass all biological materials other than timber. NTFPs have attracted considerable global interest because of their increasing role in improving rural livelihoods. NTFPs of sal (*Shorea robusta* C.F. Gaertn) forests are important to rural people in terms of foods, medicines, fodder, and domestic requirements in the central part of Bangladesh. Species composition, richness, and diversity of NTFPs—including mushrooms, herbs, climbers, and shrubsx—were compared between unmanaged (natural, mixed tree species) and successional (pure species, regenerated naturally after clear cutting) stands of Madhupur sal forests. The main results were: (i) unmanaged stands showed higher species richness than successional stands; (ii) species richness of edible and medicinal plants increased with decreased canopy closure in unmanaged stands; (iii) species richness and abundances of medicinal and edible climbers were higher in mixed species stands compared to the pure sal stands; and (iv) species richness and abundance of mushrooms increased with increasing sal tree age. Based on the study, a sustainable management approach that protects the floral diversity of the ecosystem over the long run is recommended. Also, understanding and incorporating local knowledge about conservation of forest resources is essential to sustainable forest management.

Competing land uses challenging "The Swedish Forestry Model." Sandström, C., Lindkvist, A. (*Umeå University, Sweden; camilla.sandstrom@pol.umu.se; anna.lindkvist@histstud.umu.se*).

Conflicts over natural resources have always played a significant role in societies worldwide. The increasing demand for food, fuel, and fibre has, however, led to a boost in their strength and complexity. The Swedish forest sector is not an exception to this situation. The focus on timber has been the most apparent contribution of the Swedish's forests to national interests. However because of competing land uses and a changing climate, the identification of the wider role of forests as a provider of ecosystem services has been recognised. The increasing competition over Swedish forests is however not only causing conflicts but is in fact challenging the "Swedish forestry model" allowing parallel land use across sectors. With more intensively used forests, the underlying principles of parallel land use are, however, undermined, potentially dividing the landscape into either production or protection units. In this paper we examine the range of demands competing for Sweden's forests, and how this may affect the future of the Swedish forest and the Swedish forest model. The paper concludes by discussing three future alternatives with different implications for different sectoral interests but also on future governance regimes in relation to the Swedish forestry model.

How attractive are timber production forests for nature-based tourism in Finland? Tyrväinen, L. (*Finnish Forest Research Institute/METLA, liisa.tyrvainen@metla.fi*).

Forestry as a large industry has significant impacts on the quality of tourism landscapes in boreal forests. In Finland, the rapid growth of nature-based tourism has expanded outdoor recreation activities from protected areas also into timber production forests. Today, research information on how foreign tourists assess environmental quality of timber production forests in northern Europe is limited. Moreover, environmental expectations for different nature tourism activities may vary among the clientele. This presentation describes key results of a large survey of foreign visitors' travel motives, attitudes towards forestry, and opinions of impacts of different forest managements practises on landscapes from 28 colour photographs representing different forest landscapes in summer and in winter. The data consisted of about 800 interviews conducted in Lapland, Finland, during winter 2007–2008. Results show that, in general, foreign visitors have less strict environmental requirements for forest recreation than Finns have. Moreover, forest management practices have significantly different impacts on the quality of the recreation environment during summer and winter seasons. The presentation discusses what type of adaptations are needed in traditional forest management practises in tourism development areas, and how payment schemes for environmental services (PES) could help integrate timber production and nature-based tourism.

Effects of fertilization and stand structure on new culm production of *Dendrocalamopsis vario-striata* stand. Zhou, B., Cao, Y., Wang, X., Li, Z., An, Y., Kong, W. (*Research Institute of Subtropical Forestry, China; boozex@gmail.com; fjcyh77@sina.com; rsfyrs@126.com; lizccaf@126.com; anyanfei_1@163.com; yilucanlan@yahoo.com.cn*), Wen, K. (*Pingyang Forestry Bureau, China; pywch@126.com*), Wang, G. (*Research Institute of Subtropical Forestry, China; realinter0000@126.com*).

Stand productivity is closely related to stand structure and soil management. In order to develop effective strategies for managing stands of *Dendrocalamopsis vario-striata*, a widely used bamboo timber in south China, the effect of fertilization and stand structure on new culm production (NCP) was studied. An orthogonally designed experiment was applied to 18 plots in Zhejiang, China, with three factors (stand density, culm age composition, and fertilization plan), each with three levels and two replications. The ANOVA analysis indicated that the dry weight of NCP was affected by these factors in accordance with a general linear model ($R^2 = 0.725$, $p = 0.012$). The effect of the fertilization plan on NCP was statistically significant, but those of the stand density and the culm age composition were not. Based on the comparison of NCP between different levels of the three factors, we concluded that an optimal management strategy includes a stand density of about 6,425 culm/ha; a culm age composition of 50% for 1-year-old, 30% for 2-year-old, and 20% for 3-year-old or older; and application of NPK compound fertilizer at mid-May and late July each year, each time with 500g/clump.

Posters

Seasonal change in acorn nutrient composition of six oak species in Korea. Hong, Y.S., You, Y.H. (*Kongju National University, Republic of Korea; hongfin@kongju.ac.kr*; *youeco21@kongju.ac.kr*).

Native oak tree species dominate the deciduous forests of South Korea. Although the acorns of these oak trees represent the main food source for many wildlife species, information pertaining to their nutrient composition and associated seasonal changes is limited. Thus the objective of this study was to describe the seasonal changes in the acorn nutrient composition in terms of nitrogen (N), phosphorus (P), calcium (Ca), magnesium (Mg), and sodium (Na) concentrations of six oak species, *Quercus acutissima, Q. aliena, Q. mongolica, Q. variabilis, Q. dentata,* and *Q. serrata*. Results indicated that N concentrations of *Q. dentata* acorns were lowest in the spring and fall whereas those of *Q. mongoilca* were highest in the spring and summer. P concentrations tended to decline in the summer, with *Q. serrata* and *Q. variabilis* exhibiting the highest and lowest rates of decline, respectively. Ca and Mg concentrations showed an obvious tend of decline over the seasons for all species except *Q. mongolica*. Overall, these results indicated that acorn nutrient composition varies by season and that the nature of the variability is largely species-dependent.

An index for evaluating mean annual runoff, affected by the vegetation cover in forest watersheds. Hosoda, I. (*Forestry and Forest Research Institute, Japan; hosodaik@affrc.go.jp*).

While forests play an important role in the conservation of water resources, they also consume water. The amount of water consumed is known to depend on stand age, but measuring consumption is difficult. In this paper, I used additional evapotranspiration (E_{add}) as an index to evaluate the influence of forests on runoff. E_{add} is the difference in the annual evapotranspiration calculated on the basis of the water balance method compared to using the climatic method. For approximately the past 70 years, the E_{add} values for the small forest watersheds located in the Seto Inland Sea climatic zone in Japan have ranged from 0% to 30% of the annual precipitation, depending on the vegetation cover. Mean stem volume for a watershed calculated using a digital

model of canopy height was found to be correlated to $E_{add.}$ Using the relationship between E_{add} and mean stem volume, it is possible to roughly estimate the mean annual runoff. E_{add} is a simple index for explicitly evaluating the influence of forests on runoff and will probably be useful for planning the arrangement and treatment of forest watersheds.

An experimental investigation on the root systems of *Larix kaempferi* and *Pinus koraiensis*. Kim, D.Y., Im, S.J., Lee, S.H., Hong, Y.J. (*Seoul National University, Republic of Korea; hendrix7@snu.ac.kr; junie@snu.ac.kr; shleeguy@snu.ac.kr; wow8803@naver.com*).

In Korea, damages by landslide have increased during recent decades. Vegetation has known to improve slope stability as root reinforcement on soils; in general, tree root distribution is significantly related with soil reinforcement. The objective of the study is to experimentally investigate spatial patterns of root system, and to evaluate effects of roots on hillslope stability. Two tree species, larch (*Larix kaempferi* (Lamb.) Carrière) and Korean pine (*Pinus koraiensis* Siebold et Zucc), were selected to find the root distribution, using the trench profile wall method. A total of 15 soil profile walls (1 m × 1 m) for larch and 13 walls for Korean pines were trenched. An image processing approach and spatial statistical analysis were used to analyze root distribution patterns of each species. The perpendicular root reinforcement model was also used to quantitatively evaluate the mechanical resistance of root system. Results show that the number of roots and root ratio area of Korean pine were greater than those of larch in different soil conditions. In addition, it was found that the presence of roots tended to decrease by depth and distance away from trees, and roots were not randomly distributed in spatial, but clumped.

Assessing root reinforcements on soils by *Larix kaempferi* and *Pinus koraiensis* using two different root reinforcement models. Kim, D.Y., Im, S.J., Lee, S.H., Hong, Y.J. (*Seoul National University, Republic of Korea; hendrix7@snu.ac.kr; junie@snu.ac.kr; shleeguy@snu.ac.kr; wow8803@naver.com*).

Tree roots are known to play a significant role in soil mechanical reinforcement. This study was carried out to estimate soil reinforcements by the roots of larch (*Larix kaempferi* (Lamb.) Carrière) and Korean pine (*Pinus koraiensis* Siebold et Zucc) using two different root reinforcement models, the perpendicular root reinforcement model (Wu model) and the fiber bundle model (FBM). As input data, root area ratio (RAR) and root tensile strength for each species were directly measured in the Taewha Experimental Forest, Seoul National University, Korea. As a result, soil reinforcements estimated by the Wu model ranged from 3.9 kPa to 28.2 kPa for larch, and 13.5 to 35.4 kPa, respectively; while soil reinforcements estimated by the FBM ranged from 1.9 kPa to 17.2 kPa for larch, and 7.0 kPa to 20.7 kPa for Korean pine, respectively. The overall result shows the Wu model seems to over-estimate soil reinforcement, but FBM model estimates soil-root resistance well. However, the Wu model is easy to apply in practical uses. Therefore, the value '0.57' can be used as a reduction factor of the Wu model for trees, which is derived from the relationship between the estimates by each model.

The decline of structure and function of *Tricholoma matsutake* soil colonies related to pine forest vegetation change. Koo, C.D., Kim, J.S. (*Chungbuk National University, Republic of Korea; koocdm@chungbuk.ac.kr; kimjesu@chungbuk.ac.kr*), Ka, K.H. (*Korea Forest Research Institute, Republic of Korea; kasymbio@forest.go.kr*).

Successful *Tricholoma matsutake* (*Tm*) fruiting depends on the characteristics of the fungal colony, the availability of pine trees, and the physical environment. Structural changes of a *Tm* forest ecosystem can change *Tm* production. We investigated structure and function of *Tm* colonies in Songni Mountain National Park, central Korea. The LAI of the *Tm* forest was ca 2.0 and major species were *Pinus densiflora*, *Rhododendron* spp, *Quercus mongolica,* and *Fraxinus sieboldiana*. Tree photosynthesis and transpiration ceased at the beginning of autumn, except for *Q. mongolica,* which continued until October. *Tm* colonies were partly circular, ca 8 m in diameter, grew outwards 12 cm/yr, and were ca 35 years old. No new *Tm* colony was noted. Soil moisture of *Tm* colonies was 0.5 to 4.0% lower and temperatures during September were ca 0.2 to 0.4 °C higher than areas outside colonies. Ergosterol content related to live hyphal membrane biomass was ca 5 μg/g soil at the colony front, versus ca 1 μg/g soil 20 cm back, indicating that *Tm* colonies utilized resources from the current year. Cutting competing trees such as oak did not increase pine root growth, suggesting that inappropriate vegetation control will result in fragmentation and decline of *Tm* colonies.

Spatial characteristics of gathering edible wild plants in snowy villages of northeastern Japan. Matsuura, T., Sugimura, K., Tanaka, N., Miyamoto, A., Tanaka H., Katsuki T., Taki, H., Hirata Y. (*Forestry and Forest Products Research Institute, Japan; matsuu50@affrc.go.jp; kensugi@affrc.go.jp; tanaka_hanere@ybb.ne.jp; asakom@affrc.go.jp; hirop@affrc.go.jp; katsuki@affrc.go.jp; htaki@affrc.go.jp; hirat09@affrc.go.jp*).

This study analyzed the spatial characteristics of gathers of edible wild plants in two snowy villages within the Fukushima prefecture, in northeastern Japan. The gathering activities of 13 dwellers, who were experts in collecting edible wild plants, were tracked using small GPS devices over a 3-month period (May to July 2009). The species and weight of the gathered plants (consisting of 14 edible wild plant species), as well as the total gathering time per work day, was recorded for each collector. The resultant spatial patterns were analyzed by multivariate statistics using vegetation type, terrain features, and accessibility from roadways, as explanatory variables. Results indicated that the primary gathering areas were concentrated within riparian forests, grasslands, shrub vegetation, and snow-avalanche areas where heavy snowy conditions prevented tree establishment. Some of the gathering areas were also concentrated within secondary grasslands and shrub vegetation clusters, young cedar plantations, and along roadways. The gathering areas were generally located less than 2 kilometers from roadways. These results reveal the importance of stand structure and road accessibility in the selection of gathering sites for the collection of edible wild plants within the study area.

Recovery of amount of leaves in heavily thinned hinoki cypress (*Chamaecyparis obtusa*) stands in southwestern Japan. Miyamoto, K., Okuda, S., Noguchi, M., Itou, T., Kodani, E. (*FFPRI, Japan; mkazuki@affrc.go.jp; okuchan@affrc.go.jp; mahoko@affrc.go.jp; takeharu@affrc.go.jp; kodani@affrc.go.jp*).

The objective of this study was to assess the suitability of heavy thinning (40–50% reduction in number of trees) for effective forest management in hinoki cypress plantations in Japan, focusing on recovery of leaf amount of remaining trees. A field survey

was conducted in hinoki cypress (*Chamaecyparis obtusa*) stands in southwestern Japan with different thinning treatments (30–50% thinned and un-thinned stands) and different times after thinning (1 and 6 years). One year after thinning, the stand maximum leaf area index (LAI) significantly decreased with increasing thinning intensity. Six years after thinning, the maximum LAI showed little difference among the thinned stands, although the unthinned stands still showed higher LAI values. Annual increase in LAI, an indicator of annual leaf production, versus annual leaf litterfall in the thinned stands 6 years after thinning followed the same trend as unthinned stands. In contrast, the annual increase in LAI was higher at the same leaf litterfall level in the stands 1 year after thinning. These results suggest that heavily thinned hinoki cypress stands can recover foliage equivalent to lighter thinning levels by 6 years after thinning. However, the effects of heavy thinning may depend on several factors such as altitude and tree density.

Services of forest on soil fertility. Qazi, N. (*Forest Research Institute, India; nuzhat_crystal@rediffmail.com*).

Forest services related to soil fertility are very important for the nutrient cycle. Two micro-watersheds were selected, one with dense and other with degraded oak forest. Quadrate systems were used for vegetation study. Average diameter at breast height at dense oak micro-watershed was 30.57 cm (standard deviation ± 8.22) and at degraded oak micro-watershed was 15.46 cm (standard deviation ± 6.6389). Tree density in dense forest was 487 trees/ha (standard deviation ± 209.9887) and in degraded forest was 380 trees /ha (standard deviation ± 193). Soil samples were collected from predetermined depths for soil fertility status. In dense oak forest, soil pH, organic carbon, nitrogen, phosphorus, and potassium levels were: 6.26–6.57, 1.54–3.31%, 0.0107–0.0231%, 0.0020–0.0024%, and 0.0031–0.0155%, respectively; and in degraded oak forests it was 7.31–7.57, 0.81–2.37%, 0.0080–0.0160%, 0.0016–0.0022%, and 0.0027–0.0087%, respectively. Porosity under dense and degraded forests was 45.03%–54.23% and 43.10–48.57%, respectively. Silt and clay fraction ranged from 12.67 to 14.67% and 17.83 to 20.51% respectively under dense forests, while under degraded forests it ranged from 11.00 to 14.33% and 14.40 to 17.05% respectively. Hence services of forests are beneficial to soils.

Structure of the ecosystems of La Candela Mountain Tepehuanes Durango, México. Solís, M.R. (*Universidad Juárez del Estado de Durango, México; rsolis@ujed.mx*), Aguirre, C.O. (*Universidad Autónoma de Nuevo León, México; oaguirre1@prodigy.net.mx*), Treviño, G.E.J. (*Universidad, México; ejtrevin@fcf.uanl.mx*), Corral, R.J. (*Universidad, México; jjcorral75@hotmail.com*), Pompa, G.M. (*Universidad, México; marin_pompa_garcia@hotmail.com*).

The objectives of this study were to: (1) develop a system for classifying different types of vegetation associations in the Sierra de la Candela mountain range of México utilizing Landsat ETM and MSS satellite images, and local cartography information; and (2) evaluate the effects of two silvicultural practices, thinning and selective harvesting, on stand composition and vegetation structure. Although the classification exercise initially identified 13 associations, the final set consisted of 5 key vegetative associations. Based on the analysis of two experimental plots (one established in each of the silviculture treatments), in which several neighborhood-based structural diversity indices were used, tree species mixture and diversity were greater in the selective cut than in the thinning treatments. However, both plots had a spatially clumped tree distribution, and there was no significant difference with respect to size differentiation between the treatments.

Selection of desirable species and estimation of composition ratio in a natural deciduous forest, Korea. Yang, H.M. (*Korea Forest Research Institute, Republic of Korea; ycology@forest.go.kr*), Kang, S.K. (*Forest Human Resources Development Institute, Republic of Korea; tree@forest.go.kr*), Jung, S.H. (*Kangwon National University, Republic of Korea; chsh@kangwon.ac.kr*), Kim, J.H. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr*).

Based on community structural attributes, this study recommended desirable species and species composition to maintain forest stability and improve timber values of a natural deciduous forest in South Korea. We established 138 plots along topographical positions and slopes in Mt. Gari area, and surveyed species composition, diameter, and height distribution and species diversity. We suggested that the desirable species and species composition could be based on indicators such as dominant species, potential dominant species, forest stability level, and dominance potentiality of major species in natural deciduous forest. According to these indicators, 9 of 25 tree species growing in the study forest were selected as desirable species through evaluation of dominant and potential dominant species. Based on the estimation of species diversity index for the overstory components, the reasonable forest stability levels of the index were estimated at 1.96. The recommended species composition ratios were: *Quercus mongolica,* 30%; *Acer pictum* subsp. *mono*, *Fraxinus rhynchophylla*, *Q. serrata*, and *Tilia septemlobus,* 10–15%; *Juglans mandshurica* var. *mandshuria for. mandshurica*, *Pinus densiflora*, and *Cornus controversa*, 5–10%; and *Kalopanax septemlobus,* 5%.

Regeneration process of riparian forest after large debris flow on Sado Island in Japan. Yuka, K. (*Niigata University, Japan; a06c312k@mail.cc.niigata-u.ac.jp*), Sakio, H (*Niigata University, Japan; sakio@agr.niigata-u.ac.jp*).

Natural disturbance is a key factor for enabling species to coexist, particularly in the riparian forests of Japan, where disturbances occur frequently and vary widely in terms of their magnitude and size. Although some species have adapted their reproductive strategy to reproduce successfully and survive following disturbance, the actual recovery processes have not yet been fully described. In this study, we analyzed forest structure and soil conditions in a riparian forest that had recovered following a debris flow on Sado Island. Results indicated that larger gaps were dominated by *Alnus hirsuta*, S*alix sachalinensis*, *Pterocarya rhoifolia*, *Cercidiphyllum japonicum*, whereas smaller gaps where light levels were low were dominated by *P. rhoifolia* and *C. japonicum*. Establishment patterns also varied by soil conditions: *P. rhoifolia* and *C. japonicum* tended to regenerate on coarse-texture soils, whereas *A. hirsuta* and *S. sachalinensis* tended to regenerate on fine-texture soils. Results from tree-ring analyses indicated that *A. hirsuta* and *S. sachalinensis* re-established immediately following disturbance, whereas *P. rhoifolia* and *C. japonicum* exhibited a delayed pattern of re-establishment. These results suggest that the coexistence of these riparian species following disturbance is dependent on niche partitioning and species-specific regeneration strategies.

C-02 Integrating forest products with environmental services

Organizer: Robert Deal, U.S. Forest Service, USA, rdeal@fs.fed.us.

The distribution of benefits from carbon-forestry with regard to community forest management in Nepal. Basnet Parasai, R. (*University of Twente, Nepal; rupa@mos.com.np*).

Forests are a source of food, fuel, and shelter for forest-dependent people, and are crucial in delivering manifold benefits such as biodiversity conservation, carbon sequestration, and local knowledge passed down for generations. Yet people are marginalized when it comes to decision-making with regard to forest management, and national law in Nepal does not recognise their community-based property rights (CBPRs). For sustainable forest management to maintain healthy and productive forests, recognition of CBPRs is crucial, and can ensure the survival of local knowledge and community culture. Recognition of CBPRs is important for equitable distribution of benefits and environmental justice. This paper reviews the historical antecedents and contemporary framework of national laws and policies affecting forests and forest-dependents, with a focus on distribution and benefit-sharing. This paper also addresses the question: Who will benefit from carbon-trading from community forest management under certain proposed policies if carbon-forestry is considered an environmental service?

Comparing and contrasting the role of ecosystem services in forests of developing, emerging, and developed countries. Gulca, V. (*State Agricultural University, Republic of Moldova, vitalie.gulca@gmail.com*), Deal, R. (*U.S. Forest Service, USA, rdeal@fs.fed.us*).

This study assessed the flow of ecosystem services and the role these services provide in both poor and rich countries. This research consisted of two primary objectives: (1) to assess losses of ecosystem function from disturbances including flooding and droughts, wildfire, ice-storms, insects, and invasive species; and (2)to assess the effects of forest restoration and the positive role that the creation of new forests could provide for a broad suite of forest ecosystem services. To attain these objectives we first describe some of the emerging international issues relating to ecosystem services. Then we assess the role of forest ecosystem services in different regions of the world, including developing, emerging, and fully developed countries. Also, we analyze the differences and similarities in utilization of forest services between poor and rich countries. While most developing countries' economies depend largely on natural resources, the roles ecosystem services can play for landowners in the region are not well-understood. Finally, we propose recommendations to conserve ecosystem services and help rural people in poor countries, and we suggest proposals to maintain ecosystem services in emerging and developed counties.

A modelling framework for integrated sustainable forest management. Khaiter, P.A., Erechtchoukova, M.G. (*York University, Canada; pkhaiter@yorku.ca; marina@yorku.ca*).

Along with wood products, forests generate a spectrum of ecosystem services and social benefits that are vital for humankind. A sustainable type of forest management is possible only if all the timber and non-timber related goods and services are adequately incorporated in the decision-making process. In this paper, we present a modelling framework for integrated sustainable forest management (MFISFM) that consolidates methods of simulation modelling, artificial intelligence, ecological stability, environmental economics, and optimization within a common methodological approach. The framework enables us to quantify biotic and abiotic constituents of a forest ecosystem, their interrelationships, and linkages to the system's environment at the appropriate time and space scales. It models physical, chemical, and biological processes and also quantifies and valuates ecosystem amenities under anthropogenic impact caused by forest and broader landscape activities. Based on this information, the MFISFM articulates the task of sustainable forest management as a problem of multi-objective optimization. We discuss the components of the MFISFM and demonstrate an application of the framework to the practical sustainable management of the protected boreal forests and to the analysis and selection of the alternative strategies of forest exploitation based on a set of environmental, economic, and social criteria.

Optimization of harvest planning for joint forest production of timber and carbon sequestration under the Japanese carbon offset system. Nakajima, T., Tatsuhara, S., Shiraishi, N. (*University of Tokyo, Japan; nakajima@fr.a.u-tokyo.ac.jp; tatsu@fr.a.u-tokyo.ac.jp; siraishi@fr.a.u-tokyo.ac.jp*)

Japan's Ministry of Forestry has established a forest carbon credit system, which is based on the J-ver (Japan Verified Emissions Reduction) system. The credits will be traded in the carbon market and funds reinvested in expansion of the implemented silvicultural practice area delineated for CO_2 absorption under the Kyoto Protocol. This study aimed to estimate the effects of the carbon offset system for the optimum rotation period depending on the carbon price and stand condition under the actual forest area formally identified in J-ver system. First, we confirmed that the optimum rotation lengths would increase with increasing carbon prices but decrease with increasing timber prices. Specifically, based on the J-ver accounting system, the carbon prices have a greater effect in increasing rotation age. Second, the difference between advantage and disadvantage depending on current stand age under J-VER system would be larger than timber based accounting. Finally, for medium- to long-term optimization of forest management and avoiding an econometric disadvantage for forestry profits under the existing J-ver system, it is important to consider allocating the harvesting area and stand age distribution into the management unit selected for carbon offset credit.

The globally significant role of carbon sequestration in wood products as an ecosystem service, and the emerging need to balance tradeoffs through bundling incentives to ensure other ecosystem services are provided. Oliver, C.D., Nassar N.N. (*Yale University, USA.; chad.oliver@yale.edu; nedal.nassar@yale.edu*), McCarter, J.B., Lippke, B.L., O'Neil, E.E. (*University of Washington, USA; jmac@u.washington.edu; blippke@u.washington.edu; eoneil@u.washington.edu*).

If carbon credits are given for the use of wood products rather than other building materials, then great reductions in carbon emissions can be achieved. At the global level, greater wood use in building could significantly reduce fossil fuel burning. However, maximum carbon sequestration would be at the expense of biodiversity. Although appropriately managed forest ecosystems can provide multiple services, not all services are completely compatible. A forest is modeled to assess the tradeoffs

in providing the ecosystem services values of timber, biodiversity, wind and fire protection, and carbon sequestration. Life-cycle analyses for carbon sequestration (CORRIM) and landscape projections of forests and ecosystem services (LMS, Landscape Management System) are used. The results are expanded to global considerations. The prices of different ecosystem services needed to change a landowner's management behavior are calculated using computer analyses (Toggle Program). Creative organization and bundling of incentives packages will be needed to balance the tradeoffs among commodity and non-commodity ecosystem values. Such packages may include a combination of certification, payments for providing certain habitats, and carbon credits to builders who use wood.

Participatory utilization and rehabilitation of a forest area: a case study in Gunung Kendeng Forest Resort, Banten, Indonesia. Sukandi, T. (*Forest and Nature Conservation Research and Development Centre, Indonesia; taulana_sukandi@yahoo.com*).

The study aimed to gain information on the possible factor(s) influencing the success of participatory utilization and rehabilitation of a forest area (FA). Data were collected by interviewing respondents living adjacent to the FA. The results showed that the utilization pattern of the FA had changed from destructive to constructive, in the form of maintaining trees to gain water service as well as latex and fruit products. The FA, which was degraded decades ago due to illegal logging and encroachment, had already been covered by trees. The function of FA as a water regulator was considered important by 75% of respondents. The income derived from outside FA resources, which was higher compared to the one from inside FA, and the awareness of water benefits were assumed to be factors influencing the change of utilization pattern. The change, then, influenced the success of FA rehabilitation in the study site.

Estimating long-term wood production and carbon sequestration from cork oak plantations installed after 1990 in Portugal. Tomé, M., Coelho, M.B., Paulo, J.A. (*Technical University of Lisbon, Portugal; magatome@isa.utl.pt; Martabcoelho@isa.utl.pt; joanaap@isa.utl.pt*).

Mature cork oak stands are a typical ecosystem in Portugal, characterized by a low crown cover from cork oak trees managed towards cork production combined with grazing. In recent years a large area of new cork oak plantations has been established with higher stand density. These plantations may be important not only for cork production but also for the wood from thinning that will be needed to avoid excessive inter-tree competition. Carbon sequestration may also be an important service from these plantations. Using an average yield table obtained with an existing growth model (SUBER) and information from average cork oak plantations installed after 1990 in Portugal, wood volume resulting from thinning and carbon sequestration values were estimated for the next 70 years. It was assumed that plantation rate will be maintained, as well as the percentage of the area affected by fire or abandoned. The simulations show that, due to the increasing values of initial density in new cork plantations, cork oak forests may produce a significant volume of wood that may be considered for utilizations that are now starting to appear as an alternative to fuel.

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Essential oils from trees of myrtle family offer a novel ecosystem service for pest and disease control. Batish, D.R. (*Panjab University, India; daizybatish@yahoo.com*).

Control of agricultural pests and diseases with synthetic chemicals not only deteriorates the environment but also possesses serious implications for human health. There is thus an urgent need to explore alternative methods. In this regard, natural products from plants with environmentally benign properties could be promising in managing pests and diseases of economically important plants. Trees yield a number of non-wood products including essential oils, which find extensive use in medicine, food, and the perfume industry—besides playing several roles in plant mediated interactions with other plants and organisms. Of late their role in providing regulatory ecosystem services such as disease and pest control is being explored. A series of experiments was conducted to explore the use of essential oils from aromatic trees of the myrtle family (Myrtaceae) such as *Eugenia Melaleuca, Eucalyptus,* and *Callistemon* species for managing pests, weeds, and pathogens–a novel ecosystem service worth exploiting for sustainable agriculture. The results indicate a very promising trend: the oils were found to possess herbicidal, pesticidal, and antifungal activities.

Ecosystem services as a management framework for public forests in the USA. Deal, R.L., Smith, N.M., Kline, J., Blahna, D., Patterson, T.M., Spies T. (*U.S. Forest Service, USA.; rdeal@fs.fed.us; nmsmith@fs.fed.us; jkline@fs.fed.us*; *dblahna@fs.fed.us; tmpatterson@fs.fed.us*; *tspies@fs.fed.us*).

We develop the concept of using ecosystem services as a framework for forest management, highlighting the different services that are currently provided from forest lands. This will involve enumerating and describing a broad set of benefits, both quantitatively and qualitatively, to improve public understanding of the suite of services that the Forest Service provides from public lands. We describe how an ecosystem services approach can enhance forest stewardship. This includes describing the suite of services provided by the forest, examining the potential tradeoffs among services following management activity, and building partnerships with stakeholders who benefit from the services the forest offers. Using the Deschutes National Forest in central Oregon as an example, we describe some of the key ecosystem services being provided from public forests including timber, fresh water, recreation, forest biomass, wildlife and fisheries, and other regulating and supporting services. This broad-scale approach will focus on quantifying some of the key ecosystem services and their critical link to sustaining forest ecosystems. Furthermore, this effort will demonstrate a framework and methodology to help land managers evaluate some of the potential opportunities and risks of different management activities for these services.

Globalization, multi-functionality, and new governance models for ecosystems in mountain territories. Gretter, A. (*Environmental and Natural Resources Department, Italy*; *gretter@cealp.it*), Goio, I., Gios, G. (*University of Trento, Italy; ilaria.goio@unitn.it*; *geremia.gios@unitn.it*).

Many high-value mountain territories have recently become privately managed after centuries of collective management by local populations. These mountain ecosystems are multi-functional commodities that are producing goods and services that can be grouped in three main areas: input for productive processes (timber), pure public goods (carbon sinks), and mixed goods (landscape and recreational values). A hedged optimum is the mix of these three goods that maximizes overall utility. In cases where adaptive management permits feedback between human-kind and ecosystems, it has been possible to preserve certain natural resources from overuse and misuse. Evidence from mountain territories has shown that this has happened more frequently where the management was conducted on a collective basis and within a determined community texture. The opportunity to grant economic values to those goods and services offered by ecosystems could be a useful support for driving governance within and outside the area of interest. We present some tools of political economics which could permit, in a sustainable manner, the achievement of the above-mentioned hedged optimum. Such an integrated approach could help the governance of fragile mountain ecosystems.

Previously unreported organic carbon stores in deep regolithic soils. Harper, R.J., Tibbett M. (*University of Western Australia, Australia; r.harper@murdoch.edu.au; mark.tibbett@uwa.edu.au*).

Large, previously unreported stores of carbon occur in deep, regolith profiles in southwestern Australia, most likely associated with the previous forest cover. Soil organic carbon was examined in 38 profiles, which ranged between 5 and 38 m (mean 21 m) deep. Soils had been either recently reforested or were under agriculture in an area with an annual rainfall of between 399 and 583 mm. Soil carbon contents decreased systematically with depth, with mean values of 2.30, 0.41, 0.23, and 0.12% in the 0–0.1, 0.1–0.5, 0.5–1.0, and 1–5 m depth increments. Samples taken from between 5 and 38 m contained between 0.16 and 0.01% carbon. The mean amount of carbon stored to full regolith depth was 274 t C/ha, and this can be compared with the mean carbon content to 0.5 m (the IPCC standard sampling depth) of 58 t C/ha and 163 t C/ha to a depth of 5 m. Many of the world's soils are much deeper than 0.5 m, and with numerous reports of rooting to depths of many meters it is likely that global soil carbon stores are significantly under-represented. The implications of land-use change (e.g., reforestation, deforestation) and climate change on these stores require resolution.

Production of kenaf (*Hibiscus cannabinus* L.) on tin tailings and its potential for phytoremediation. Ho, W.M., Ang, L.H. (*Forest Research Institute Malaysia, Malaysia; howaimun@frim.gov.my*; *anglh@frim.gov.my*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*).

Tin mining activities spurred the economy of the Malaysia Peninsula in the early 1900s. Mining areas were stripped of natural forests, leaving behind mine tailings contaminated with heavy metals and thus unsuitable for cultivation of food crops. This study explored the suitability of kenaf (*Hibiscus cannabinus* L.) production on nutrient-deficient sand tailings and the potential of this non-food crop for phytoremediation of lead (Pb). The study used a factorial design with nine combined treatments of organic (0, 80, 160 g) and inorganic (0, 5, 10 g) fertilizers. Selected plants were harvested for determination of biomass and analysis of Pb. Kenaf from treatment 8 (80 g organic fertilizer and 10 g inorganic fertilizer) had the highest accumulation of fresh and dry above-ground biomass. The total amount of Pb taken up in the aboveground parts was about 105 mg Pb/ha and the roots accumulated 21 g Pb/ha. Therefore, the amount of Pb removed by kenaf around the root zone is approximately 34% in the first rotation. In conclusion, kenaf provides not only an alternative to food-crops on Pb-contaminated sand tailings but offers a solution for soil decontamination through phytoremediation.

Characteristics of rainfall runoff and groundwater level change at the Milbot Bog in Mt. Cheonseong, Korea. Jung, Y., Lee, H., Lee, S. (*Yeungnam University, Republic of Korea; ava1983@nate.com; hhlee@ynu.ac.kr*; *silver-2004@nate.com*).

This study was conducted to investigate the hydrological characteristics of groundwater level change and rainfall discharge processes caused by tunnel construction at Milbot Bog located in Mt. Cheonseong. Data were collected from July 2004 to May 2008. The occurrence time of the direct runoff and peak flow caused by rainfall at Milbot Bog tended to be slower than those at a general mountain basin. The annual runoff rates have slightly increased from 2004 to 2008: 0.26, 0.13, 0.16, 0.25, and 0.27, respectively, regardless of the tunnel construction. The recession coefficient of the direct runoff in short-term hydrograph ranged from 0.89 to 0.97, which is much larger than that of the general mountain basin, 0.2–0.8. The recession coefficient of the base flow ranged from 0.93 to 0.99, which is similar to that of the general mountain basin. Average groundwater levels decreased annually from 2004 to 2008, −8.48 cm, −14.60 cm, −20.46 cm, −20.11 cm, and −28.59 cm, respectively. Therefore, it seems that the Milbot Bog is losing its function as a bog, although in this study we could not conclude that the changes of groundwater level were caused by the tunnel construction.

The valuation of ecosystem services for sustainable forest management: an example from Taiwan. Khonkaen, P., Feng, F.L. (*Chung Hsing University, China-Taipei*; piyapit@gmail.com, flfeng@nchu.edu.tw).

Ecosystem services (ES) represent the benefits that people obtain from ecosystems. These natural assets provide a multiplicity of benefits to humans, including provisioning, regulating, cultural, and supporting services. The valuation of ecosystem services must consider stocks, flows, and resilience. This study uses GIS data on bio-physical conditions such as vegetation cover, carbon flux, and stock; and altitude and slope to develop a framework for the evaluation of ecosystem services. We also used a 5S spatial technologies procedure. The results showed the amount of carbon storage by trees. We found a correlation between estimated tree age, carbon stock, and carbon sequestration. This information can be used to support decision-making and sustainable forest ecosystem management.

Ecological restoration as economic stimulus: potential regional economic impacts of the southwestern ponderosa pine restoration in the U.S. Kim, Y.S. (*Northern Arizona University, USA.; ysk@nau.edu*).

The conditions and processes of ponderosa pine ecosystems in the American Southwest have been dramatically altered by past management. Significant research and restoration efforts support the need for large-scale restoration treatments by prescribed burning and mechanical thinning. I present potential economic impacts of two collaboratively developed treatment scenarios of four national forests to help land managers and community leaders take full advantage of social and economic development

opportunities that can be leveraged through ecological restoration projects. The largest treatment scenario, mechanically treating 1.7 million acres, would cost about 1 billion U.S. dollars at the current rate, and can generate more than 1.3 billion U.S. dollars of total output and 14,820 jobs in local economies. The results do not include potentially significant economic impacts from utilizing woody biomass generated by mechanical thinning treatments. In addition to ecological benefits, ecological restoration treatments can create sustainable, "green collar" jobs in rural communities of the Southwest and generate social and economic benefits. To be sustainable, planning for ecological restoration should include qualitative and quantitative monitoring of social and economic conditions, in addition to ecological outcomes of the treatments. This study provides baseline information for such monitoring efforts in the future.

Data gathering for purposes of biodiversity valuation: a case study from the Czech Republic. Marušák, R., Merganič, J., Urbánek, V., Zahradník, D. (*Czech University of Life Sciences Prague, Czech Republic, marusak@fld.czu.cz; merganic@fld.czu.cz; urbanek@fld.czu.czs zahradnik@fld.czu.cz*).

We present a data-collection methodology for valuing ecosystems services, which we apply to a case study using the University Forest Enterprise (UFE) Kostelec nad Černými lesy, Czech Republic. We stratified our sample based on age, stand density, and site index using a two-phase sampling protocol. In the first phase we collected 50 variables on one quarter of the plots using FieldMap technology. In the second phase, fewer variables data were collected from all the plots. We used data from the first phase to estimate unmeasured variables. Finally, we calculated an integrated biodiversity index for each plot.

The estimation of forest soil carbon accumulation rate by a slide cycle method. Sakai, M. (*Forestry and Forest Products Research Institute, Japan; kmsakai@affrc.go.jp*), Maesako, S. (*Kumamoto Prefecture Forestry Research Center, Japan; maesako-shunichi@pref.kagoshima.lg.jp*), Shimokawa, E. (*Kagoshima University, Japan; sabos@service1.agri.kagoshima-u.ac.jp*).

This study estimates the accumulation rates of forest soil carbon by a slide cycle method on Shirasu steep slopes in Kagosima Prefecture, southern Kyushu, Japan. In this area, the recurrence interval of landslides is estimated to be at 80–120 years. The mean annual temperature and mean annual rainfall are 17.6 °C and 2240 mm/year. We surveyed tree census, soil profile, soil property, and soil carbon at three transitional stages: 16 years, 60 years, and 90 years after a landslide. On the landslide, vegetation recovery proceeded by natural regeneration. The above-ground biomass in 16-year, 60-year, and 90-year stands are 12 tC/ha, 69 tC/ha, and 240 tC/ha respectively. The soil carbon in 16-year, 60-year, and 90-year stands are 10 tC/ha, 26–35 tC/ha, and 54 tC/ha respectively. The accumulation rate of soil carbon is estimated to be 43–63 gC/m2/yr. That value is two to four times greater than the values (0.7–12.0 gC/m2/yr) that Schlesinger reviewed in temperate forest, suggesting that a catalyzing effect occurs in this area.

Characterization of forest fragments with a potential to maintain environmental quality in the eastern part of Lake Nicaragua in 2010. Salazar, E. (*Universidad Católica del Trópico Seco, República de Nicaragua; stanislaosalazar@yahoo.com.mx*).

The study was carried out in the eastern region of Lake Nicaragua (84° 30′ – 85° 30′ western longitude, 11° – 12′ northern latitude). This region contains forest fragments suffering from progressive degradation despite their role in fulfilling important environmental functions. The main objective was to identify forest fragments with potential to improve environmental quality. Six fragments were selected, and in each a square plot of 10,000 m^2 was established; within them were 10 sub-plots of 1,000 m^2, three of which were chosen at random. The diversity and tree structure, stored carbon from the air, and forest management were studied. Of 657 taxa, 131 species were found that belonged to 115 genus groups in 103 families; among them there were species of commercial value, mainly *Cordia alliodora.* Fragment 4 showed highest number of species. Fragment 3 had the highest abundance, with 550 individuals/ha. Fragments 1 and 3 showed the highest quantity of stored carbon (30 Mg of C/ha). The forests studied also host an important diversity of flora, which should be conserved but is highly threatened. Forest fragments 1, 3, and 4, could be integrated into projects of climate change mitigation due to their carbon-storing capacity.

Comparison of eco-hydrological characteristics of two forest ecosystems in northern subtropics, China. Wang, X., Zhou, B., Cao Y., Kong, W. (*China Academy of Forestry, China; wangxm831@yahoo.com; benzhi_zhou@126.com; rsfyrs@126.com; kongwj@126.com*).

It is important to study the hydrological function of vegetation in East China due to extensive anthropogenic disturbance in this region. To compare different hydrological characteristics of different forest types, rainfall distribution was studied in a *Quercus Glauca*-dominated natural secondary forest and a managed bamboo plantation in Miaoshanwu Natural Reserve of Zhejiang province. The results showed that during the rainy season (March–August 2009), throughfall, stemflow, and canopy interception contributed an average of 51.4%, 7.2%, and 35.3% to the total rainfall respectively for the natural secondary forest. For the bamboo plantation, throughfall accounted for 75.1%, stemflow 7.2%, and canopy interception 17.7%. The rainfall that can initiate stem flow is 3.3 mm for the natural forest, and the maximum water-holding capacity of the litter layer is 1.725 mm, higher than that in bamboo plantation (2.3 mm and 0.916 mm). The surface runoff coefficient and annual runoff sediment in natural secondary forest was 0.09% and 16.29 $kg \cdot hm^{-2}$ respectively, lower than that in bamboo plantation (0.18% and 67.34 $kg \cdot hm^{-2}$). The possible factors influencing precipitation distribution in forest ecosystems, as well as recommendations for future forest management in this area, are discussed.

C-03 The use of quantitative forest sector modeling in environmental policy analysis

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Lessons learned from quantitative analyses of forest bioenergy policies. Alavalapati, J.R.R. (*Virginia Tech, USA; jrra@vt.edu*), Banerjee, O. (*RMGEO Consultants Inc., Canada; onil@rmgeo.com*), Dwivedi, P., Kukrety, S., Huang, M., Lal, P., Susaeta, A. (*University of Florida, USA; puneetd@ufl.edu; sid.forester@gmail.com; myhuang2@ufl.edu; pankajlal@ufl.edu; asusaeta@ufl.edu*).

Concerns for environmental quality and energy security have prompted nations across the world to formulate policies to promote the use of forest biomass for energy. The use of forest biomass for energy is expected to result in environmental, economic, and social impacts at local, regional, and national levels. Analyzing these impacts requires a suite of modelling techniques. Recently, we have assessed the impacts of policies such as renewable portfolio standards (RPS) and renewable electricity standards (RES) on the economy, environment, and society. In particular, we have applied an analytical hierarchy process (AHP) to assess stakeholders' perceptions towards forest bioenergy; a life cycle analysis (LCA) to estimate emission reductions of forest biofuels; attribute based choice (ABC) models to quantify public willingness to pay a premium for forest biofuels; a dynamic optimization to estimate the effect of bioenergy markets on the profitability of forestlands; an econometric model to estimate the effect of bioenergy markets on forest products markets; and a computable general equilibrium model to determine economy-wide impacts of forest bioenergy policies. We discuss the rationale for the choice of these techniques, discuss their strengths and weaknesses, and present key results. We offer suggestions for future advancements of these techniques.

The viability of forest biorefineries under different policy and price structures. Hetemäki, L. (*Finnish Forest Research Institute, FINLAND; lauri.hetemaki@metla.fi*).

Increasing scarcity of oil reserves and high CO_2 emissions from using oil have led to the development of renewable biofuels. This trend is supported increasingly by various energy policy measures, both at regional (e.g., EU) and national levels. Biorefineries offer one important way to increase biofuel production. In the forest sector, the biorefinery concept is especially interesting for numerous reasons. For example, biofuel can be produced energy-efficiently in integrated pulp and paper mills because of synergy gains in production processes and raw material procurement. However, within forest biorefinery platforms, there are a number of different raw-material, output mix, and technology possibilities. This study analyzes what kinds of price and policy structures favor investments into each forest biorefinery type, and which types of paper and pulp mills are favorable for biofuel production. We present a market model of profit maximizing pulp and paper mills that allows investments into different biorefinery technologies, and also for the related heat and power (CHP) technologies. The model is utilized for numerical simulations, in which the impacts of different energy price levels and policy measures on the biorefinery investments and raw-material choices are analyzed.

Natura 2000 and the sustainability of the European forest sector. Kallio, A.M.I. (*Finnish Forest Research Institute, Finland; maarit.kallio@metla.fi*), Moiseyev, A. (*European Forest Institute, Finland; moiseyev@efi.int*), Schelhaas, M.J. (*Alterra, The Netherlands; MartJan.Schelhaas@wur.nl*), Solberg, B. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no*).

Our study addresses the impacts of Natura 2000 on the European forest sector and the forest sector's sustainability. Under Natura 2000, some forests are either partially or entirely set aside from timber production, which decreases the market supply of timber and thereby has an adverse impact on the forest industry. The overall impacts are considered in relation to issues such as forest owner incomes; forest industry turnover and profits; employment; energy consumption in the forest industries; paper recycling rates; carbon sequestration; self-sufficiency of Europe in relation to fibre and forest products; and the value of the net exports of the sector. We report the results for Europe, divided into four sub-regions with respect to two baseline development scenarios for 2005–2020, which seek to parameterise the IPCC storylines A1 and B2 to the global forest sector. The baseline growing stocks, the restrictions placed on forest management and timber supply by Natura 2000, and the carbon sequestered in the forests are quantified using the EFI-SCEN forestry simulation model. The global forest sector model EFI-GTM is used to project the development of the market-driven sustainability indicators.

Climate policies: what effects on the French forest sector? Lecocq, F., Caurla, S., Delacote, P., Barkaoui, A. (*Laboratory of Forest Economics, France; franck.lecocq@nancy-engref.inra.fr; sylvain.caurla@nancy-engref.inra.fr; philippe.delacote@nancy-engref.inra.fr; ahmed.barkaoui@nancy-engref.inra.fr*).

Forests can contribute to climate change mitigation in two ways: by sequestering carbon in forest biomass and in wood products, what we call "stock effect"; and by substituting high-energy products with wood products such as fuelwood instead of fossil fuel or construction wood instead of concrete, what we call "substitution effect". Climate policies can focus on stock effect or on substitution effect, or both. This paper assesses the impacts of three different policies using a new model for the French forest sector. We consider two substitution effect policies: a policy to boost fuelwood consumption and a policy to boost building wood consumption; and a stock policy to sequestrate carbon in forest. We define four scenarios by combining these three policies. First, results clearly show that substitution policies increase wood product prices and forest-owner revenues. This effect is highly significant since wood product prices increase by 50 to 300% depending on the level of demand increase. However, sensibility analysis shows that this effect highly depends on price elasticity of supply. Second, it is likely that, even with an optimistic carbon price, sequestration in forest biomass does not lead to tensions over wood product supply and forest stock.

A comparative analysis of forest models with endogenous and exogenous wood prices and use. Sjølie, H.K. (*Norwegian University of Life Sciences, Norway; hanne.sjolie@umb.no*), Latta, G. (*Oregon State University, USA; greg.latta@oregonstate.edu*), Solberg, B., Trømborg, E., Gobakken, T. (*Norwegian University of Life Sciences, Norway; birger.solberg@umb.no; erik.tromborg@umb.no; terje.gobakken@umb.no*).

In Norway, two primary models used to study the forest sector impacts of changing political and economic conditions are Gaya and NTM (Norwegian Trade Model) II. The simulation model Gaya has detailed representation of the forest resource, but exogenous prices and use of wood. The optimisation model NTM focuses on the forest industrial sector and has only a rough forest growth model with exogenous forest investments/management. Elements of these two models are combined in NorFor, a new forest sector model for analysing impacts of changes in policy and market conditions on the Norwegian forest sector. The NTM components provide detailed tracking of wood in industry, with endogenous industry input and end-use allocation and

prices, while the incorporation of Gaya allows for detailed forest growth as a function of forest investments/management and carbon tracking "from cradle to grave." Norfor is a dynamic spatial partial optimisation model with endogenous investments in forestry and the forest industry; has endogenous wood product use and prices; and provides carbon dynamics in forest, industry, and end use. This study will compare and contrast harvest levels and carbon dynamics under various scenarios of carbon pricing using NorFor and Gaya, that is, with and without wood price endogeneity.

Environmental policy analysis with the global forest products model. Turner, J. (*Scion/New Zealand Forest Research Institute Ltd., New Zealand; James.Turner@scionresearch.com*), Buongiorno, J. (*University of Wisconsin, Madison, USA; jbuongio@wisc.edu*).

Many contemporary environmental issues have international dimensions that call for a multi-country or even global perspective. For forestry, quantitative models such as the Global Forest Products Model (GFPM) have proved effective in addressing various international policy questions. The GFPM represents the global forest sector at the individual country level, where policy decisions are ultimately made. It predicts changes in forest area, forest stock, demand and supply, net trade, and prices for the main forest industries. The data can be, and have been, modified to fit various needs in different countries. This paper summarizes briefly the main features of the GFPM, then describes recent applications to environmental policy analysis. A current project is investigating the global outlook for wood and forests with the bioenergy demand implied by scenarios of the intergovernmental panel on climate change. A previous study has dealt with the effects of illegal logging on the world forest industries, trade, and inventory. Another has investigated the impact of exotic species on the trade of forest products. We look at what was learned from these applications, and how this knowledge can be used to improve the GFPM and other forest sector models for better environmental policy analysis.

Posters

Timber and water yield modelling using WoodstockR and Macaque forest and hydrologic models. Battad, D., Miller, V., Villanueva, G., Li, C., Sutton, M. (*Department of Sustainability and Environment, Australia; Dionisio.Battad@dse.vic.gov.au; Valerie.Miller@dse.vic.gov.au; Grimaldo.Villanueva@dse.vic.gov.au; Cai.Li@dse.vic.gov.au; Michael.Sutton@dse.vic.gov.au*).

The Victoria State government issued the white paper, *Securing Our Water Future Together*, also known as *Our Water, Our Future,* in 2004 to ensure the sustainable management of all water sources: to provide for the needs of the environment, communities, farms, and businesses. Under action 2.21 of the white paper, one of the government's commitments was to investigate options to improve water yield, which includes potential changes to forest management practices in the major catchments that supply water to the city of Melbourne, Victoria. The Department of Sustainability and Environment (DSE) implemented the Harvesting in State Forests Supplying Water to Melbourne project. One component of the project is to investigate the impacts of various future management options (timber harvesting options) on water yield within the water catchments in the Central Highlands, Victoria. This paper describes the development of a modelling approach and the results from the assessment of nine (9) forest harvesting regimes on timber and water yield using the WoodstockR forest modelling system and the Macaque water yield model, specifically on the data inputs, Woodstock model structure and constraints, and outputs from the different models.

C-04 The role of institutions and institutional economics in sustainable forest management

Organizers: Shashi Kant, *University of Toronto, Canada, shashi.kant@utoronto.ca;* Martin Hostettler, *Cycad, Switzerland, martin.hostettler@cycad.ch;* Yaoqi Zhang *Auburn University, USA, Yaoqi.zhang@auburn.edu.*

Linking physical, economic, and institutional constrains of land use change and forest conservation in the hills of Nepal. Krishna Bahadur, K.C. (*University of Hohenheim, Germany; krishna@uni-hohenheim.de*).

This paper analyses the changes in spatial patterns of agricultural land use during 1976–2000 along the altitudinal gradients in a watershed in Nepal. Land change pattern was examined using information of land use derived from satellite images from 1976, 1990, and 2000. During the 24-year period from 1976 to 2000, agricultural land use increased by 35% at the cost of loss of forestland. Agricultural expansion was most conspicuous at higher elevations. About 36%, 18%, and 6% of forestlands were converted into agricultural activities from higher, middle, and lower elevations respectively in 1990–2000. Results show that forest losses were smaller if they were located around high-income areas and near administrative centres compared to areas located around low-income areas and far from the administrative centre. Spatial trajectories are then contrasted with particular attention to the socioeconomic condition and institutional arrangements governing access to land resources. The study finds that while overall land change patterns in the region are largely explained by elevation and socioeconomic condition of people living adjacent to the forestland, more specific, sub regional, trajectories reflect the signatures of institutions governing access to land.

Avoiding counter productive carbon policies. Lippke, B.R., Oneil, E. E. (*University of Washington, USA; blippke@u.washington.edu; eoneil@u.washington.edu*).

As climate mitigation efforts transform the value of carbon with institutions creating incentives as well as regulating markets, the avoidance of unintended consequences becomes challenging. Life cycle inventory and analysis (LCI/LCA) research tracks carbon and other services from forest to products including displacement of fossil emissions when wood substitutes for fossil fuels or fossil intensive products. Incentives that do not target uses that displace the most emissions will likely steal the feedstock from more effective uses, thus increasing rather than decreasing emissions. Similarly, under-valued habitas may be reduced. We apply life cycle research to identify positive and negative leverage points in reducing carbon emissions and their impacts on old-forest habitat. Ethanol subsidies, forest carbon credits, and renewable energy standards steal the feedstock of higher leverage uses, while

a carbon tax effectively penalizes the largest emitters. Reducing the cost of collecting forest residuals reduces emissions. Both carbon taxes and incentives affect the cost of sustaining habitat. Institutions need to consider life cycle implications to sustain forests and their multiple values. While only the carbon tax provides the proper price signal with the highest reward for the greatest carbon emission reduction, increasing habitat values may be justified.

The ban on the exportation of some timber species: impact on the promotion of timber resources, cutting, and tax revenues in Cameroon. Meyanga Tongo, Y. (*National Centre of Education/Ministry of Scientific Research and Innovation, Cameroon; meyanga_yves@yahoo.fr*), Ngouanfo, S.E. (*HCR, TCHAD; sngouanfo@yahoo.fr*).

The law of 20/01/1994, modified by the decree N°99/001 of 31 August 1999, was aimed to stop the exportation of some timber species during a 5-year period. Has the decision to halt the exportation increased the export value of other timber species? Does this measure lead to a fall in tax revenue? What measures can be adopted to fill the revenue gap created by the ban on exportation of some timber species? Appropriate documentations were found in the Ministry of Environment and Forestry, and customs services. Observations were made in local woods industries, local woods markets, Douala Seaport, wood depots, and fa alling site. Those data were collected and ranked chronologically, and analysed using the gap model. As expected, this measure led to an increase in the local use of prohibited and even unprohibited species, and of domestic wood companies. But on the other hand, there was a sharp fall in the Cameroon timber products revenue. Must government over-tax local wood companies to bridge the gap, or lift the ban on prohibited species? Both decisions have far-reaching consequences: a reduction in local wood companies, extinction of prohibited species, and loss of government revenue.

Forestland usage right market: a case study in Zhejiang, China. Xu, X. (*Zhejiang Forestry University, China; zjfcxxy@yahoo.com.cn*), Zhang, Y. (*Auburn University, USA; yaoqi.zhang@auburn.edu*).

Forestland use right transfer is currently considered a major step and platform of China's forestland tenure reform, considering that most forestland in the collective area is managed by individual households and total privatization seems not acceptable for the time being. To know the current status of forestland usage right market, this study conducted a survey to 222 farmers in eight villages in Linan and Anji county, Zhejiang Province. The features of farmer's participation in the forestland transfer are analyzed in terms of transfer size, channels, and obstacles. Results show 113 households engaged in land transfer, indicating an active market. Households got land from the collective usually by bid, while transfer between households is usually by private negotiation, and mostly within their own villages. The main arrangement was through written contract. The main purpose of getting more land is to raise management scale, while transferring out land is due to lack of labor, capital or too remote of the land. A Probit model was applied to analyze the household behaviors of the transaction. Some policy recommendations are provided.

Implementing ecological restoration efforts in China more effectively. Yin, R. (*Michigan State University, USA; yinr@msu.edu*).

China has undertaken several programs of ecological restoration (ERPs) in recent years, including the Natural Forest Protection Program, the Sloping Land Conversion Program, and the Desertification Combating Program around Beijing and Tianjin. With huge government investments, great progress has been made in implementing these ERPs and thus improving the environmental and socioeconomic conditions. To complete them successfully and to fundamentally transform the targeted ecosystems, however, it is essential for China to embrace a more balanced and comprehensive approach to ecological restoration. This approach must include: adopting better planning and management practices; strengthening the governance of program implementation; emphasizing the active engagement of local people; establishing an independent, competent monitoring network; and conducting adequate assessments of program effectiveness and impact. It is our view that in each of these areas, well-organized and effective scientific research and policy changes must be pursued, and the international community needs to get engaged in a wide range of assistance. The purpose of this paper is to address these issues carefully and provide concrete suggestions for more effective implementation of the ERPs.

Posters

Actors in local forest management for private forests in Japan. Ishizaki, R., Oka, H., Tsuzuki, N. (*Forestry and Forest Products Research Institute, Japan; ryokoi@ffpri.affrc.go.jp; oka@ffpri.affrc.go.jp; nobyuki@ffpri.affrc.go.jp*).

In order to promote both the environmental and economic functions of forests, an effective forest management system is crucial. In Japan, almost 60% of forests are privately owned, but ownership of most of them is fragmented: owners have lost interest in their forests and no longer use them. The support system for such forest owners, which is mainly based on extensive subsidies for forestry, is becoming seriously inadequate and needs to be reformed to ensure sustainable forest management. This paper discusses, based on empirical studies, how the forest management system in Japan should be rebuilt. We focus on two important actors in local forest management: forest owners' associations and municipalities. Forest owners' associations, whose main members are households owning private forests, are expected to play a key role in supporting and organizing small-scale fragmented forests. Municipalities, as basic local government units in Japan, have acquired most authorities for monitoring local forest practices in the past two decades. However both of them have some problems. We suggest improvements for these actors to effectively support private forests.

Role of Krasnoyarsk region's forests in the global account of the main greenhouse gasses. Laletin, A.A. (*Institute of Forests, Russian Federation; slal@mail.ru*), Laletin, A.P. (*Friends of the Siberian Forests, Russian Federation; sibforest@akadem.ru*), Sokolov, V.A. (*Institute of Forests, Russian Federation; vsokolov@forest.akadem.ru*), Laletina, I.D. (*Siberian Federal University, Russian Federation; innasib@mail.ru*).

The Krasnoyarsk region's land reserves total 236.7 million hectares; 66% of them (156.6 million hectares) are forests. The Krasnoyarsk region's forests contain 9.6 billion tons of phytomass on a dry basis (more than 2% of the global forests' phytomass). The method that is being developed by International Institute for Applied Systems Analysis, Austria, together with

Institute of Forests n.a. V.N. Sukachev SB RAS, has been chosen as the main approach for the quantitative estimation of the account of the main greenhouse gasses. The stock of phytomass has been reduced by 3.4% for the past 10 years because of the reduction of lands covered by forests and the reduction of forest density (1.9% and 4.1% respectively). The main reserve of phytomass is concentrated in the region's forests (about 85%). There is a considerable reserve of tree detritus (about 35.4% of phytomass reserve) in the Krasnoyarsk region. The stocks of carbon in the region's soils are about 40.3 billion tons, i.e., the ratio of soils' carbon and vegetation carbon is 6.1:1. The reserve of total nitrogen in the soils is about 2.7 billion tons, i.e., the carbon and nitrogen contents in the soils are in the ratio of 14.9:1.

Towards sustainable management of non-timber products: hickory forest as a case study. Shen, Y. (*Zhejiang Forestry University, China; shenyueqin-zj@163.com*), Zhang, Y. (*Auburn University, USA; yaoqi.zhang@auburn.edu*).

The contribution of hickory forest management to local farmers and rural economic development was investigated and analyzed based on surveys to 152 households, 20 hickory nut companies, and 500 hickory nut consumers; and 10 participatory group interviews in Linan and Chunan counties, Zhejiang Province. The results indicate that incorporation of local community, farmers, processing enterprises, government, and scientific and technological personnel in the decision-making are very important to promote sustainable management. The households' awareness of and willingness for ecological and sustainable management is analyzed using a logistic model. Results show that variables such as age and sex of household head, and area variables, have significant impacts on the willingness to use ecological methods of hickory management at the 5% level. Three suggestions are made to carry sustainable management: (1) Promoting the ecological way of hickory management according to local circumstances; (2) The ecological management of non-timber forest products is multi-participatory process in which the officials of government, technicians and farmers should be engaged; and (3) The detailed model of ecological management of hickory should synthetically consider the economic, ecological, and social benefits.

Analysis of financial instruments promoting non-market environmental forest services–case of the Czech Republic. Sisak, L., Pulkrab, K. (*Czech University of Life Sciences, Czech Republic; sisak@fld.czu.cz; pulkrab@fld.czu.cz*).

Multifunctional forestry ensures effective reproduction of market and non-market forest services. Provision of non-market environmental services is very demanding and limiting for forest owners, tenants, and managers; and worsens financial efficiency, that is, decreases revenues from timber production and sales, and brings about additional costs. Different financial instruments are used to promote provision of non-market forest services. Of them, financial means from public sources are the most important. But in the Czech Republic as in many countries the financial means are understood, in bulk, as subsidies representing gifts from the public to forest owners. Nevertheless, it is necessary to differentiate subsidies from reimbursements of financial loss in timber production or even from payments by public institutions for catering non-market environmental services, and treat them separately. This would contribute substantially to a higher standard of decision-making on the resources allocation, and to the transparency of forestry financing. The data analysis results show the larger part of financial means, declared as subsidies, are in fact by their socio-economic nature either compensations or purchases of non-market services by public authorities.

C-05 Short rotation forestry for livelihood security, energy and carbon sequestration

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Trees, energy, and livelihoods in rural Africa: is there a role for short-rotation forestry? Chomba, S. (*University of Copenhagen, Denmark; schomba@life.ku.dk*), Lamond, G., Sinclair, F.L. (*Bangor University, United Kingdom; g.lamond@bangor.ac.uk; f.sinclair@cgiar.org*), Minang, P. (*ASB Partnership, Kenya; a.minang@cgiar.org*).

While the clean development mechanism (CDM) has funded many energy projects in China, India, and Brazil, there has been sparse uptake of forest projects globally and any CDM projects at all in Africa. Reasons for this include the high initial establishment costs and stringent modalities associated with monitoring, reporting, and verification. Recent estimates of the global extent of agroforestry, reveal a vast tree resource on farms (almost half of agricultural land in Africa has more than 10% tree cover) and United Nations Framework Convention on Climate Change (UNFCCC) negotiations are opening up opportunities for carbon storage in a broader range of land uses, and existing tree cover, to be valued. It remains difficult for the large number of smallholder farmers in Africa to capture benefits from carbon markets and funds. Simpler approaches to assessing time-averaged carbon stores on agricultural land, combined with community carbon monitoring, could open up possibilities for enhancing rural livelihoods through higher tree cover. Trees may also diversify and sustain African farming systems so that there could be co-benefits for long-term food security.

Reducing environmental impacts of short-rotation coppices through evidence-based integrated decision-support tools. Dimitriou, I. (*Swedish University of Agricultural Sciences, Sweden; ioannis.dimitriou@vpe.slu.se*), Bolte, A. (*Johann Heinrich von Thünen-Institut, Germany; andreas.bolte@vti.bund.de*), Aronsson, P. (*Swedish University of Agricultural Sciences, Sweden; par.aronsson@vpe.slu.se*), Baum, C. (*University of Rostock, Germany; christel.baum@uni-rostock.de*), Berndes, G. (*Chalmers University of Technology, Sweden; goran.berndes@chalmers.se*), Busch, G. (*Bureau for Applied Landscape Ecology and Scenario Analysis, Göttingen, welcome.balsa@email.de*), Köhn, J. (*Beckmann Institute for Bio-production Technology Lines e.V., Germany; jk@dr-joerg-koehn.de*), Lamersdorf, N. (*University of Göttingen, Germany; nlamers@gwdg.de*), Leinweber, P. (*University of Rostock, Germany; peter.leinweber@uni-rostock.de*), Weih, M. (*Swedish University of Agricultural Sciences, Sweden; martin.weih@vpe.slu.se*).

The agricultural land surface cultivated with short-rotation coppice (SRC) using willow and poplar for production of biomass for heat and electricity is expected to increase in the short term. As a perennial crop, SRC differs from arable crops in physical traits

and management practices, and gaps in knowledge concerning its environmental impact exist. "Reducing environmental impact of SRC through evidence-based integrated decision support tools" (Rating-SRC) is a research project funded within the framework of ERA-NET Bioenergy. It will evaluate the impacts of SRC on soil, water, biodiversity, and landscape issues, and will propose ways to mitigate negative and increase positive impacts. Moreover, factors strengthening SRC as a sustainable energy crop, such as the recycling of by-products from society back to SRC, will be considered in the general evaluation. The main aim of the project is to provide relevant stakeholders (policy makers at local and government level, commercial actors, environmental and bioenergy agencies, farmers, landscape planners, and others) with decision-making support tools to assess the sustainability of SRC as an agricultural crop for the production of biomass for energy. This paper will describe the experiments and research results obtained so far to provide scientific knowledge to support decision-making.

Innovation in methodology and methods of forest carbon stock estimation. Elias, E. (*Bogor Agricultural University, Indonesia; elias2956@yahoo.com*).

Until now, the estimation of forest carbon stocks is still using an equation of a relationship between tree biomass and its diameter at breast height (DBH), and an assumption that the average carbon content in vegetation biomass is 50 per cent on dry-weight basis. Based on the types of biomass from various tropical forest types, the use of this assumption may lead to a less accurate estimation of forest carbon stocks. To reduce uncertainty, accurate carbon accounting methods are required. This study has successfully developed accurate carbon accounting methodology and methods, which include (i) a field survey of forest carbon mass by using the existing forest inventory standards, (ii) a methodology and methods to measure trees biomass in the field and carbon content of tree biomass in the laboratory by using ASTM standards, and (iii) tree carbon mass equation models, which are built based on a significant relationship between carbon mass of the tree and its DBH and than applied to assess forest carbon stocks of some forest types (e.g., the community forest of *Paraserianthes falcataria* L. Nielson).

Fueling the future with woody biomass: can fertigation of short-rotation woody crops enhance biomass production on agricultural fields? Jose, S. (*University of Florida, USA; sjose@ufl.edu*), Henderson, D. (*Missouri Department of Conservation, USA*).

Woody biomass has received considerable attention in the recent past as the "fuel of the future." Although forestland has the potential to supply biomass, short-rotation woody crops (SRWC) established on abandoned agricultural fields, alone or in combination with food crops (agroforestry), present another opportunity. Development of such bio-energy systems provide expanded markets and ecosystem services such as carbon sequestration and biodiversity conservation. In order to examine the feasibility of "fertigation" (fertilization along with irrigation) as a management strategy to enhance biomass production of SRWC, a field trial was conducted in the southern United States. The biomass production of cottonwood, cherrybark oak, and sycamore was assessed with five treatments—control; irrigated (IRR); and irrigated with 56, 112, and 224 kg nitrogen (N) ha-1 yr-1. Cottonwood had the lowest survival but the highest biomass production. Biomass reached its peak for cottonwood and sycamore in IRR, and in the 112 kg N treatment for cherrybark oak. Higher N fertilization increased N leaching without apparent benefits to tree growth. These results suggest that species and site-specific cultural practices that produce the maximum biomass without adverse environmental effects need to be identified before fertigation can be adopted widely for SRWC production on agricultural fields.

Biomass production and *Liriodendron tulipifera* in Korea: status and prospects. Ryu, K.O., Kim, I.S., Choi, H.S. (*Korea Forest Research Institute, Republic of Korea; koryu95@korea.kr; kimis02@korea.kr; forgene@korea.kr*).

It is projected that the future demand of biomass in the world will increase continuously, and the situation is similar in the Republic of Korea itself. In the forestry sector, prospective short-rotation woody crops are the solution for this problem. Since 2008, a forest bio-cycling plantation (FBCP) project using yellow poplar (*Liriodendron tulipifera*) has been undertaken by the Korea Forest Service. The area of FBCP will be expanded up to 100,000 ha by 2020 for promotion of biomass production. Yellow poplar, a fast-growing tree species, was introduced from eastern USA into Korea during the 1970s. According to our field test results, yellow poplar is well-adapted and grows well at temperate regions in Korea, except under severe environments. The volume growth (m^3/ha) and carbon sequestration (tC/ha/yr) of yellow poplar at age 30 are 1.3–2.7 and 1.6–2.7 times higher than that of major native tree species (*Pinus densiflora*, *Quercus acutissima,* etc.), respectively. The status of yellow poplar breeding and the FBCP project in Korea will be discussed.

Short-rotation forestry: an eco-efficient land use management system. Sharma, R. (*Department of Forestry and Natural Resources, India; chauhansk@dr.com*).

Increasing pressure of swelling human/livestock populations, shrinking per capita land, deteriorating natural resources, acute energy shortages, climate change, etc. have altered livelihood options and sustainability. These problems are being increasingly recognized and the paramount importance has been placed on trees–their role in the forests as well as outside the forests.
A number of new forms of forestry have emerged that place greater emphasizes on livelihood security, energy, environment, natural resource conservation, and sustainable development. Since existing forests globally cannot continue to meet the basic requirements, therefore, short-rotation woody crops are essentially required to be managed intensively to meet the wood shortage. Short-rotation forestry is the rapid silvicultural practice to reforest areas of barren forest/deforested mountains/salty grounds, etc.; enhance farm income from subsistence farming; meet increasing domestic/industrial timber and energy requirements; generate employment; mitigate adverse influence of global climate change; and also save the virgin forest wealth. The concept of short-rotation forestry has a very little scientific history; therefore, an effort has been made in this paper to present data on productivity of fast-growing species, their natural resource utilization patterns, environmental amelioration potential, and perspective approaches for sustainable land management.

Potential evaluation of short-rotation forestry as the feedstock of fast pyrolysis for bio-oil in China. Si, H., Chang, J., Han, Y., Gou, J., Ren X. (*Beijing Forestry University, China; sihui@bjfu.edu.cn; cjianmin@bjfu.edu.cn; hyx.m.s@163.com; jinsheng.gou@gmail.com; renxueyong@126.com*).

Theme C: Forest Environmental Services

A consequence of current energy crisis and climate problems has been technology advancements in the development of energy alternatives and high-value-added chemicals. Bio-oil (derived from forest wood by fast pyrolysis) systems for heat, power, fuel, and chemicals has show a great potential. Feedstock cost is the dominant factor related to the bio-oil production. At present, feedstock mainly comes from forest residues and wood industrial wastes in China; their collection radius and logistic cost rises with the plant scale. Consequently, the industrial application has not developed well in China. However, encouraging benefits have been confirmed from using short-rotation forestry as the feedstock for bio-oil systems in some European countries. In China, short-rotation forestry has developed very fast under the lead and support of government policies in recent years. Dendromass was mainly used in wood-based industries, but based on the present circumstances of China, important issues have been presented and are discussed in this paper, including land use, forest plantation and management, policy trends, economic situation, energy consumption, and outlook of bio-oil technologies. The potential of short-rotation forestry as the feedstock for bio-oil was evaluated and the sustainable integration system of forest and bio-oil was prompted.

Posters

Effect of dissolved organic carbon by different thinning intensities in temperate forest. Chiang, P.N., Yu, J.C., Wang, Y.N., Liu, S.W. (*National Taiwan University, China-Taipei; pnchiang@ntu.edu.tw; 1329@exfo.ntu.edu.tw; m627@ntu.edu.tw; dannis@exfo.ntu.edu.tw*).

Plantation thinning and associated managements can influence the functions and structure of forest ecosystems as well as the status and dynamics of soil nutrients and organic matter that affect the forest ecosystem and related environment reciprocally. The objective of this study was to investigate the influences of thinning intensities to soil dissolved organic matter and soil ions. This study was carried out in a 40-year-old *Cryptomeria japonica* plantation located in central Taiwan. Thinning intensity was separated into control, 40%, and 60%. Before and after thinning, soil was sampled and analyzed for soil properties, dissolved organic carbon (DOC), and ions. The DOC and K^+ concentrations extracted from fresh soil of the control treatments were significantly higher than those of thinning intensities. It is suggested that DOC and K^+ were leaching down by rainfall after thinning treatments. The nitrate concentration extracted from fresh soil increased with thinning intensity. It indicated that fresh litter accumulated in the soil, the litter decomposed, and DOC was released by microbes and transformed to nitrate. Therefore, DOC plays an important role after plantation thinning practices. The results can also be a reference for nutrient management of plantation.

Biomass production of birch on cut-away peatlands–energy wood with short rotation? Hytönen, J., Aro, L. (*Finnish Forest Research Institute; jyrki.hytonen@metla.fi, lasse.aro@metla.fi*).

Approximately 0.8–1.0 million ha of peatlands are suitable for peat harvesting in Finland. At present, peat is harvested on 62,000 ha. Forestry is considered as the main re-use option for cut-away peatlands. Growing of industrial round wood is the main objective, but one option could be growing of biomass for energy production. Mostly birch forests on peatlands are dominated by downy birch (*Betula pubescens*), but on cut-away peatlands also silver birch (*B. pendula*) has been shown to regenerate naturally. Natural seeding of birch, especially on fertilized cut-away peatlands, can be abundant. Therefore, we studied growing naturally regenerated birch along with willow stands for energy according to short-rotation management principles such as dense stands. The fertilized (control, PK, wood ash fertilization) birch stands were grown as un-thinned dense thickets for energy wood (rotations of 16 and 21 years). Fertilization increased biomass production of birches. Leafless above-ground biomass production of two (16+21 years) energy wood rotations was 145–155 Mg DM ha^{-1}. The highest biomass yield was achieved with a rotation of 37 years in an un-thinned stand (211 Mg ha^{-1}).

Genetic improvement of *Dalbergia sissoo* for growth, productivity, and carbon sequestration. Kumar, A., Bhatt, A., Dobhal, S. (*Forest Research Institute, India; ak_meena@yahoo.com; julupari@gmail.com; shivanido@gmail.com*).

Dalbergia sissoo Roxb. is grown on the Indian subcontinent for timber production. Genetic improvement of species was started by screening and developing promising genotypes to improve productivity, quality, and carbon sequestration. Thirty-six genotypes were evaluated for G × E interactions to test growth performance and carbon sequestration in three geographical locations. Index value based on six growth and quality parameters was developed; clone 247 obtained maximum value (97.50) followed by clones 3 (95.00), 19 (92.50), 24 (92.50), and 128 (92.50). Though mean carbon sequestered across the locations was 13.56 lbs, clone 3 sequestered maximum carbon (23.65 lbs) followed by clone 201 (23.34 lbs) and clone 41 (21.54 lbs). Clones 66, 204, and 12 not only performed poorly for growth and quality parameters but also sequestered only 1.88, 2.58, and 3.45 lbs of carbon, respectively. The G × E analysis depicted significant influence of genotypes and growing locations on growth performance, quality, and carbon sequestration. Patiala was found to be the most suitable location for the expression of genotypic worth and carbon sequestration (19.85 lbs) followed by Ludhiana (16.29 lbs) and Hoshiarpur (5.64 lbs). Nonetheless, the performance *per se* needs to be tested for substantially longer duration to understand future performance.

Transition characteristics from wood to charcoal during carbonization. Kwon, S.M., Kim, N.H., Chun, K.W. (*Kangwon National University, Republic of Korea; ksm7689@kangwon.ac.kr; kimnh@kangwon.ac.kr; kwchun@kangwon.ac.kr*).

Understanding the mechanisms of transition characteristics from wood to charcoal is one of the important keys for the pyrolysis process of wood-based biomass. However, the mechanisms for wood carbonization are not fully understood because of the complexity caused by the varying physical and chemical properties of wood. The objective of this study, therefore, is to clarify the transformation characteristics from wood to charcoal. Wood blocks were carbonized in an electric furnace under nitrogen gas atmosphere (1kg cm^{-2}) at 250, 300, 350, 400, 450, 500, 600, and 700 °C. Carbonization was carried out by heating the wood samples from room temperature to the final carbonization temperature with a heating rate of 5 °C min^{-1}. After reaching the final carbonization temperature, the samples were kept for 10 minutes at constant temperature and then rapidly soaked into the sand for cooling. In the carbonization processes, the volume, vessel diameter, and cell wall thickness of the wood samples were decreased with increasing the temperature. On the other hand, the weight loss, pH, and heating value were increased with increasing the carbonization temperature.

Short-rotation coppice in a self-consumption wood energy micro-chain in central Italy: LCA analysis. Marchi, E. (*University of Florence, Italy; emarchi@unifi.it*), Verani, S. (*CRA-PLF, Italy; stefano.verani@entecra.it*), Sperandio, G. (*CRA-ING, Italy; giulio.sperandio@entecra.it*), Sirna, S., Picchio, R. (*Tuscia University, Italy; sandrosirna@unitus.it; r.picchio@unitus.it*).

Renewable energy sources are becoming increasingly important to promote sustainability and address the impacts of global warming. Woody biomass is one of the most common forms of renewable energy production. This study analyzed the sustainability of the wood-energy micro-chain realized inside the CRA-ING of Monterotondo, central Italy, with the purpose of producing woody biomass for self consumption. The energetic/environmental analyses were made by developing LCA methodology, by means of GEMIS software. The model was implemented by setting the system for the wood-energy chain as well as for other different system inputs. The woody biomass plantation was a SRC poplar with AF2, AF6, and Monviso clones. The average plantation production was 10.2 $t_{d.m.}ha^{-1}year^{-1}$. The cost of production of the fresh biomass chips was from 42.22 €/t (AF2) to 59.24 €/t (Monviso). The energetic budget of the plantation was compiled with the GER method, and gave output/input index variables from 9.6 to 16.5. The global results of emissions, for 1 kWh of warm water, was 34×10^{-3} kg CO_2eq., 19×10^{-3} kg CO_2, 21×10^{-6} kg CH_4, 45×10^{-6} kg N_2O, 22×10^{-12} kg perfluoromethane, and 3×10^{-12} kg perfluoroethane.

Influence of different types of fertilization on the growth of fast-growing tree species. Marušák, R., Kratochvilova, Z., Zahradník, D. (*Czech University of Life Sciences Prague, Czech Republic, marusak@fld.czu.cz; kratochvilovaz@fld.czu.cz; zahradnik@fld.czu.cz*).

Sewage sludge application can be an environment friendly and cost-effective way to increase biomass production on poor soil, and recycle nutrients from human residues with positive effects on the environment. Two experimental short-rotation plantations of willows (Tordis and S-smithF-218) and poplars (Maxvier and Wolterson) in the Czech Republic near Příbram have been planted, using four different types of fertilization:, sewage sludge, mycorrhizal, mycorrhizal in admixture with sewage sludge, and control (without any). Sewage sludge had a negative impact on rooting compared to the control treatment. Best results in the case of survival index were observed using only mycorrhizal fertilizer. The average dry weight of the whole plant in the case of no fertilization was only 50 percent of the dry weight of a plants fertilized by admixture of mycorrhizal and sewage sludge fertilizer. Mycorrhizal and sewage sludge separately recorded three-quarters of the dry weight. Generally, sewage sludge in most of the cases supported better growth, and best results were reached under utilization of an admixture of sewage sludge and mycorrhizal inoculation.

Short-rotation biomass production of fast-growing tree species planted in different environmental conditions. Shin, H., Yeo, J.K., Koo, Y.B., Kim, H.C., Lee, E.D. (*Korea Forest Research Institute, Republic of Korea; hannashin@forest.go.kr; jkyeo@forest.go.kr; ybkoo@forerst.go.kr; simixwiz@ynu.ac.kr; hahaha8331@hanmail.net*).

Biomass production of fast-growing tree species planted in three experimental sites having different climate and environmental conditions was compared to find most suitable poplar clones and tree species at each site. The same 21 clones of *Populus* spp., *Salix* spp., and other fast-growing tree species were planted in reclaimed land, fallow land, and riparian buffer zones. In fallow land located in the southern part of the temperate region in Korea, biomass production and the number of coppices after first-year harvesting were better and more than other sites such as reclaimed land or riparian buffer zone. A hybrid of *Populus alba* × *P. glandulosa* and a clone of *P. euramericana* showed superior survival and biomass production in all sites; however, yellow poplar (*Liriodendron tulipifera*) and silver maple (*Acer saccharinum*) were weak to salt of reclaimed land. Estimated maximum first-year biomass production was 7.8 tons/ha in case of using the Ay48 clone (*P. deltoides*) on fallow land. First-year biomass production of 72–30 clones of *Populus alba* × *P. glandulosa* and 97-19 clones of *P. deltoides* (Lux) × *P. deltoides* (Harvard) was estimated at 1.9 and 1.2 ton/year/ha in reclaimed land and riparian buffer zone, respectively as the best biomass production.

Changes of soil carbon and nitrogen with development in larch plantations of northeast China. Yang, K. (*Chinese Academy of Sciences, China; yk@dlnu.edu.cn*), Zhu, J. (*Chinese Academy of Sciences, China; jiaojunzhu@iae.ac.cn*).

Conversion of native forests to monocultural larch plantations is a common forest management strategy in northeast China. In order to understand the soil nutrient dynamics with larch plantation development, we explored soil total carbon (C) and nitrogen (N) in *Larix olgensis* plantation stands originally converted from natural secondary forests (NSF) at ages of 15, 28, and 44. Results showed that the concentrations of soil C (68.50 g kg^{-1}) and N (6.13 g kg^{-1}) in NSF stands were 1.63–2.44 and 1.65–2.44 times higher than those in the larch plantations with different ages in 0–15 cm soil layer. In the 15–30 cm soil layer, soil C and N in NSF stands were also significantly higher than those in larch plantations. Soil C and N generally decreased with stand age of larch plantations mainly due to less litter and slower decay rate. Furthermore, poorer site preparation practices, especially removal of surface litter, also played a critical role in decreasing soil C and N with stand age of larch plantations. These results suggest that compared with larch plantation stands, NSF stands are the better forest ecosystems conserving soil nutrient pools.

Association analysis for adventitious rooting traits in *Eucalyptus tereticornis* using sequence tagged site (STS) markers. Yasodha, R., Dasgupta, M., Shanmugapriya, A. (*Institute of Forest Genetics and Tree Breeding, India; yasodha@icfre.or; ghoshm@icfre.org; geopriya@gmail.com*).

Adventitious rooting in *Eucalyptus* is an economically important quantitative trait with moderate heritability. Selection of best individuals with high rooting ability determines the success of operational clonal plantations. Quantitative trait loci (QTL) controlling significant phenotypic variation in traits related to vegetative propagation have been identified in few eucalypt species using sequence tagged site (STS) markers and homeologies among linkage groups established. Use of these markers in related species requires identification and verification of the potential QTLs that control major phenotypic variation. The present study was undertaken to identify potential STS markers for rooting trait in *Eucalyptus tereticornis* following the association analysis approach. The species shows rooting variability from 10 to 90%, and phenotyping for rooting characteristics was performed by multiple settings at different seasons and years. Thirty-three STS markers linked with vegetative propagation traits, 10 mapped simple sequence repeat (SSR) markers, and 10 expressed sequence tag-simple sequence repeats (EST-SSRs) were cross-amplified in phenotypes *E. tereticornis* with contrasting rooting potential. The linkage disequilibrium (LD) value (D′) ranged from 0.49 to 0.80, and LD decay (r^2) varied from 0.02 to 0.13, which has provided the basic information to select candidate STS markers for identifying marker-trait associations in *E. tereticornis*.

C-06 Forest carbon credit markets and the forest sector

Organizers: David Bengston, *U.S. Forest Service, USA, dbengston@fs.fed.us*; Yeo-Chang Youn, *Seoul National University, Republic of Korea, youn@snu.ac.kr*; Zuomin Wen, *Nanjing Forestry University, China, zmwen@njfu.edu.cn*; Hemant Kumar Gupta, *Forest Survey of India, India, hemantgup@gmail.com.*

Flexible carbon markets and small-forest owners. Bigsby, H. (*Lincoln University, New Zealand; bigsbyh@lincoln.ac.nz*).

From the perspective of a small-forest owner, carbon markets are too inflexible to accommodate the wide variety of forest types, age class distributions, forest sizes, and management strategies that characterise this class of ownership. Two key factors contribute to the inflexibility. The first is that forest-based systems for sequestering carbon are focussed largely on creating permanent stores of carbon on defined areas of land, and with a one-off, upfront payment to the forest owner for the carbon. The second factor is that the payment system for carbon is generally based on matching a specific buyer and seller of carbon. This paper presents a flexible alternative for marketing sequestered carbon—carbon banking. Carbon banking works in the same as a financial institution, accepting 'deposits' of carbon from forest owners in exchange for an annual payment, and 'lending' carbon to those who need carbon offsets in exhange for an annual payment. This provides an opportunity for small forest owners to participate in carbon markets because payments are based only on current carbon sequestered and they receive current value for carbon rather than what effectively represents the capitalised value of the future benefits of sequestering carbon.

Evolution of Australian climate change forest policy in the post-Kyoto period (1997–2009). Harper, R.J., Buizer, M. (*Murdoch University, Australia; r.harper@murdoch.edu.au; m.buizer@murdoch.edu.au*).

Forests can be used to mitigate climate change via reforestation, replacement of fossil fuels (bioenergy), or avoidance of emissions by either improving forest management or avoiding deforestation. Australian governments (state and national) have explored a range of policy options for forests and climate, with major elements remaining constant despite changes in political incumbency. Insights from these deliberations may aid international forest policy development. Australia ratified the Kyoto Protocol in 2007, and met its Kyoto target mainly by including avoided emissions from deforestation under Article 3.7 and sequestration from the reforestation of farmland under Article 3.3. Article 3.4 forest management was not included, due to methodological concerns. Reforestation is included in an emissions trading scheme that commenced in NSW in 2003, and a national emissions trading scheme is before the national parliament. A national renewable energy target was legislated in 2009 and includes bioenergy produced from forestry. Economic modeling suggests that up to 25 million ha of farmland could be converted to carbon sinks, and as the area of arable land is limited conflicts may develop. New regulatory or financial instruments may be required to reduce conflicts and optimize environmental benefits, such as water and biodiversity enhancement, from this reforestation.

Comparative analysis of the legal framework on forest policies and carbon markets relating to climate change. Park, M.S., Koo, J.C. (*Seoul National University, Republic of Korea; mpark@snu.ac.kr; sele78@snu.ac.kr*), Chun, J.K. (*Korea Legislation Research Institute, Republic of Korea; jkchun@klri.re.kr*), Youn, Y.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*).

There are some countries in which governments have formulated and are implementing special legal instruments in response to climate change. The legislation forms the backbone of the government's strategies to mitigate and adapt to climate change. This research compares laws enacted to deal with climate change in some countries where forestry activities are vigorous. The Clean Energy Jobs and American Power Act (2009) of the United States, the Climate Change Response Act (2002) of New Zealand, the Climate Change Law (2002) of Japan, and the Basic Law draft for Low Carbon Green Growth (2009) of the Republic of Korea are dealt with. Through content analysis, these laws are analyzed with the focus on objectives, targets, participating actors, and strategies to mitigate and adapt to climate change in the field of forestry. In particular the legal systems' treatments of national carbon markets, including forest carbon credits, are intensively compared. The legal systems on forestry and climate change are interpreted with consideration of national position and global context. It is expected that this research will contribute to understanding various forest policies and carbon markets in mitigating and adapting to climate change.

The opportunities for forest carbon projects in the U.S. voluntary carbon market. Seol, M.H., Cao, X. (U*niversity of Washington, USA; mistral@u.washington.edu; caoxz@u.washington.edu*), Youn, Y.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*).

Forestry projects have been popular for carbon offsets because forests efficiently sequester carbon, have emotional appeal to consumers, and contribute to the enhancement of biodiversity. While Europe has retreated from forest projects, the U.S. carbon market shows a different development pattern. In our research, 107 carbon offset providers, consisting of 30 U.S. (28%), 27 UK (25%), 12 Canadian (11%), 19 EU except for UK (18%), 15 Australia/New Zealand (14%), and 4 others (4%), were identified by the Carbon Catalog and analyzed. By type of organization, providers included 73 profit-oriented companies (POCs, 66%) and 34 non-profit organizations (NPOs, 34%). The means of carbon offset prices were significantly different among regions ($F = 6.44$, $df = 5$, $p < .000$). Tukey's test clarified that the mean of U.S. prices ($13.82) was significantly lower than that of the EU ($29.84; $p<.000$). The mean number of projects that NPOs conducted (4.62) was significantly higher than conducted by POCs (2.96; $t = 2.031$, $df = 105$, $p < .05$). In the U.S. carbon market, 15 organizations conducted forestry projects (50%); 6 of 15 conducted only forestry projects; and 4 of these 6 were NPOs. The mean number of projects that NPOs conducted (4.08) was significantly higher than conducted by POCs (2.71; $t = 1.159$, $df = 5$, $p < .05$).

Urban forests and carbon credits: assessing the market potential. Siry, J., Poudyal, N. (*University of Georgia, USA; jsiry@warnell.uga.edu; npoudyal@warnell.uga.edu*), Bowker, M. (*U.S. Forest Service, USA; mbowker@fs.fed.us*).

Urban forests have great potential to sequester and store large amounts of carbon. Maintaining tree coverage and selling carbon credits could help local governments become involved in climate mitigation actions. However, the role of urban forests in carbon

sequestration has been to date largely overlooked. We know little about willingness and motivations that local governments have for increasing carbon storage and that potential buyers have for purchasing urban carbon credits. A survey of local governments in the U.S. revealed that their willingness to participate in carbon markets was driven by the degree of urbanization, awareness of their voting constituents, and need for additional revenues. The results also suggested that local governments would benefit from better understanding of costs and benefits associated with urban forest carbon storage. We are now analyzing the results of a survey of potential buyers of urban forest carbon credits associated with the Chicago Climate Exchange to assess their interest in acquiring carbon credits generated by urban forests and willingness to pay price premiums for improving their environmental image. Both surveys will be used to develop an urban forest carbon sequestration protocol that will facilitate the creation of markets for urban forest carbon credits.

Mixed economic instruments for forest carbon credit markets. Wen, Z. (*Nanjing Forestry University, China; zmwen@njfu.edu.cn*).

In order to mitigate global warming, many governments have demonstrated their commitment to implement the target of the Kyoto Protocol. This has caused the emergence of carbon markets to make greenhouse gases a commodity to be traded in the world. The global externality caused by carbon emissions has created extensive concern in the international community. According to the polluter pays principle, the market mechanism could be introduced into carbon trading to reduce the externalities associated with carbon emissions, with external economies changed into ecological benefits and external diseconomies changed into ecological costs. Based on profit maximization, different private costs of mitigating carbon emissions could stimulate carbon trading, with variation in price reducing externalities. This paper systemically analyzes various elements of carbon credit markets using externality theory, and discusses the impacts on forest carbon credit markets of using mixed policy tools. Introducing the state of development of the carbon market in China after the Kyoto Protocol could support the analysis of carbon sequestration policies, and increase understanding of trends in the forest carbon credit market of tomorrow.

Willingness-to-pay of the private sector for forest carbon offset projects: the case of South Korean companies. Youn, Y.C., Koo, J.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr; sele78@snu.ac.kr*).

The Republic of Korea is preparing a carbon credit market that is meant to facilitate the participation of the private sector in efforts to reduce greenhouse gas (GHG) emissions. Apart from the compulsory commitment to reduction of GHG required by the regulation of the government, private corporations could consider participating in voluntary emission reduction through carbon offsets such as tree planting. This research aims to estimate the willingness-to-pay of private companies in South Korea for carbon offset credits from forestry projects such as forest management, afforestation, reforestation, and/or REDD (reducing emission from deforestation and forest degradation). We conducted a survey of 200 small and large corporations engaged in manufacturing and service. We used a double bounded contingent valuation logit model to elicit the value of willingness-to-pay for carbon offset credits per ton of CO_2 equivalent. The null hypothesis was that there is no difference in the willingness-to-pay between groups of corporations categorized by type of business and size, and their commitment to sustainable business management gauged by their membership in the Global Compact initiative of the United Nations and the Korea Business Council for Sustainable Development.

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The present status of the treatment of forest sections in main countries' emission trading systems. Choi, S.I., Joo, R.W., Bae, J.S. (*Korea Forest Research Institute, Republic of Korea; csi9626@forest.go.kr; rwjoo@forest.go.kr; forestroy@forest.go.kr*).

Emission trading systems are one means of greenhouse gas reduction, which make use of the market mechanism to control total emissions from greenhouse gas sources. Under emission trading systems, the EU excluded the forest sector due to the non-permanence of forests and the imperfect solution to the problem of leakage. On the other hand, the USA, Australia, and Japan acknowledge afforestation, reforestation, and forest management activities as carbon offsets, contributing to the cost-efficient mandatory reduction of greenhouse gases. It is desirable that the forest sector be included as a carbon offset business, a flexible system, rather than be included in the allocated market of emissions trading when adopting Korean total mass emissions trading, because it can lead to sustainable forest management by acknowledging the absorption of greenhouse gases by forests. In addition, the type of the forest sector participating may depend on the result of negotiations on the compulsory reduction of Korean post-2012 greenhouse gas and on the inclusion of the LULUCF, so sufficient time needs to be set aside in order to reflect the results of the negotiation.

Carbon credits: a new horizon in mitigation of climate change in the Himalayan region. Khosla, P.K. (*Shoolini University Biotechnology and Management Sciences; India; khoslapk_2001@rediffmail.com*).

India, particularly the Himalayan states, can take advantage of its green wealth to earn carbon credits. The issue is elaborated with a case history of HP, located in the western Himalaya. The state has taken a lead in mitigating climate change through carbon sequestration. Earlier, forest harvesting constituted a prime source of revenue; but now, standing trees can yield more income through carbon credits. Comprehensive policy following a whole-landscape approach to reducing emissions and managing carbon stocks is highlighted. Carbon gains are credited for afforestation, reduction in deforestation, and increases in management intensity. Selections of productive genotypes, especially fast-growing trees like poplar, are enumerated. Approaches using agroforestry systems in agroclimatic zones are discussed, whereby trees provide additional income and diversity of food sources besides carbon enhancement. Use of hydropower projects and energy-saving mechanisms are discussed in terms of earning carbon credits. The paper highlights success stories showing that technologies are widely adopted when their scientific principles are understood and socioeconomic benefits are convincing. How far these approaches are successful in achieving capacity building of communities and carbon sequestration are discussed.

Modeling the measurement of environmental services of forest carbon sinks in China. Zhang, Y. (*Beijing Forestry University, China; zhangyin@bjfu.edu.cn*).

In order to promote the development of markets for environmental services in China, we created a measurement model of forest carbon sinks and analyzed characteristics of this model by the forest stock-converted method using national forest inventory data from 1990 to 2007.Our results show that the goodness of fit R^2 is 0.998 for the measurement model of forest biological carbon sinks, the F-value is 6581.48, and its corresponding P-value is 0.00, which indicate that the model has strong statistical significance. We then applied the minimum value method in economic cybernetics based on the measurement model and calculated the optimal trade-off price of forest carbon sinks in China, which is $10.11-$15.17/tC. This value is slightly greater than the international carbon tax at present. We also calculated the minimum volume of forest harvesting due to consumption of carbon reserves related to economic development in China, and suggest it should be 426 million m^3 per year. We further suggest that the shadow prices of estimation of forest carbon sinks should be used in the carbon market, and the cultivation cost for plantations should be reduced so as to promote the development of forest carbon sink markets in China.

C-07 To what extent can payments for forest environmental services be pro-poor?

Organizers: Stephen Garnett, *Charles Darwin University, Australia, Stephen.Garnett@cdu.edu.au;* Terry Sunderland, *CIFOR*, *Indonesia, r.septiva@cgiar.org.*

Payments for forest environmental services: institutional forms and experiences in Eastern Africa. Okwuosa, E.A. (*Kenya Agricultural Research Institute, Kenya; adaobiokwuosa@gmail.com*), Wario, A. (*Moi University, Kenya; wradano@yahoo.com*), Mogaka, H. (*Association for Strengthening Agricultural Research in Eastern and Central Africa, Uganda; h.mogaka@asareca.org*), Omondi, H. (*Moi University, Kenya; hro.opiyo@hotmail.com*), Byamukama, B. (*Nature Harness Initiatives, Uganda; bbyamukama21@yahoo.com*), Nsombo, B. (*University of Kinshasa and INERA, Democratic Republic of Congo; blandinensombo@yahoo.fr*).

The conventional approach to addressing forest conservation in eastern Africa focuses on government-led conservation measures directed to conform to strict guidelines of access by forest-adjacent communities who view forests as an important source of livelihood. These restrictions have not altered the current pace of forest destruction leading to deterioration in quality of environmental services. New forest policy tools are required to create or consolidate the shift in forest management from the traditional production function towards more multi-stakeholders and multi-functional goals with a focus on local livelihood improvement. On the basis of existing synthesis literature describing payment for environmental services (PES) and by means of analysis of selected case studies that have attempted to establish successful PES schemes in the context of watershed management and carbon sequestration, this paper seeks to analyse the potentials and challenges in different institutional forms applied in these schemes. The analysis shows that markets for forest services have different drivers, sizes, and levels of maturity. Performances in effectiveness, equity, relevance, and resilience are highly variable between schemes, and the strength of any scheme lies in improving livelihoods of forest-adjacent populations.

Hearing voices from the poor: effective communication of PES ambitions and capabilities. Petheram, L. (*Charles Darwin University, Australia; lisa.petheram@cdu.edu.au*).

The concept of people paying for the provision of environmental services has percolated down from the powerful to the poor. A new market has arisen from this top-down process that might advantage poor people, but rarely has it been possible for the poor to communicate their own perspectives on the design of pro-poor PES schemes. This powerlessness is often exacerbated by high levels of illiteracy and difficulty in understanding many of the concepts underpinning PES or the constraints in its application. We discuss the value of involving poor providers and their perspectives in the development of PES projects, so that their poverty needs are incorporated into scheme design. We suggest that incorporating these perspectives is likely to lead to more effective PES projects, where participants are more willing to participate and adhere to PES rules and conditions. Experiences from working with indigenous people in Cat Tien National Park in Vietnam will be presented. The research provides insight into factors important to consider when working with potential providers to understand their perspectives on PES.

PES for the poor: lessons from Vietnam. Pham, T.T., Garnett, S.T. (*Charles Darwin University, Australia; brissiesugar@gmail.com; Stephen.Garnett@cdu.edu.au*).

"Payments for environmental services" is a relatively new concept in Vietnam, and the government has recognized potential of the idea to help the rural poor emerge from poverty. Participants in a range of pilot schemes around the country were interviewed to understand the issues that need to be considered if pro-poor PES is to be effective in a country with a strong central influence at all levels of governance, from the national to the local. At most sites independent third parties had been instrumental in negotiating PES, although government remained the strongest player. Prices paid for services covered costs in only a few of the cases, and would not have covered transaction costs except that these were covered by donors. Effective PES also drew heavily on voluntary contributions from farmers who were keen to see pilot schemes work. Lessons from pilot schemes will need to be incorporated into protocols and institutionalized if efficiencies in setting up PES schemes are going to benefit the poor. There will also need to be transparent systems established to enable equitable distribution of benefits from purchaser to provider.

Why are poor people to be engaged in PES schemes? Suh, S.E. (*Seoul National University, Republic of Korea; bobysarang@hotmail.com*).

Payment for ecosystem services (PES) is actually separate from the valuation of nature's own value (absolute, innocent), which encourages the incommensurability issue; rather, PES faces the conflicts within human society, questioning how to utilize

nature-based property rights. PES enables trade-offs for payers and actors: (1) payers can enforce/project/reflect/transfer their norms or policies over other authorities with payment; and (2) actors can change B.A.U. performances or income sources with compensation. Payers may worry about the possibility of leakage or policy ineffectiveness, and actors may worry about the potential of permanent economic dependency, or loss of future development opportunities. It is true that the cost of environmental services will rise as the actors' incomes grow, or as their awareness of schemes and negotiation skills are improved. It is also true that PES is cost-effective when it is targeted to the poorest actors as an incentive system. Even with many barriers to overcome—such as transaction cost of communication, abysmal power of negotiation, heterogeneous coalition of individuals and communities, illegal use or occupation of nature, and poor knowledge for implementation—PES will work effectively as long as payers have more money than actors, and those actors live close to nature.

C-08 Culture, Economics, and Sustainable Forest Management

Organizers: Shashi Kant, *University of Toronto, Canada, shashi.kant@utoronto.ca*; Martin Hostettler, *Cycad, Switzerland, martin.hostettler@cycad.ch*; Hans Heinimann, *ETH, Switzerland, hans.heinimann@env.ethz.ch.*

Landowner's discount rates and forest management behavior: is there a link? Atmadja, S. (*Center for International Forestry Research, Indonesia; s.atmadja@cgiar.org*)**,** Sills, E. (*North Carolina State University, USA; erin.sills@ncsu.edu*).

Discount rates are fundamental parameters in forest economics. They measure willingness to trade current consumption with investment for the future; those with high discount rates are less willing to reduce current consumption for future returns. For example, higher discount rates are theoretically associated with shorter rotation lengths. But empirical estimates of discount rates and their relationship with forest management decisions are scarce. We address this by testing the link between forest management behaviors and discount rates of small, limited resource woodland owners in North Carolina and Virginia, elicited through a choice experiment involving a series of trade-off questions between two harvesting scenarios. As expected, landowners with higher discount rates are more likely to have harvested in the recent past. However, discount rates are poor predictors of behaviours such as contacting foresters for management assistance, and investing in timber stand improvement. Written wills – which are crucial for safeguarding land inheritance of future generations – are (unexpectedly) more likely among landowners with high discount rates. Thus, the empirical importance of discount rates is not uniform across behaviours. In many cases, other factors – such as acreage, distance to woodland, and tenure – are more closely related to forest management behaviour.

Describing the real forest: non-blackboard forest economics. Hostettler, M. (*Cycad, Switzerland; martin.hostettler@cycad.ch*), Deegen, P. (*TU Dresden, Germany; deegen@forst.tu-dresden.de*).

Ronald Coase criticized economics for its blackboard approach. Following his suggestion we present a novel approach to forest economics, which emphasizes dynamic social coordination and disequilibrium. Rapidly leaving the magic forest of Robinsonian optimizing and instantaneous Walrasian exchange, the second best forest is described by frictional Coasean exchange. But looking back, we learn that our enriched models of the market process still explain only a minor part of what we really observe. We leave the market square and enter the public square. Further on we introduce politics without information and romance. This third best world is governed by myopic self-interested individuals processing really sparse information (Hayekian knowledge problems). Major procedures for social coordination (shaping forests) are democracy, bureaucracy, and corporatism, producing important phenomena such as rent-seek and agency costs. Thinking about time and institutional change, we finally incorporate Austrian insights such as Knightian uncertainty, equity capital, residual income, Kirznerian discovery and entrepreneurship, or Smith-Menger-Hayek-Polanyi type of coordination (spontaneous order). Describing real forests is complexity science. Muddling through with trial and error is probably the best advice one can give to students of forest economics.

Non-anonymous behavior of aboriginal people. Kant, S. (*University of Toronto, Canada; shashi.kant@utoronto.ca*), Vertinsky, I. (*University of British Columbia, Canada; Ilan.Vertinsky@sauder.ubc.ca*).

The standard assumption of anonymity among different interacting agents may hold for the market situations. However, in resource management situations, specifically in community and Aboriginal context, most of the interactions are non-anonymous. Hence, for forest management decision making, an understanding of the preference of the members of a specific group with respect to the members of other group is critical. We organized behavioral experiments–Dictators Game, Ultimatum Game, Trust Game, and Social Capital Game–in an Aboriginal community (First Nation) in Canada. The participants were asked to reveal their preferences, through four different games, with respect to members of five different groups. The groups included an anonymous group, two-groups based on gender (man and woman), and three groups based on age (young, middle-aged, and elder). Fifty-eight people (29 males and 29 females) from the community participated in these games. In this paper, we present a theoretical framework for non-anonymous human behavior and empirical findings, based on the statistical analysis of four games data, from the Aboriginal community in Canada. We also discuss implications of these findings for forest management in Canada.

Faustmann model in a real world. Zhang, Y. (*Auburn University, USA; yaoqi.zhang@auburn.edu*), Kant, S. (*University of Toronto, Canada; shashi.kant@utoronto.ca*).

The Faustmann model is often claimed as the golden rule of forest management and the cornerstone of forest economics. However, only a limited number of forest managers, in developing as well as developed countries, are aware of the Faustmann model, and many of them feel that the model does not incorporate real situations. Conceptually the model does not incorporate context-dependent and dynamic preferences, and therefore the model cannot explain diversity of forest rotations/forest harvesting decisions followed by forest managers that are based on biological maturity of forests, sustained timber supply based on the production capacity of a manufacturing-unit, and economic and social needs of private forest owners. Similarly, the estimated land values based on Faustmann Model are unable to reflect the market values of forestland. For example, the market values of

large number of forestlands, sold to the timberland investment management organizations (TIMOs) and the real estate investment trusts (REITs) in the USA, are quite different than the Faustmann-model-based land expectation values. In this paper, we discuss many issues that contribute to the differences between Faustmann model outcomes and observations from the real world. We also suggest mechanisms to reduce these gaps between theory and real world.

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Impacts of China's changes on Japan and other main countries' forest sectors. Michinaka, T., Tachibana, S. (Forestry and Forest Products Research Institute, Japan, *zhangyf@affrc.go.jp;* binn@affrc.go.jp), Turner, J.A. (*SCION, New Zealand, James. Turner@scionresearch.com*), Hori, Y., Hirano, Y. (*Forestry and Forest Products Research Institute, Japan, horijas@affrc.go.jp; hiranoy@affrc.go.jp*).

The objective of this research is to analyze the impacts of China's changes in domestic market and international trade in forest products on Japan and other main countries' forest sectors by adopting the Global Forest Products Model (GFPM), a dynamic economic equilibrium model dealing with 180 countries and mainly 14 forest products. First, price and income elasticities of demand for global forest products are estimated by adopting cluster analysis and panel analysis. Cluster analysis is introduced by grouping countries by their level of per capita GDP, per capita consumption of forest products, and forest coverage rate. Panel analysis is then undertaken for every cluster, and price and income elasticities for every cluster are estimated. Second, by using a new set of the elasticities of demand and different sets of input data, including GDP, forest resources, etc., we simulate the global forest sector in the GFPM model. For making scenarios of Chinese socio-economic and forest sector situations, we conduct field surveys of Chinese forest management, processing industry, and so on. We analyze long-term projections for global forest products production, consumption, and trade; and the impacts of China's changes in domestic market and international trade in forest products on global forest sector.

Introduction effects of forest certification on the domestic market of shiitake mushroom in Korea. Shin, H.J., Kim, E.G., Ahn, B.I. (*Gyeongsang National University, Republic of Korea; neoria@gnu.kr; egkim@gnu.kr; ahn@gnu.kr*), Kim, J.S. (*Korea Forest Research Institute, Republic of Korea; jskim99@forest.go.kr*).

Using the equilibrium displacement model, this study aims to simulate the effects of introducing the shiitake mushroom market to forest certification. For the study, we applied the model to certification expenses for FSC-certified forests over 5,000 ha until December 2009. Simulation scenarios are classified as six sorts, considering marginal certification costs and the rates of import price changes. In these simulation scenarios, we used minimum, maximum, and mean marginal costs on the certification expenses in Korea when the rates of import price change were zero or −5%, −10%, and −15%, based on DDA tariff reduction scenarios. Simulation results show that the equilibrium quantity has a slight falling tendency and price is a little increasing: Q: −0.074 to −0.013%, P: 0.02 to 0.06% in fresh shiitake market, and Q: −2.4E-06 to −7.7E-06%, P: 1.7E-06 to 9.3E-06% in dried shiitake market, when the rate of import price change was zero. While equilibrium quantity and price has an upward tendency: Q: 3.2 to 9.7%, P: 8.5 to 25.5% in fresh shiitake market and Q: 1.9 to 4.0%, P: 2.3 to 7.0% in dried shiitake market, when the rates of import price change were −5% to −15%.

C-09 Economic valuation of forest ecosystem services

Organizer: Mohammed Ellatifi, *Sylva-World, Morocco; mellatifi@yahoo.fr.*

Economic valuation of watershed functions of transboundary forests in eastern and central Africa. Adano, W.A., Omondi, H., Kipkoech, A. (*School of Environmental Studies, Kenya; wradano@yahoo.com; hro.opiyo@hotmail.com; akkipkoech@gmail.com*), Mogaka, H. (*ASARECA, Uganda; h.mogaka@asareca.org*).

Economic theory stipulates that under perfect conditions markets allocate resources in a sustainable manner. However, externalities are common with trans-boundary resources because of uncoordinated regional policies that result in inefficient allocation and unsustainable use of environmental resources. This paper uses household production and contingent valuation approaches to value watershed functions of the Mt. Elgon (Uganda/Kenya border) and Albertine Rift (Uganda/Democratic Republic of Congo border). Cross-sectional data were obtained from households, and time-series data were obtained from the organizations that manage or exploit forest resources. In these landscapes, water is commonly used for rural domestic use, irrigation of crops, and to supply urban populations. The expansion of agricultural activities and human settlement has fragmented forest habitats, increased water abstraction for irrigation, and negatively influenced water quantity and quality. A model relating farmland expansion and climate change to the forest-based water supplies predicts decreased forest-supported hydrological services. Any alterations in the current forest-cover and composition would significantly affect ecosystem services and reduce food production and incomes of the vulnerable forest-dependent communities. Putting a price on ecosystem services across boundaries can link potential sellers of the forest services to the emerging markets for payment for environmental services involving the forest-adjacent communities.

Avoided deforestation opportunities and biodiversity conservation challenges of mining in Guyana: torn between two lovers. Caesar, J.C. (*University of Guyana, Guyana; jccaesar@yahoo.com*).

Guyana's rainforests provide a plethora of ecosystem services that support and sustain the well-being of its citizens and more so its indigenous peoples who are more culturally dependent on forest biodiversity and related services. Emerging from national climate mitigation forest policy advocacy is a draft national low carbon development strategy recently launched with extensive public consultations as the nation's blueprint for climate-friendly sustainable development. Guyana's climate change era forest conservation and ecology policy on avoided deforestation seeks to provide a model economic valuation construct for rewarding developing countries endowed with large pristine rain forests with the requisite economic returns on ecological services provided for climate change mitigation. In so doing local initiatives would ensure sustainable development and the achievement of

millennium development goals without overdependence on massive forestry and mining activities detrimental to avoided deforestation. The concept engenders other types of sustainable economic development, minimizing deforestation and devolving to the well-being of local communities and indigenous peoples. The challenge is how best to handle sustainable mining and forestry activities without jeopardizing the rigorous REDD Monitoring, reporting and verification system. We discuss emerging policy and related governance structure provides possible solutions.

Valuing the tradeoffs of Tunisian forest plantations. a choice experiment application. Daly-Hassen, H. (*INRGREF, Tunisia; dalyhassen.hamed@iresa.agrinet.tn*), Riera, P. (*University of Barcelona, Spain; prieram@gmail.com*), Mavsar, R. (*EFIMED, Spain; robert.mavsar@efi.int*), Gammoudi, A. (*INRGREF, Tunisia; nour_elhoudag@yahoo.fr*).

Successive afforestation programs were undertaken in Tunisia that tripled the forest surface area in the past 50 years. Forest plantations can offer many environmental services, such as reduction of dam sedimentation, carbon sequestration, and enhancement of biodiversity, in addition to recreation. On the contrary, management of forest plantations may restrict the use of the forests for grazing and collection of forests products for the local population. In this paper, we used the choice experiment method to estimate the change of the social-welfare due to the changed availability of different forest goods and services. The obtained results show that, decreased sedimentation of water dam capacities by 1% would increase the social welfare by $US 1.83 per person and year, and increased carbon sequestration would increase the social welfare by $ 0.05 per ton of CO_2 sequestered. In contrast, limiting access to the planted areas for local population for grazing and other uses would decrease the welfare of the society by $ 4.23 per year. These results underline the tradeoffs between the environmental benefits and the community forest uses.

Bundling of ecosystem services to increase forest value and ensure sustainability. Deal, R.L., Zhou, X. (*U.S. Forest Service, USA; rdeal@fs.fed.us; xzhou@fs.fed.us*).

There has been increasing interest in the use of market-based approaches to add value to forestland and to assist with conservation of natural resources. While markets for ecosystem services show potential for increasing forestland value, there is concern that the lack of an integrated program will simply add to the complexity of these services without generating significant public benefits. These fragmented programs often result in the restoration of many small sites that lack ecological integrity and are unlikely to offer the benefits provided by protection of larger and more contiguous areas. An integrated approach that combines or bundles services and provides financial incentives for forest landowners may be more effective to achieving broad conservation goals, including fish and wildlife habitat, improved watersheds, carbon sequestration, and other ecosystem services at an ecologically relevant scale. We outline policy and regulatory frameworks for some of the emerging markets for ecosystem services in the USA, and discuss the role that different regulatory agencies play for each of these services. We then assess the potential benefits for bundling different ecosystem services including carbon credits, water quality trading, and wetland and species mitigation banking, and develop an integrated approach for bundling these services.

Ecosystem services and conservation of biodiversity in the Atlantic forest of Brazil, Ditt, E.H. (*Instituto de Pesquisas Ecológicas, Brazil; eduditt@ipe.org.br*), Knight, J.D. (*Imperial College London, UK; j.d.knight@imperial.ac.uk*), Mourato, S. (*London School of Economics, UK; S.mourato@lse.ac.uk*).

Increasing belief in the potential contribution of market based mechanisms for conservation has been stimulating the creation of systems of payments for ecosystem services (PES). For planning these systems it is crucial to understand ecosystem services' values and how they are affected by land use changes. The current study focuses in these issues in a set of catchments in the Cantareira water supply system in Brazil. Assessments of ecosystem services integrated with geographical information systems, followed by application of techniques of valuation, resulted in the creation of economic value maps in alternative land use scenarios. The estimated total economic value (TEV) of ecosystem services in 7,624 hectares of land in the study area would be US $49.4 million per year if the landscape were entirely occupied by forest. More than 90% of this value refers to the service of removing carbon dioxide from atmosphere. However, in the current land use scenario, estimated TEV is reduced to US $30.7 million per year due to conversion of native forests. The economic value maps indicate how these values can be split and spatially distributed for addressing PES properly. These procedures can be useful in policies and private mechanisms to integrate business with conservation.

Valuating forest environmental services: a way to combat deforestation and forest degradation. Ellatifi, M. (*Sylva-World, Morocco; mellatifi@yahoo.fr*).

Like all forests, Mediterranean forests provide a wide array of benefits. But the most important of these benefits are environmental services. Very often, due to market failure, official statistics reflect only marketed, tangible forest products. The values of many environmental forest services are not captured, and not taken into account in national GDP calculations. This situation results in minimizing the total economic value of these forests, and generating more pressure on forest resources, causing deforestation and forest degradation. This paper gives a review of the situation in the Mediterranean region. It also presents new methods to enhance the estimation of environmental forest services, and correctly represent the forests in the national GDP. Such enhancement of forest value in national economic statistics will help decision makers make the right decisions vis-à-vis the forests and, therefore, help to combat deforestation and forest degradation.

Aesthetics and values of forest landscapes in central Europe. Gruehn, D. (*Dortmund University of Technology, Germany; dietwald.gruehn@udo.edu*).

Recent landscape preference studies reveal that scenic quality to a considerable extent depends on the provision of landscapes with forests. In most central European countries more than 30% of total area is covered by forests, such as in Germany. At present forest landscapes are subjected to conditions of forest management innovation as well as climate change. Hence, large-scale changes of forests in the future with regard to their structure, habitats, or diversity are likely. A survey was carried out among inhabitants of different parts of Germany, questioning about demographic factors (e.g., sex, age, school, and professional

qualifications, importance of nature and environment, frequency of outdoor trips) as well as different scenic qualities such as variety, uniqueness, and beauty of forest landscapes. The study explores various factors to account for variability in preference judgments for particular forest landscape scenes. Variance is examined and discussed in relation to level of preference/scenic quality, in relation to possible group differences, and in relation to landscape ecological factors, (e.g., forest type on different levels of phytosociological hierarchy), as well as biodiversity indicators. Potential impacts of climate change and modification of forest management methods are also discussed.

Valuation of forest ecosystem services and natural capital of a western Himalayan watershed: a case study. Gupta, H. (*Ministry of Environment and Forest, India; hemantgup@gmail.com*), Gupta, A. (*Loreto Convent, India; anuguptaevs@gmail.com*).

Forest ecosystem goods and services and the natural capital stocks that produce them make great contribution to national economy and human welfare both directly and indirectly. This paper evaluates the economic value of natural capital stocks and the annual output flow of forest ecosystem goods and services taking a western Himalayan watershed as a case study. Based on literature reviews and the context of the case study site, the framework, contents, and methods for forest ecosystem valuation have been analyzed and selected. Forest conservation is for multiple uses, that is, consumptive and non-consumptive commercial uses. For example, forests are used for water regulation and recharging of ground water, soil conservation, protection of habitat and wildlife, biodiversity, ecosystem services, micro-climatic functions, and carbon sequestration. These non-market forest benefits mainly contributed to the non-forestry sector of the economy and to the social groups who did not own and manage the forests. The analysis of the distribution of forest benefits indicates that the value of forest goods and services to non-forestry sectors of the economy accounted 92% of the total flows for the water and environmental sector. Extensive policy implications were analyzed as per the results of the forest valuation study.

Forest eco-compensation in the context of pipeline constructions in Georgia. Kimeridze, M. (*GTZ, Georgia; mariam.kimeridze@gtz.de*), Herbst, P. (*IUFRO, Austria; hp@net4you.at*), Susan, Ch. (*UNIDO, Austria; c.susan@unido.org*).

Disagreement between the government of Georgia and international oil corporations on eco-compensation measures required to off-set environmental damages caused by large scale oil and gas pipelines resulted in the application of the habitat-hectare methodology to define the necessary scope of eco-compensation measures for environmental damages related to the construction of the pipelines. The habitat-hectare scoring method is a common approach to determine the value of vegetation in non-monetary units. The habitat score is derived by assessing a number of site-based habitat and landscape components against a pre-determined "benchmark." Benchmarks have to be defined for different ecological vegetation classes (EVCs). In total, 262 plots with a total area of 141.82 ha of land classified as forest were assessed using the habitat-hectare methodology. The total value of these forest areas amounts to 80.51 habitat-hectares. The scope of the eco-compensation measures required to assure that no net loss in forest habitats occurs depends on the period of time the party causing the deforestation can be committed to look after the afforestation. Depending on the EVC and the condition of the forest at the moment of clearing, the compensation ratio for the care-taking period varied from 1:2.5 up to 1:6.8 ha.

Urban dwellers' willingness to pay for recreational services of urban forests in Korea. Koo, J., Park, M., Chun, J., Youn, Y. (*Seoul National University, Republic of Korea; sele78@snu.ac.kr; mpark@snu.ac.kr; andrew78@snu.ac.kr; youn@snu.ac.kr*).

Approximately 90% of Korean people live in urban areas. Demand for urban forests is increasing. To provide suitable urban forest services, it is valuable to evaluate urban forest policies. There are several methods to evaluate the value of forests and the effects of forest policies. This research attempts to apply a choice experiment in evaluating the consumer's willingness to pay (WTP) for using an urban forest. The choice experiment is a suitable method for evaluating environmental goods with multiple attributes. The effects that each attribute contributes to the consumer's WTP are measured by comparing parameters of attributes. Respondents are allowed to evaluate trade-offs between entrance fees and five attributes of an urban forest, including size, gradient, biodiversity, accessibility, and education programs and signage. Some 800 dwellers from urban areas responded to the survey through face-to-face interviews. As a result, this research offers three key pieces of information: the annual willingness to pay (WTP) per person for using urban forests, the most significant attributes of urban forest values, and the indirectly measured values of urban forests. This research is expected to provide policy-makers with quantitative information for selecting appropriate policy alternatives.

Ecosystem services evaluation for a subtropical evergreen broadleaved forest ecosystem in the Three Gorges Areas of China. Liangyi, R. (*Beijing Forestry University, China; raoliangyi@bjfu.edu.cn*).

This paper evaluates the services of a subtropical evergreen broadleaved forest ecosystem in the Simian Mountain National Forest Park in Three Gorges Areas of China by using the methods of opportunity-cost and market price replacement etc. Six types of values of forest ecosystem services—including water conservation, soil conservation, air purification, carbon dioxide fixation, biodiversity maintenance and tourism—are calculated based on field forest resources investigation data, statistics data from a local travel agency, and related published studies and reports. The water conservation service includes two aspects, such as water yielding and water quality protection; while the soil conservation service includes three aspects, such as soil immobilization, fertility preservation, and soil erosion and sediment mitigation. The results indicate that the annual gross forest ecosystem services values in this area amount to 978.24 million yuan, of which 235.5million yuan are for water conservation service, 139.85 million yuan for soil conservation service, 193.25 million yuan for carbon dioxide fixation service, 140.34 million yuan for air purification service, 158.90 million yuan for biodiversity maintainence service, and 110.4 million yuan for tourism service. The methods for evaluating the services of subtropical evergreen broadleaved forest ecosystem and the potential factors influencing ecosystem services values are also discussed in the paper.

Successful valuation and compensation for forest ecosystem services: a policy dilemma. Mason, L., Lippke, B. (*University of Washington, USA; larrym@u.washington.edu; blippke@u.washington.edu*).

In a less constrained world, ecosystem services provided by forests were historically taken for granted as infinitely available and cost-free. Today this is no longer the case, as indicated by growing public concern about the sustainability of wildlife habitats,

clean water, carbon sinks, view sheds, and other non-market forest values. Non-governmental organizations have attempted to incentivize provision of forest ecosystem services. Three examples of programs instituted to promote provision of forest ecosystem values include forest certification, tradable development rights, and credits for carbon sequestration. The comparative effectiveness and potential for unintended consequences for these three program types will be discussed. Another possibility for rewarding provision of sustainable forest ecosystem services, however, may be governmental imposition of greenhouse gas emission reduction policies that favor wood utilization over polluting non-wood product alternatives. The potential for green building standards coupled with carbon taxes to deliver surrogate reward for provision of forest ecosystem services will be considered. While not tied directly to ecosystem services such as wildlife habitats or view sheds, statutory recognition of the role of forests in greenhouse gas emissions reductions may offer new market support of forest ecosystems while sustaining wood product streams, increased renewable energy, and viable forest industries.

Economic value of rehabilitated areas (forest and land) as the basis for incentive system arrangements at Nglipar sub district, Gunung Kidul district, Yogyakarta-province, Indonesia. Nurfatriani, F. (*Ministry of Forestry Indonesia, Indonesia; nurfatriani@yahoo.com*).

One effort to improve the function of forest and land at Nglipar is through conducting forest and land rehabilitation (FLR) using the agroforestry pattern. Currently, it is predicted that there is a gap between total benefits from FLR activities and the tangible benefit received by the farmers who are involved in FLR activities. For these reasons, economic valuation of all benefits produced from FLR activities, both tangible and intangible, is necessary. This research aims to elaborate total economic value (TEV) of FLR results as the basis for an incentive system arrangement. TEV is calculated by using the market price, replacement cost, and contingency valuation methods; and it is based on estimating direct use, indirect use, option, and existence values. The result shows that the TEV of FLR in Kecamatan Nglipar is Rp 95.8 billion/year, of which 19.41% is direct benefits, 2.33% is indirect benefits, 2.05% is option value, and 76.2% is existence value. If the existence value is excluded, the TEV reaches Rp 22.8 billion/year, of which the highest value is direct-use value (81.57%), followed by indirect use value (9.80%) and option value (8.63%).

Valuing the benefits of dryland forest restoration in central Chile. Schiappacasse, I. (*Universidad de Concepción, Chile;ignacio.shiappacasse@gmail.com*), Nahuelhual, L. (*Universidad Austral, Chile; lauranahuel@uach.cl*), Vásquez, F., Echeverría, C. (*Universidad de Concepción, Chile; fvasquez@udec.cl; cristian.echeverria@udec.cl*).

Agricultural and urban expansions have led to loss and degradation of forest landscape in central Chile. In 3 decades (1976–2008), 38% of dryland forests have disappeared, causing a serious decline in ecosystem services. At present their value and the evaluation of whether restoration is cost-effective have not been studied in Chile. Our objectives were: (i) to determine the traditional patterns of dryland forests use; (ii) to explore the attitudes of local people towards restoration actions; and (iii) to estimate the net benefit of dryland forest restoration. Research methods combined participatory surveys and structured interviews. To determine benefits of forest restoration, the structured survey included contingent valuation questions that allowed for the calculation of willingness to pay measures. We used satellite imagery to analyse landscape changes and estimate the restoration costs. Overall results suggest that low income and lack of productive alternatives induce local people to carry on forest-extractive activities that promote landscape degradation. There is a substantial benefit of restoring forest ecosystem services in Colliguay (US$ 85,950), although this amount is substantially less than the estimated costs of restoration (US$ 273,000). A pending challenge is the need to explore compensation mechanisms that encourage landowners to engage in forest restoration practices.

Valuation of forest ecosystem services in China: a meta-analysis based approach. Wu, S., Meng, X., Li Z. (*Chinese Academy of Forestry, China; wu.shuirong@gmail.com; mxj517@sina.com; zyli@caf.ac.cn*).

Forest ecosystem services make important contributions to national economies and human welfare. In the past 2 decades much progress has been achieved in understanding the value of forest ecosystem services and their valuation methods. There exists a whole range of examples of valuing forest ecosystem services at various levels over the world. This paper reviewed 228 valuation studies within China. Forest ecosystem services in these studies were grouped into eight categories: watershed services, soil stabilization and erosion control, agricultural protection, carbon sequestration and oxygen release, air quality and temperature regulation, recreation and tourism, biodiversity, and social-culture benefits. Applying a meta-analysis approach, this paper presented the ranges of estimated values within each category for all China and by region and province. The total value of forest environmental services for the whole country ranged from 8.0 to 71.6 thousand yuan RMB $ha^{-1}yr^{-1}$ converting each estimate into year 2004 using the China consumer price index and other conversion factors. Some comparisons with previous results of attempts to estimate the total value of forest ecosystem services of China and the rest of the world were made. The progress and issues in forest valuation methodologies in China were also discussed in this paper.

The non-market value of recreation in an iconic New Zealand planted forest. Yao, R., Dhakal, B., Turner, J., Barnard, T. (*Scion/New Zealand Forest Research Institute Ltd., New Zealand; Richard.Yao@scionresearch.com; Bhubaneswor.Dhakal@scionresearch.com; James.Turner@scionresearch.com; Tim.Barnard@scionresearch.com*).

Forest recreation is an important environmental service from forests. Although there is no user fee for recreation in a planted forest, this does not imply that the value of recreation is zero. This study estimates recreational values that mountain bikers and walkers place on an iconic New Zealand planted forest; Whakarewarewa in Rotorua. To estimate the economic value of the existing forest, we used the travel cost method. To examine the values of changing different forest features (e.g., management block size, mix of species) for recreation, we used the choice modelling technique. Survey data were collected through face-to-face interviews of 709 forest users in 2008 and 2009. Results from the travel cost analysis suggest that the value of the forest for recreation is approximately $5.2 million/year for walkers and $9.4 million/year for mountain bikers. The latter is almost five times the annual timber revenue from the forest. Results from choice modelling indicate that users prefer more species and tree ages within a stand and less radiata pine in the landscape, although these changes would not influence the frequency of their visits to the forest. The preference for changes in forest features was stronger for walkers than mountain bikers.

Valuing enhancement of indigenous biodiversity in New Zealand's planted forests. Yao, R., Turner, J., Scarpa, R., Barnard, T., Rose, J. (*Scion/New Zealand Forest Research Institute Ltd., New Zealand; Richard.Yao@scionresearch.com; James.Turner@scionresearch.com; rscarpa@mngt.waikato.ac.nz; Tim.Barnard@scionresearch.com; john.rose@sydney.edu.au*).

Planted forests provide important habitat for indigenous biodiversity. New Zealand's 1.8 million ha of planted forest provides habitat for at least 116 threatened native species, including iconic species such as brown kiwi (*Apteryx mantelli*), bush falcon (*Falco novaeseelandiae*), and green gecko (*Naultinus elegans elegans*). Although a recent study shows that New Zealanders place a high value on enhancing native species on private land, no study has estimated the value New Zealanders place on threatened native species found in exotic planted forests. This study used stated preference techniques to estimate the amount that people would be willing to pay to support a programme to enhance biodiversity in planted forests. We used phone-mail and phone-internet surveys of more than 700 individuals across New Zealand. Overall results suggest that New Zealanders place a high value on increasing the number of threatened species in planted forests, particularly iconic birds such as the brown kiwi and bush falcon. Results also indicate that people living in urban areas place a higher value on the proposed biodiversity programme than people in rural areas. Conversely, rural people would be willing to provide more volunteer days in bird counting and/or habitat restoration in planted forests than urban people.

Posters

Valuation and conservation of the Philippine tropical forest: a case study of the Makiling Forest Reserve. Camacho, L.D. (*University of the Philippines Los Baños, Philippines; camachold@yahoo.com.ph*).

The tropical forests of the Philippines provide a range of tangible and intangible benefits. However, the sustainability of these benefits is not assured due to lack of adequate forest protection. One factor contributing to forest losses and degradation is the absence of appropriate valuation of the multifunctionality of the forests. In this paper, the TEV of the benefits derived from a typical tropical forest was estimated, using different valuation techniques. The study area was the Makiling Forest Reserve (MFR), well-known for its unique and diverse ecosystem and a representative sample of the country's tropical rainforest. Analysis of the survey data indicates that the capitalized value of the benefits derived from MFR ranges from P16.38 million (US$0.41 million) for market-based forest products to P28,857.68 million (US$721.44 million) per year for the value of biodiversity protection. Estimates of the study show a capitalised total economic value of MFR to be approximately P31.72 billion (US$0.8 billion). The total value of opportunity cost of MFR is estimated at P13,072 million (US$327 million). The results have generated a 2:1 ratio of benefits to opportunity cost of preservation. The findings in this paper demonstrate that MFR is a unique and valuable asset worthy of conservation.

Estimation of environmental service value of urban forests using contingent valuation method (CVM): Gwanak, Bukhan, and Daegu Ap Mountain. Chun, J., Koo, J., Lee, E., Youn, Y. (*Seoul National University, Republic of Korea; andrew78@snu.ac.kr; selenium78@hotmail.com; norannamu@snu.ac.kr; youn@snu.ac.kr*).

Several studies have estimated the economic value of urban forests in Korea; however, most of these efforts have mainly focused on recreational services. So this study estimated visitors' WTP for the maintenance of overall environmental services, including recreational services, of urban forests using CVM. On the one hand, this study contains four visitors' environmental perceptions as independent variables such as use satisfaction, relative importance of urban forest conservation compared with other urban problems, etc. The number of sites is three, and the sample size is around 500 people respectively. As a result, annual average WTPs of the individual are $48 for Gwanak Mountain, $24 for Bukhan Mountain, and $7 for Daegu Ap Mountain. On the whole, the amount of suggested tax, degree of education, household income, and "relative importance of urban forest conservation compared with other urban problems" affect WTP, but degrees of affection and P-values are somewhat different in each site. Consequently, each urban forest needs independent management policies because each forest has different environmental values and influential factors. On the other hand, we can contain people's preferences about specific policies or institutes such as "no net loss of green space" as environmental perceptions in the future research.

Influence of resource characteristics on recreational benefits of forest. Chun, J., Youn, Y. (*Seoul National University, Republic of Korea; andrew78@snu.ac.kr; youn@snu.ac.kr*).

Various studies on value of forest recreational sites have been actively performed; however, researchers have passively examined the characteristics of resources influencing the value of recreation. The aim of this research is to estimate the recreational benefit and further discover characteristics of resources affecting the magnitude of such benefit using the travel cost method on 33 natural recreational forests in Korea. As a result, the total annual benefit of recreational forests was estimated to range from about 650 thousand US$ to 370 billion US$, with increases directly proportional to the average age of trees, the rate of acicular trees and natural forests on forest floors, and the number of public transportation services. Consequently, Korean people take greater benefit from acicular forests with influence of pine tree culture and their rising interest in healthy substances including phytoncide. On the one hand, the benefit from a natural forest appeared to be greater than that from an artificial forest owing to the desire of those who wished to enjoy nature while leaving the city. Convenient accessibility also influenced the recreational benefit positively, in which people could take greater benefit from a recreational forest with better accessibility with frequent public transportation service.

Environmental services in small-scale community forest management: challenges and opportunities. Dhakal, M., Khadka, M.B. (*Ministry of Forest and Soil Conservation, Nepal; maheshwar.dhakal@gmail.com; mbkhadka@gmail.com*).

One of the objectives of small-scale community forest management is livelihood improvement of local communities who are living in and around the forests. This objective is largely based on forest products that are used on daily basis for minimum livelihood. Along with these forest products, this study aims to assess the environmental services in small-scale community forest management and their linkage to livelihood improvement of local communities. The results showed that besides timber and non-timber forest products, forests produce various environmental services on a regular basis, enhancing livelihoods of local

communities. The commonly produced environmental services are carbon (CO_2) sequestration, biodiversity conservation, landscape beauty, and water cycle regulation. Local communities measured the economic value of timber and non-timber forest products through pricing mechanisms; they also collected a community fund and carried out some livelihood improvement activities from it. However, the environmental services produced by the forests are seldom measured in economic-terms. This study suggests options for measuring environmental services in economic-terms aiming additional positive effects to livelihood improvement of local communities. Although it may pose methodological challenges, the case is highly crucial for small-scale community forest management, where local communities depend on the forests for minimum livelihoods.

Methods of value accounting in forest conservation of soil. Jin, Y. (*Beijing Forestry University, China; jinyanping11@163.com*).

This presentation discusses value accounting methods for conservation of forest soils. It concludes that various methods of value accounting could be used depending on whether the issue is reduction of soil erosion, sediment, or nutrient loss; improvement in quality of air and water; addition of soil nutrients; control of sand; or minimizing losses from disasters. Different methods should be used in different situations, and pricing in value accounting of forest conservation of soil is very important. All problems—such as differing land values for different times, places, and uses—must be resolved properly. If the use of the land is known, the value of land should be calculated according to the use of the land. If the use of land is not known, the value of the land should be calculated according to the probability of the land use. Either way, the value of land may be more expensive in the future.

Economic valuation of forest landscape function using a conditional logit model. Kim, D.H., Kim, E.G. (*Gyeongsang National University, Republic of Korea; kdh221@gnu.kr; egkim@gnu.kr*), Yoo, J.C. (*Chung Buk National University, Republic of Korea; jcyoo@chungbuk.ac.kr*), Park, D.K. (*Korea Forest Research Institute, Republic of Korea; pdk5920@forest.go.kr*).

The purpose of this study is to estimate the economic value of the forest landscape function using a conditional logit model, applied by choice experiment. For the study, we chose attributes and levels of forest landscape; specifically, attributes included: topographical forest type, forest type, forest density, recreational factor (side trip, accessibility of valley), and WTP. Based on factors, we made 48 choice sets with balanced and orthogonal form using SAS 9.1. The efficiency of the questionnaire was 6.02 (D-Error: 0.1) and choice set and socio-economic variables were selected. To reduce the cognitive load of respondents, the 48 choice sets were divided into 4 types in the questionnaire, so that respondents could respond to 12 choice sets respectively. The study population was citizens from seven metropolitan cities including Seoul, and we asked annual WTP per household by using the interview questionnaire, a total of 267 copies. As a result, Mcfadden'Rho had 0.45, and we couldn't find statistical similarities except for urban forest, forest density, recreational factor, and level of WTP. Average annual WTP per household for forest landscape was 104,723 won (Korean currency). Based on the outcome, total economic value of Korean forest landscape has reached approximately 1.6 trillion won.

Contribution of tropical forest management to local farmers' economies in north, Atlantic, and south Costa Rica. Meza Picado, V.H. (*National Univesity, Costa Rica; victor.meza@waldbau.uni-freiburg.de*).

Most conservation projects have been undervaluing the multifunctionality of local farmers' forests, reducing benefits to support their livelihoods. Hence, the main focus of this study was to identify the more relevant factors for rentability and integrity of forests managed by local farmers through successive cutting cycles. With this purpose we assessed the dynamics of ecological groups and opportunity costs to forestry land-use. Scenarios were elaborated for various types of forest, combining criteria as payment for environmental services (PES), harvest intensity, and distance to markets. We used a cash-flow approach to provide estimates of forest management costs; the production function was built using15 years of empirical data from continuous forest inventory with permanent samples. Results indicate that with a forest value of US$900 ha^{-1} and under current conditions it is not attractive to manage natural forest; therefore, the possibility for the forest to provide sustainable inputs and flows depends on the assumptions used to calculate its rentability. However, forest contributions to household economies will be higher in those cases where livelihoods are primarily based on subsistence farming activities.

The economic value of water for commercial use in upper Brantas sub-watershed, at East Java-Indonesia. Nurfatriani, F., Muttaqin, Z. (*Ministry of Forestry Indonesia, Indonesia; nurfatriani@yahoo.com*; *zahrul.muttaqin@anu.edu.au*).

This research was aimed at calculating the economic value of hydrological benefits associated with protecting forest in the upper Brantas sub-watershed at East Java. The hydrological benefit was limited to commercial uses of water from the forest, which included: tap/drinking water, hydropower generation, and industrial uses. The economic value is calculated using the full cost method, in which the cost should be paid by all users gaining benefits. The full cost for providing water was Rp. 316.22 billion per annum, consisting of operational cost, opportunity cost, and externalities. Calculated cost was further used to determine a tariff for water usages by allocating the full cost proportionally to the users using a simplified benefit-based method with a cost-centre approach. The results revealed the ideal tariff that covered production cost including externalities was Rp 116.70/kWh for electricity, Rp 217.79/m^3 for tap water, and Rp 607.34/m^3 for industries. Environmental economic values for each water usage were obtained from the difference between current and ideal tariff; they were Rp 76.92 billion for electricity, Rp 42.95 billion for tap water, and Rp 63.96 billion for industries. The environmental values showed the value that should be compensated to forest management in the upper stream.

Web-interface for geo-referencing forest socio-economic surveys. Palma, J. (*ISA-UTL, Portugal; joaopalma@isa.utl.pt*), Yao, R., Payn, T. (*SCION/New Zealand Forest Research Institute, New Zealand; richard.yao@scionresearch.com; tim.payn@scionresearch.com*).

In New Zealand, 90% of forests consist of one type of exotic tree: Radiata pine (*Pinus radiata*).A study on the management of such exotic planted forests in New Zealand for the conservation of threatened native animals and plants (e.g., kiwi, kakabeak) is underway, and socio-economic questionnaires provide an important tool to understand public views on the role of exotic forests for the native species. In such questionnaires, is important to understand the relationship of the answers to landscape elements, either natural (e.g., mountains) or more artificial (e.g., buildings). An online tool to geo-reference the answers has been developed

to retrieve (and treat with confidentially) coordinates by the interviewed. The tool uses a mix of programming languages (HTML, Javascript, PHP, and Ajax) as well as the GoogleMaps© application programming interface to interact with users to locate their living places. The tool supplies the coordinates to the analysts, who through landscape metrics will relate the qualitative importance given by certain answers to the proximity to certain elements in the landscape. The tool can be adapted to any survey that could consider the coordinates of the answers as an added value to the questionnaires analysis. Tool link: http://home.isa.utl.pt/~joaopalma/surveys/nzfalcon.

The valuation of use value of forestry in Seoul by contingent valuation method. Park, J.Y. (*Sejong University, Republic of Korea;*), Lee, H.C. (*Sejong University, Republic of Korea;*), Kim, T.H. (*Sejong University, Republic of Korea; parkshawn@naver.com; leeheech@sejong.ac.kr; syaoran12@hanmail.net*), Park, D.K. (*Korea Forest Research Institute, Republic of Korea; pdk5920@forest.go.kr*), Lee, E.M. (*Sejong University, Republic of Korea; choose8@hotmail.com*).

Because of increases in population concentration in large cities, along with mental and psychological exhaustion, a reconsideration of recreation time has become prominent. In addition to various recreational resources, forests provide numerous benefits, including biodiversity preservation, water purification, and carbon sequestration. To estimate the value of non-market goods, like forests, the contingent valuation method (CVM) has been widely used, and was adopted for this study. The purposes of this study are: first, to derive the determinant for willingness to pay; second, to estimate the use-value of forest in Seoul; and third, to compare the results derived by different methodology. Four different valuation methods were used: double-bounded (DBDC), single-bounded (SBDC), non-parametric analysis (NPA), and Tobit Model (TM). From the results we derived the mean WTP at 8,724 won/person per visit from DBDC, 12,606 won/person per visit from SBDC, 7,656 won/person per visit from TM, and 9,966 won/person per visit from NPA. To estimate the aggregated value of forests in Seoul, the mean WTP from DBDC was multiplied by number of mountain visits and number of adults in the capital area. As a result, the aggregated value of forest in Seoul was estimated to be about 456.8 billion won.

Governance perspectives on the provision of non-market forest goods and services. Ramcilovic, S. (*European Forest Institute and University of Joensuu, FYR of Macedonia; sabaheta.ramcilovic@efi.int*), Mavsar, R. (*European Forest Institute/Mediterranean Regional Office, Spain; robert.mavsar@efi.int*), Weiss, G. (*University of Natural Resources and Applied Life Sciences, Austria; gerhard.weiss@boku.ac.at*).

Forest ecosystems provide a multitude of goods and services of crucial ecological, social, and economic importance for the society. The relationship humans have with forests and forestry is continuously changing. Recently these changes show an increased demand for ecological, social, and cultural services derived from forests. This paper is based on a study of development and marketing of non-market forest goods and services (FORVALUE Study). It presents some of the key issues concerning non-market forest goods and services, including: the importance of non-market forest goods and services in the EU; the challenge of marketability; and the role of new governance principles in the development and marketing of non-market forest goods and services. It shows that non-market forest goods and services are considered important and their importance is expected to further increase in the EU. It discusses different policy and institutional strategies to address the challenge of their marketability. Finally, it concludes that development and marketing of non-market forest goods and services call for new governance principles, such as stakeholder participation, cooperation, cross-sectoral coordination, and institutional arrangements.

The assessment of shrubbery's forest ecosystem services evaluation in China. Wei, J. (*Inner Mongolia Agricultural University, China; jiangshengwei@hotmail.com*), Wang, B. (*Research Institution of Forest Ecology, China; wangbing@caf.ac.cn*).

A series of assessment index systems suitable for forest ecosystem services was set up. We assessed the economic value of forest ecosystem services of China on the basis of the data of long-term observations, the forest resource in 2008, and data of social commonality. Results show that the total value of shrubbery's forest ecosystem services is 1.80 trillion RMB yuan·yr^{-1}, accounting for 17.92% of the total value of the forest ecosystem services in China. The value of shrubbery forest ecosystem services per unit area is 335 hundred RMB yuan hm^{-2}·yr^{-1}. In the six services, the order is water supply(50.82%), biodiversity conservation (20.38%), soil conservation (12.03%), carbon fixation and oxygen released (9.92%), environmental purification (5.47%), and forest nutrition storage (1.38%). With 49 species of trees across the country, shrubbery is ranked as the first for total value of ecosystem services, although the value per unit area of shrubbery for ecosystem services is ranked 42nd. The adaptability of shrubbery is strong and its distribution area is large; shrubbery plays an important role in forest ecosystem services of China.

Measurement the value of bottomland protective forest ecosystem services in the lower Yellow River. Xie, H., Li, C.R. (*Shandong Agricultural University, China; xiehuicheng@gmail.com; chrli@sdau.edu.cn*), Xu, J.W. (*Shandong Academy of Forestry Science, China*).

Because of its considerable ecological, economic, and social benefits, protective forest is taken as an important ecological engineering tool to realize sustainable development of agriculture and forestry in fragile areas in China, such as floodplain of the Yellow River. In this paper, the protective plantations in Changqing district, Jinan city, were selected as an example to assessment their ecosystem services. A measurement and assessment index system—which includes 3 first-class indices, 10 second-class indices, and 21 third-class indices—was set up by the expert consults method. The method of space substituting time and simulation in combination with location surveys was used to evaluate the ecosystem services. The value of ecosystem services varied with poplar varieties, stand density, and stand age. The total ecosystem service value of a 9-year-old Zhonglin 46-poplar plantation with planting spacing 3 × 3 m was 73,385.14 CNY·ha^{-2}·yr^{-1}, including: the value of climate regulation 131.21 CNY·ha^{-2}·yr^{-1}, biological control 448.3 CNY·ha^{-2}·yr^{-1}, water conservation 12,614.6 CNY·ha^{-2}·yr^{-1}, soil conservation 32,874.13 CNY·ha^{-2}·yr^{-1}, gas regulation 11,46.9 CNY·ha^{-2}·yr^{-1}, waste treatment 6,775.28 CNY·ha^{-2}·yr^{-1}, and the average income from food and timber production 16,620 CNY·ha^{-2}·yr^{-1}. The results show that poplar protective forest in this area is of great value for sustainable development.

Economic and public benefits of the green area index and the green seal project, and the importance of the urban forest in Timburi, Brazil. Ziantoni, V., Hermoso, L. (*Universidade Federal do Paraná, Brazil; vziantoni@gmail.com; letiziahermoso@gmail.com*), Duarte, D. (*Universidade Estadual de Londrina, Brazil; douglasambiel@hotmail.com*), Estevez, R. (*Universitat de Lleid, Spain; roiestevez@yahoo.es*).

The "Green Seal" is an environmental evaluation criteria created by the Environment Secretary of Sao Paulo, Brazil, which allows towns that have obtained a mark greater than 80% to receive priority of public funds, also encouraging towns to participate directly in the environment policies known as "Sharing Environment Management". Timburi is a rural town of 2,558 inhabitants. The study aimed to produce the urban forest inventory document of the town, to be used as a base to reach the "Green Seal" classification and to support its management and conservation in the future. The green area index (GAI) is the total sum of green areas divided by the total number of inhabitants. The GAI was calculated at 32.57 m^2/person. The total number of trees was 2,121. The total green area covered 14% of the town; 50% of the species are of NTFP use. The prognosis shows a possible growth of 15% (GAI) for the next 4 years. More than 80% of the local population understands the importance of conservation. The GAI of Timburi was found to be greater than most Brazilian towns; Timburi has been awarded the "Green Seal" and is an example of ecological development.

C-10 Impact of global environmental change on forest ecosystem services

Organizers: Pavel Cudlin, *Institute of Systems Biology and Ecology, Czech Republic; pavelcu@usbe.cas.cz;* Elena Paoletti, *IPP-CNR Florence, Italy; e.paoletti@ipp.cnr.it.*

Impact of global environmental change on forest ecosystem services: an overview. Cudlin, P. (*Academy of Sciences of the Czech Republic, Czech Republic; pavelcu@usbe.cas.cz*), Paoletti, E. (*IPP-CNR, Italy; e.paoletti@ipp.cnr.it*).

Forest ecosystem services are the benefits people obtain from forest ecosystems. These include provisioning services such as food, water, and timber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling. Over the past 50 years, rapid and extensive environmental changes in land use, climate, and the atmosphere have resulted in a substantial loss or degradation in ecosystem services, while demands for services have been increasing. A large proportion of European forests have been under the long-term impact of acid rain, ozone, and climate extremes. Deterioration of forest health status results not only in decrease of biomass production (provisioning service) but also in transpiration rate (air-conditioning service), root system development (water regulation service), ability of forests to create biotopes (supporting services), etc. Because of changing temperatures, precipitation, and patterns of increasing atmospheric CO_2 concentrations, the capacity and the long-term stability of forest ecosystem service provision will probably be negatively affected. A review of present knowledge about the impacts of global environmental changes on forest ecosystem services will be presented, with focus on the energy, wate, and nutrient cycles.

Climate change effects on semi-natural Alpine ecosystems and on utility flows provided by forests. Goio, I., Gios, G. (*University of Trento, Italy; ilaria.goio@unitn.it; geremia.gios@unitn.it*).

Human society derives many essential goods and fundamental life-support services from natural ecosystems. Climate change is a serious and long-term challenge for natural ecosystems and for semi-natural alpine ecosystems which are important multi-output production systems. In our presentation we propose a simulation model for the Autonomous Province of Trento (Italy) which evaluates: the impact of temperature increase on the annual benefits produced by semi-natural alpine ecosystems; the pressures driven by agricultural sector with the extensions of the cultivations (to the detriment of the forest) with reference to the surfaces they occupied at the end of 19th century. In particular, using the total economic value (TEV) we estimate an economic profile of the sum of the values of utility flow which derive from semi-natural alpine ecosystems. These utility flows are usually not taken into consideration because they are of a public service nature, and therefore there is no market for them. This makes for an interesting case when trying to evaluate the consequences of climatic changes on these components within the total economic value. The final object is to analyse the effects that an increase of temperature of 2°/4°C over future years could happen in the alpine region.

Impacts of elevated CO_2 on forest biodiversity and carbon storage. Lukac, M. (*Imperial College London, UK; m.lukac@imperial.ac.uk*).

The role of the world's forests in the provision of forest products and services is well-known; however, the effects of global climatic change on this provision are not fully understood. Rising levels of atmospheric CO_2 will increase forest growth in the future, both directly via stimulation of photosynthesis and indirectly by increasing ambient temperature. If forest tree species respond differentially, this may have profound effects on forest growth and health, species composition, and the functioning of forest ecosystems. Thus, the capacity and the long-term stability of forest ecosystem service provisions that we currently take for granted will probably be affected and altered. This lecture will present the current state of knowledge on how future levels of atmospheric CO_2 will affect forest productivity, and will explain the implications for forest biodiversity conservation and the forests' capacity for carbon capture and storage. Latest findings from large-scale experiments in forests will be presented and the challenges for future research outlined. As ecosystem services provided by forests are the foundations of life on Earth, we must be able to predict how they will be affected by future climate and to devise coping mechanisms.

Photosynthesis process under global environmental change as one of the keystones of provisioning, supporting, and regulating ecosystem services. Marek, M.V. (*Institute of Systems Biology and Ecology, Czech Republic; emarek@usbe.cas.cz*).

Forest ecosystem functions are strongly dependent on photosynthetic activity, which is a key physiological process supporting life. Moreover, photosynthetic activity is a basis for the biological pumping of atmospheric carbon into biomass and forest soils,

respectively. The future relation between photosynthetic activity and global environmental change will be mainly realized via a well-known phenomenon called CO_2 fertilization effect. Observed stimulation of photosynthesis under enhanced atmospheric carbon is currently regarded as an important reason for observed massive biomass increment, particularly of European forests during recent decades. However, this relation is complicated because of a weak quantitative linkage between photosynthesis and growth of woody biomass. Photosynthetic assimilatory activity is strongly related to the environmental status, that is, microclimatological parameters within the forest stand, the synoptic situation, air pollution impacts, and forest management. Besides solar radiation, air humidity, or more precisely water potential of the air, and soil water status are important controlling parameters strongly affecting actual photosynthetic activity via stomata responses. Thus, it is evident that the physiological background of forest ecosystem energy and mass exchange (i.e., photosynthetic activity) could be identified as a keystone of provisioning, supporting, and regulating forest ecosystem services.

Social values for forest environmental services at risk from wildfire in northwest Montana, USA. O'Donnell, D., Venn, T. (*University of Montana, USA; derek.odonnell@umontana.edu; tyron.venn@umontana.edu*), Calkin, D. (*U.S. Forest Service, USA; decalkin@fs.fed.us*).

Current United States federal wildland fire management policy requires fire management priorities to be set on the basis of values to be protected (including non-market values); however, there is limited information about the value society places on forest environmental services at risk. The Forest Service continues to give defacto priority to protecting private property. This paper reports the findings of a choice modeling non-market valuation survey that inquired about wildfire management preferences of residents of Flathead County, Montana. Management strategies were defined in terms of cost; number of homes evacuated per annum; area of timberland burned per annum; and annual effects of wildfire on recreation opportunities, air quality, and ecosystem health. The marginal willingness of an average household to pay for one less home evacuation per annum was $0.28, compared with $13.36 for a one-day reduction in the number of unhealthy smoke days per annum and $1.90 for a one percentage point reduction in the annual probability that recreation opportunities will be affected by wildfire. These findings suggest the focus of wildfire managers on structure protection is not efficient in Flathead County, and social benefits could be enhanced by redirecting wildfire management resources to the protection of forest environmental services.

Impact of biological invasions on forest ecosystem services under global change. Santini, A. (*Consiglio Nazionale delle Ricerche, Italy; a.santini@ipp.cnr.it*), Roques, A. (*INRA, France; alain.roques@orleans.inra.fr*).

Forests and woodlands harbor a great part of the world's biological diversity. Moreover, they provide long-term carbon storage, and regulate biogeochemical cycles and erosion. During the past 30 years, these ecosystems have been exposed to pressures from an increasing connectedness and globalization, which has amplified the frequency and effects of biological invasions. The downfall of physical and/or political barriers resulting in the opening of new trade routes has increased both the speed and magnitude of invasions. Invasive species have modified forest ecosystem dynamics at different levels, through progressive reduction in genetic diversity leading to extinction of certain species (e.g., chestnuts, due to chestnut blight in North America) or communities (e.g., *Satyrium w-album,* threatened with extinction by DED), and altered biogeochemical cycles. Moreover, land-use and climate change interact with trade systems, favoring the spread and impact of existing invasive species, establishment of new invasive species, and alteration of effectiveness of control strategies. Indeed, altered weather patterns can increase vulnerability of forest ecosystems to infestation by native and introduced pests and pathogens, and can facilitate establishment of alien plants or animals coming from warmer areas. This will lead to less diverse and less productive ecosystems unable to exert their multifunctional roles.

Posters

The role of land use/cover on ecosystem services in a changing climate: focus on hydrology and biodiversity Herkendell, J. (*European Environment Agency, Denmark; josef.herkendell@eea.europa.eu*).

Recent studies on climate change predict a clear and rapid hydrological change in mountain catchments driven primarily by rising temperatures and changing precipitation patterns. Relatively dry mountain environments in the Mediterranean, for example, are expected to face longer and more frequent dry spells, whilst an increased water surplus is predicted for catchments on northern Fenno-Scandinavia. The changes, in turn, are expected to strongly accentuate the importance of land use/ cover on the quantity and quality on major ecosystem services, which is by itself an important driver of current hydrological patterns and ecosystem services and biodiversity in mountain areas. The aim of one EEA project is to analyse changes in mountain water catchments on the basis of models, and in particular, the services with respect to water and biodiversity and how this varies in different bioclimatic regions in Europe. Different components of the study will be analysed and integrated at EEA, including the role of climate change impacts, sustainable forest management, and water management as well as biodiversity. The results of this study will contribute to the ongoing discussion on how to best adapt sustainable forest management and water management to climate change impacts.

Web-explorer of forest ecosystems services under climate change. Palma, J. (*Instituto Superior de Agronomia, Portugal; joaopalma@isa.utl.pt*), Palmer, D., Hock, B., Payn, T. (*Scion/ New Zealand Forest Research Institute, New Zealand; david.palmer@scionresearch.com; barbara.hock@scionresearch.com; tim.payn@scionresearch.com*).

Climate change will change the dynamics of forest environmental services. All the change complexity involved is difficult to visualize under an easy and accessible information tool capable of integrating several services that forests can provide.
A preliminary "Web-Explorer of Forest Ecosystems Services" was developed for New Zealand where forest managers and the general public can observe what are the predictions of the different forest environmental services under current and future climates for each location in the territory. Carbon storage, soil erosion, biodiversity, nitrate leaching, and water balance are the preliminary forest environmental services envisaged. The tool uses a mix of programming languages and techniques (HTML, Javascript, PHP, and Ajax) as well as the GoogleMaps© application programming interface to interact with New Zealand

online-stored geographical information to supply different models´ needs. A score system is calculated for the user reference where tradeoffs can be observed by changing the climate variables in the models. The tool (http://home.isa.utl.pt/~joaopalma/projects/tranzfor/wefes) is under development and expecting "expressions of interest" for further improvement. It has already enabled good interaction among those with different scientific backgrounds as well as interest from private forest organizations.

Quantifying hydrologic C loss from forest soils using real-time monitoring of stream organic carbon. Park, J.H., Jeong, J.J. (*Kangwon National University, Republic of Korea; jihyungpark@kangwon.ac.kr; jjjplush@naver.com*), Bartsch, S. (*University of Bayreuth, Germany; svenja.bartsch@uni-bayreuth.de*).

Carbon sequestration represents one of the most important environmental services provided by forests in a changing climate. Compared to carbon dioxide fluxes between the atmosphere and forests, much less is known about soil carbon losses resulting from hydrologic export of organic carbon in forest streams. To provide a more accurate estimate of hydrologic C losses during the monsoon period, real-time monitoring of dissolved organic carbon (DOC) and particulate organic carbon (POC) using a spectroscopy-based probe was conducted in a forest stream draining a small mountainous watershed. Real-time measurements showed a strong linear relationship with the results from laboratory analyses of DOC and POC. Concentrations of DOC and POC increased rapidly with rising flow, with magnitudes of response depending on the intensity and duration of each of seven rainfall events over two-month monitoring period. Decreases in DOC concentrations following peak flow occurred much faster than those of POC. Although the concentrations and fluxes of POC were usually lower than those of DOC under base flow conditions, POC export increased nonlinearly in response to increasing rainfall amount and intensity. The results emphasize the importance of hydrologic carbon export, particularly that of POC, for C storage and loss in forest soils.

Climate risks to stream water quality in a forested mountain watershed. Park, J.H., Lee, H.J. (*Kangwon National University, Republic of Korea; jihyungpark@kangwon.ac.kr; suni211@hanmail.net*).

Provision of clean water represents one of the most important environmental services provided by forests. To assess climate-induced risks to stream water quality in steep mountainous terrain, a biweekly water quality monitoring, combined with intensive storm sampling during the summer monsoon, was conducted in a small forested watershed in Korea. Biweekly water quality monitoring showed higher concentrations of suspended sediments, dissolved organic carbon (DOC), and particulate organic carbon (POC) over the monsoon period than during drier months. Concentrations of dissolved nutrients were generally higher under drier conditions, as indicated by higher concentrations of sulfate and chloride and electrical conductivity. Intensive storm sampling showed nonlinear increases in concentrations of suspended sediments and POC during extreme rainfall events, which resulted in rapid soil C loss exceeding DOC export under base to moderate flow conditions. Concentrations of dissolved nutrients decreased with rising flow, with some time lag depending on the nutrient. Overall results suggest that rainfall variability exerts a key control on stream water quality and hydrologic C export, as exemplified by monsoonal increases in suspended sediments and organic carbon and unusually high concentrations of dissolved ions during extended droughts.

C-11 New developments in forest management accounting and reporting to ensure sustainability

Organizers: Hans Jöbstl, *University of Natural Resources and Applied Life Sciences, Austria, hans.joebstl@boku.ac.at;* Bernhard Möhring, *University of Göttingen, Germany; bmoehri@gwdg.de.*

Environmental accounting: an experimental evaluation of biodiversity. Goio, I. (*University of Trento, Italy; ilaria.goio@unitn.it*), Gretter, A. (*FEEM, Italy; gretter@cealp.it*), Gios, G. (*University of Study of Trento, Italy; geremia.gios@unitn.it*).

Biodiversity is relevant for our future: it is valuable to society, and choices made by society have had and are continuing to have effects on biodiversity. However, there is no clear consensus about how biodiversity should be measured, in part because of the difficulties in applying an economic evaluation to biodiversity with respect other environmental assets. This presentation attempts to assess from an economic point of view some components of biodiversity for an alpine forest using the total economic value approach (TEV). In particular we compare the estimates of the values of biodiversity and the market goods provided by two different alpine areas. In the first case we consider a forest oriented to the maximum wood production, while in the second a multi-functional forest cultivated according to the naturally driven management. These kind of evaluations allow us to highlight how the value of biodiversity in the multifunctional forest is greater than the loss of wood production connected to a naturally-driven management forests. The final objective is to propose policy tools to compensate local actors for the loss they incur using the last mentioned technique.

How can natural risks be integrated into forest valuation criteria? Möhring, B. (*University Göttingen, Germany; bmoehri@gwdg.de*).

Climate change will escalate the frequency and intensity of natural hazards such as storms, droughts, insects, etc. in forest management. This development indicates that the adequate consideration of natural risks will be a central task for economic evaluation and decision making. However, looking at traditional forest evaluation criteria such as land expectation value, stand expectation value, soil rent, internal rate of return, etc. reveals that these figures are usually calculated on the basis of secure assumptions. Survival or damage probabilities respectively are usually not taken into account. This paper presents practical suggestions on how to integrate risk into evaluation models by age-dependent survival functions. Survival functions describe the probability that forest stands of a given age survive a time interval of a certain length and simultaneously quantify the probability of damage during the specific time span. The analysis uses two parameter WEIBULL-functions. Tree species specific survival functions, which were derived from forest data, are combined with forest production and evaluation models. Thereby it can be demonstrated how the parameters of the survival function influence the economic evaluation criteria. This approach allows forest management to incorporate risks into the process of evaluation and decision making.

Factor for eco-friendly development of forestland in Korea. Park, Y.K., Roh, H.J., Jeon, J.H. (*Korea Forest Research Institute, Republic of Korea; parkkyu1@forest.go.kr; poulpican@sungshin.ac.kr; junjeon@forest.go.kr*).

This study was done to develop criteria and factors of eco-friendly forestland development that prevent indiscreet conversion of forests and harmonize between development and conservation. It was performed on five types of forestland—residential land (RL), factory sites (FS), golf course (GC), skiing area (SA), and accommodation facilities (AF)—using 10 factors for eco-friendly development. The main results were: (a) ratio of original shape of RL, FS, AF, GC, and SA are more than 20%, 20%, 30%, 40%, and 60%, respectively; (b) slope of RL, FS, GC, and AF are below 20° and SA is below 35°; (c) building height of all types is below 16 m but can be added or reduced within 25% of the height considering location of topography and skyline of forest; (d) cutting edge height of RL and FS is below 10 m and that of GC, SA, and AC is below 16m; and (e) green space ratios of RL, AF, and FS are 40%, 40%, and 30% or more, respectively. Regarding the institutional aspects, this study introduces simplified operations of related regulations, and tax incentives for eco-friendly practices, such as maintaining the original shape of forestland.

Valuing forest externalities: an international EU-funded COST Action (CA) on elaborating non-market valuation protocols. Shechter, M. (*University of Haifa, Israel; shechter@econ.haifa.ac.il*), Riera, P. (*Universitat Autonoma de Barcelona, Spain; pere.riera@uab.es*), Signorello, G. (*University of Catania, Italy; g.signorello@mbox.unict.it*), Thiene, M. (*University of Padua, Italy; mara.thiene@unipd.it*), Navrud, S. (*Agricultural University, Norway; stale.navrud@umb.no*).

European COST Action E45 provides a good practice protocol for non-market forest valuation that deals with total economic value (TEV), accounting for non-linearities, the use of values/unit of surface, benefits transfer (BT) preferred procedures, and construction of a forest valuation database. It also contains warnings on double counting and the influence of non-linearities (interactions and satiation) in the TEV aggregation. In multi-attribute valuation methods it is advised to plan for two-way interactions, since it is likely that forest attributes could be complements or substitutes and may have satiation points; for instance, recreationists may prefer denser forests but maybe not 100% density. There is a tendency to express non-timber values per unit of surface, like dollars per hectare, to add them to timber values per hectare or scale them up for the forest area analyzed; advice is to report values per person or household instead. The preferred BT procedure is the transfer of unit values with adjustments for income from valuation study sites as similar as possible to the policy site. Guidelines on the construction of new forest valuation databases are applied to a European one, which is the most complete available source of non-timber forest values.

Posters

Young people's expectations about the functions served by artificial and natural forests: a study of high school students in Kobe, Japan. Kawase, M. (*Kyoto University, Japan; molly-polly@hotmail.co.jp*).

Public demand for forest services can constitute one of the criteria used in forest management accounting because such functions benefit the public. Forests in Japan are generally classified into two types, artificial (uniform planting of cedar and cypress) and natural (primary forest and secondary forest of broadleaf trees). However, few studies have distinguished between these two types of forest. This study was designed to obtain detailed information about the expectations of young people with respect to the functions served by the two types of forest, to aid in evaluations of the status of the forest system. Questionnaires were distributed to high school students in the city of Kobe, Japan, in 2008 and 2009, yielding 591 responses. The respondents were classified according to interest in forests, background and demographic characteristics, present preferences, and so on. The main finding was that students expected more from natural than from artificial forests in all areas except timber production. Compared to the total sample, those interested in natural forests placed more importance on protecting rare species and on land and water resources in these areas.

Applying an AHP method by means of the free software MPC for making forest management decisions. Pérez Rodríguez, F., Rojo Alboreca, A. (*Universidad de Santiago de Compostela, Spain; forestalsoft@hotmail.com; alberto.rojo@usc.es*).

At present it is indispensable to use methodologies that support decision making in forest management because the requirements of society, which has a growing awareness of the concept of sustainability, call for the consideration of many economic, social, environmental, and technical criteria for evaluating a certain number of alternatives in order to reach a defined goal. The availability of software, program user-friendliness, and costs of application or of licences may be limiting factors when it comes to applying a decision support method in forest management, especially in times of economic restraints. The analytic hierarchy process (AHP) method, suggested by Saaty in 1980, has been widely used for decision-making in many areas, including forest management, thanks to the possibility of managing quantifiable and non-quantifiable variables, which allows us to objectify the latter by degrees of preference or weight in paired comparisons. This study presents the application of a free software in Spanish that helps eliminate the barriers of application of this methodology under circumstances of great limitations.

Does the downed and dead wood inventory of the United States have the power to detect carbon flux? Woodall, C., Bradford, J., Westfall, J., Hatfield, M. (*U.S. Forest Service, USA; cwoodall@fs.fed.us; jbbradford@fs.fed.us; jameswestfall@fs.fed.us; mahatfield@fs.fed.us*).

Across the United States the carbon (C) flux of down woody material (DWM) detrital pools has largely been simulated based on forest stand attributes (e.g., stand age). DWM C flux has only recently been assessed using large-scale forest inventories for the nation. Given the relatively small flux of DWM C and sparse sample intensity of current forest inventories, the question remains whether DWM C flux can be monitored nationally with statistical power. Using a large-scale DWM C inventory across the north-central United States, a power analysis was conducted to determine the probability of current inventories missing a substantially large DWM C flux. DWM C flux was found to be relatively static with an annual flux rate not statistically different from zero. Current inventory sample intensity may only be able to detect annual DWM C flux if it exceeds 1, 4, and 6+ percent nationally, regionally, and at state-levels, respectively. It appears as though the DWM C inventory of the United States has the statistical power only to detect annual DWM C flux at the national level, whereas at smaller state-scales the inventory has the statistical power to detect C flux only when massive disturbances occur to DWM C stocks.

C-12 Energy forests—social impacts and environmental services

Organizers: Jaime Amezaga*, Newcastle University, UK; j.m.amezaga@ncl.ac.uk;* Neil Bird*, Joanneum Research, Austria, neil.bird@joanneum.at.*

Bioenergy and forest resources: what strategies provide energy and climate change mitigation. Bird, D.N., Pena, N., Zanchi, G. (*Joanneum Research, Austria; neil.bird@joanneum.at; naomi.pena@joanneum.at; giuliana.zanchi@joanneum.at*).

The rush to bioenergy for energy security and climate change mitigation is increasing the stress on forests. If the bioenergy is agriculture-based, then land use change that indirectly replaces lost agricultural production causes deforestation. If the bioenergy is forest-based, then the increase in biomass consumption causes a decrease in forest resources until a new sustainable equilibrium is reached. For these reasons, the short-term climate change mitigation benefits of bioenergy have recently been questioned. In previous studies, we created a model that compares the supply and demand of food energy globally or on a per-country basis. When combined with land-use change statistics, the model can identify the amount of deforestation required to satisfy food energy demand if land traditionally used for agriculture is converted to produce biomass for energy. A second model has been created that identifies the portion of wood extraction that is non-renewable. Finally, if the forest resources are not being harvested optimally, there may be room for increasing biomass consumption for bioenergy. In this presentation, we will use the results from these various models to identify land-use change and bioenergy strategies that provide energy and climate change mitigation.

Impact of short rotation coppice (SRC) cultivation on water quality. Dimitriou, I., Aronsson, P. (*Swedish University of Agricultural Sciences, Sweden, ioannis.dimitriou@vpe.slu.se; par.aronsson@vpe.slu.se*).

The surface of agricultural land cultivated with short rotation coppice (SRC) using willow and poplar for production of biomass for heat and/or electricity is expected to increase in the short term in a range of European countries. This will have implications for various environmental issues. As a perennial crop, SRC differs from arable crops in physical traits and management practices. Concerning groundwater quality, results so far imply low nutrient leaching when SRC is cultivated compared to other "conventional" crops, but effects in the long term concerning SRC plantations cultivated for several years applied with recycled by-products such as sewage sludge and wastewater should be also considered for a general evaluation of the SRC impact on groundwater. Extensive sampling of groundwater from several SRC fields in Sweden cultivated for several years was conducted, and results concerning N and P leaching are discussed in this paper. These results are compared to respective N and P in the groundwater of adjacent to SRC "conventional" crops. With the help of these results, the overall environmental impact of SRC on water quality will be evaluated.

Analysis of bioenergy production models in India and Uganda through stakeholder engagement. Harrison, J.; Amezaga, J. (*Newcastle University, UK; j.a.harrison@ncl.ac.uk; j.m.amezaga@ncl.ac.uk*).

Multiple concerns over biomass use for energy generation have initiated a perception change regarding whether it contributes towards sustainable global development. EU AidCo's Re-Impact project focuses on bioenergy impacts in Africa and Asia, including detailed stakeholder analysis (SA) of production in India and Uganda. In India, four models of *Jatropha curcas* production were identified. The critical distinction in terms of impacts was whether production occurred on government or private land. Key concerns with government land: plantation management; price fixing; lost access to previously communal resource rights; no tenure status improvements. For private land: farmers at highest risk of poor yields; price fixing; availability of under-utilised land on small farms. In Uganda, seven models of woody biomass for energy were considered; the distinction being whether they were corporately or privately led. Key issues for corporately led models: no/ little inclusion of farmers/landless; unlikely to improve local energy access; unreliable regulation leading to negative environmental impacts. For privately led: new technologies contrary to tradition; seasonal, at best, involvement of landless; limited availability of land on small farms; sustainability of woodlots. Results expose positive and negative impacts, highlighting the need for local SA to fully understand the sustainability of bioenergy projects.

Forest-based energy in China: transitions and sustainability. Kahrl, F. (*University of California, USA; fkahrl@berkeley.edu*),Su, Y. (*World Agroforestry Centre, China; suyufang@mail.kib.ac.cn*), Tennigkeit, T. (*UNIQUE Forestry Consultants, Germany; timm.tennigkeit@unique-forst.de*), Xu, J., Yan, M. (*World Agroforestry Centre, China; J.C.Xu@cgiar.org*; *yanmei@mail.kib.ac.cn*).

Forest biomass is, and will continue to be, an important part of China's energy supply. Although currently the dominant use of forest-based energy in China is for meeting rural cooking and space heating needs, new technologies and changes in policy will encourage a shift toward greater use of forest biomass in power generation, combined heat and power (CHP), and in the production of liquid transportation fuels. Drawing from a series of studies undertaken by the authors in southwest China's Yunnan Province, this paper provides an overview of the economic, social, and environmental dimensions of China's transition in forest-based energy. The paper examines three new uses of forest-based energy in greater depth: small-scale power generation, CHP in timber processing facilities, and jatropha biodiesel for motive power. In all three cases, the paper argues that transitions must be timed with reforms in forest governance and management to ensure economic, social, and environmental sustainability. The paper concludes with recommendations for policy design and an agenda for demonstration-based research.

The expansion of plantations in Indonesia's Papua: avoiding deforestation while promoting responsible investments. Komarudin, H., Obidzinski, K., Andrianto, A. (*Center for International Forestry Research, Indonesia; h.komarudin@cgiar.org; k.obidzinski@cgiar.org; a.andrianto@cgiar.org*)

Driven by the goals to strengthen the position of Indonesia as a key player in pulp and paper production on the global scene, and to turn this country into a major producer of crude palm oil and biofuels, the government issued policies to expand timber plantations and biofuel estates (mostly oil palm) by a combined 14 million ha over the next 10 years. The ongoing expansion of

plantations has raised concern over deforestation and forest degradation and adverse effects on indigenous people's access to resources in Indonesia's Papua, the largest intact block of tropical rainforest left in the Asia-Pacific region. To address this concern, collaborative research has been undertaken by CIFOR and its partners aiming to (1) better understand the changes taking place in Papua's forest cover, factors behind the change and likely impacts of to-date and future on rural livelihoods; (2) identify legal and institutional frameworks relating to key vectors of deforestation and degradation; and (3) identify recommended options to advance responsible investments and improved forestry investment policy-making. The findings have thus far indicated deforestation trends, underlying causes, and gaps in legal and institutional settings that hamper sustainable investments and social impacts on local livelihoods.

Firing socio-economic questions in the forest: what are the impacts of fuelwood in the Democratic Republic of Congo? Schure, J., Ingram, V., Awono, A. (*Center for International Forestry Research, Cameroon; j.schure@cgiar.org*; *v.ingram@cgiar.org*; *a.abdon@cgiar.org*).

Despite being located in the heart of world's 2nd largest tropical forests, timber for fuel is becoming a problem in the Democratic Republic of Congo (DRC). Although firewood and charcoal are the dominant sources of energy for households, information about environmental and socio-economic aspects is sparse. The study's approach combines a value chain and livelihood perspective to distill the main indicators of the fuelwood sector around two urban centers, Kinshasa and Kisangani. Key factors of the natural environment were identified as: the type of wood-producing environment, the quality of wood, sustainability, and seasonality. The socio-institutional context consists of: the actors, sociology of the chain, household strategies, governance, and institutions. Market characteristics, product economic characteristics, and poverty indicators shape the economic context. Interviews with stakeholders and surveys with fuelwood producers, traders, and consumers around the cities provided social, economic, and environmental data. A monitoring mechanism will be presented to track the sustainability of the fuelwood sector in the long term. These data will be made available to inform policymakers from concerned sectors (especially: energy, agriculture, environment, forest, and land use planning) about burning fuelwood issues and to inform policy development about how to reconcile environmental and livelihood needs.

Understanding social impacts of bio-energy programs: a case study from India. Tiwari, S., Borgoyary, M., Reddy, A. (*Winrock International India, India, sunandan@winrockindia.org; mamta@winrockindia.org; arvind@winrockindia.org*).

Changes in land use patterns have the potential of having three-fold, interrelated impacts: environmental, economic, and social. Bio-energy plantations for the production of biofuels, such as biodiesel, is a significant land use change that India and several other countries are promoting as a means for substituting fast depleting crude oil reserves. However, the direct, indirect, and cumulative impacts of this changed land use need to be assessed and better understood at a program design stage so as to be able to develop alternative strategies where necessary. For a country like India, which despite its recent economic surge continues to remain an agrarian society with the majority of its population dependent on land-based natural resources for their livelihoods, understanding the social and economic impacts of the biofuels program, which comprises significant land use changes, at the grassroots level becomes a critical first step. This paper presents the results of a pilot social impact assessment of a government-initiated bio-energy program in the Indian State of Chhattisgarh. It outlines the process followed, identified social impacts at the local level, and potential alternative strategies for mitigating unfavorable impacts.

Potential impacts of *Jatropha* plantations on key ecosystem services in Southern Africa. Von Maltitz, G., Gush, M., Everson, C. (*CRIR, South Africa; gvmalt@csir.co.za; Mgush@csir.co.za; CEverson@csir.co.za*), Borman, G. (*University of the Witwatersrand, South Africa; garethborman@gmail.com*), Blanchard, R. (*CRIR, South Africa;RBlandchard@csir.co.za*).

Plantations of *Jatropha curcas* L. (*Jatropha*) are being proposed as a key feedstock for biodiesel production throughout most of southern Africa, though it is banned in South Africa due to concerns over potential invasiveness. *Jatropha*, as a plantation crop, is new to the region and hence many potential environmental impacts are unknown. Likely impacts on key ecosystem services of water, biodiversity, and carbon are investigated based on results from a 4-year-old research plantation and modelling approaches. Detailed water use has been obtained from the experimental plots and through the use of heat pulse techniques on individual mature trees. Carbon impacts are investigated using a partial lifecycle approach focusing in detail on soil and above ground carbon fluxes using the CENTURY model. Key to the carbon investigation is the potential impacts from land use transformation. Two key biodiversity impacts are considered: impacts from invasiveness and impacts from land use transformation. Results suggest that management options can greatly influence levels of impacts on carbon and biodiversity. The fact that *Jatropha* is able to enter periods of dormancy during times of water stress limits its hydrological impacts compared to trees such as *Eucalyptus*.

Posters

Energy from forests: policy trends in China, India, Uganda, and Southern Africa. Amezaga, J., Harrison, J., Boyes, S. (*Newcastle University, UK; j.m.amezaga@ncl.ac.uk; j.a.harrison@ncl.ac.uk; s.l.boyes@ncl.ac.uk*).

Rising fossil fuel prices, energy security, and global warming are driving interest in large-scale bioenergy production from woodlots and oil-seed plantations. Despite its potential as a rural development mechanism, bioenergy sustainability is globally debated. In wood-fuel terms, forest resources are often poorly managed and degraded with unsustainable extraction. With liquid fuels, high petroleum prices and demand drive national self-sufficiency campaigns, not always supported by impact assessment. EU AidCo funded Re-Impact (www.ceg.ncl.ac.uk/reimpact) focuses on the impacts of bioenergy production in Southern Africa, India, China, and Uganda. A sustainability framework (SF) has been developed to identify appropriate areas for bioenergy systems, considering sustainable, pro-poor, water, and biodiversity issues. Possible tradeoffs with carbon sequestration and other benefits are also included. In China the focus has been the modern biomass transition in Yunnan Province, looking both at *Jatropha curcas* and forest; in India the implementation of the biofuels strategy in Chhattisgarh State; in southern Africa the prospects for biofuels in the SADC region; and in Uganda the potential for biomass-based energy from short-rotation plantations. The case studies show the need for evidence-based policies considering land-use and equity issues. Bioenergy projects need to be established on sound management models with technical and economic viability.

Potential impacts of bioenergy plantations on environment in China. He, Y.J. (*Chinese Academy of Forestry, China; hyjun163@163.com*), Máthé, L. (*WWF International, UK; lmathe@wwf.panda.org.*).

As a result of the rapid economic development, China will be confronted with a severe energy crisis and environmental protection problems in future decades. Concerns about energy security paired with the need to tackle climate change have led to increasing support for the development of new domestic sources of energy. Plantation bioenergy is an alternative to fossil energy. In this paper, the resource potential and development status of plantation bioenergy are analyzed, as well as the potential impacts of bioenergy plantations on the environment, focusing on land use, tree species, soil, water, biodiversity, and the carbon cycle. The results show that: (1) reducing energy consumption by increasing energy efficiency is the most important issue; (2) the most critical environmental issue is the use of genetically modified trees for bioenergy production, which will pose an incalculable threat to biodiversity; and (3) in addition to effects from plantation establishment, bioenergy production may have implications on managed plantations by extracting substantial amounts of forest residues on a large scale and in an unsustainable way. Finally, some recommendations to mitigate and even avoid negative impacts on environment are proposed.

Reforestation strategies, benefits and challenges in Ghana. Opoku-Boamah, N.C., Sato, T. (*Tokyo University of Agriculture, Japan; nelcapt@yahoo.co.uk; satota@nodai.ac.jp*).

Even though degradation and deforestation of forest resources have long been on the campaign agenda of environmentalists, they seem to have gained much attention nowadays with climate change issues dominating global discussions. Reforestation, especially in developing countries, has attracted a lot of attention from the developed world. In Ghana, the high deforestation rate (2% or 684 km² per annum) and wood deficit situation call for immediate measures to restore forest cover, increase industrial and fuel wood supply, and sustain livelihood sources. Plantation development has for a long time been identified as one of the important strategies required to meet the demand for wood resources in Ghana, where the rate of forest loss remains high. In Ghana, a number of reforestation initiatives are underway. This study focuses on reforestation strategies, benefits, and challenges in Ghana. The study methods included project site visitation, interviews, and literature review. First, the results showed the different kinds of reforestation initiatives on various scales. Again, results revealed the social, economic, and environmental benefits associated with reforestation; as well as the challenges. The level of success so far is very high, hence the need for further support and co-operation towards amelioration of global warming.

C-13 Agroforestry for climate change adaptation

Organizers: August Temu, *World Agroforestry Centre-ICRAF, Kenya, a.temu@cgiar.org*; P.K. Nair, *University of Florida, USA; pknair@ufl.edu.*

Farm forestry: a viable option to poverty alleviation and climate change amelioration in Ghana. Ameyaw, L.K., Obiri, B.D. (*Forestry Research Institute of Ghana, Ghana; kofilord@gmail.com; bdobiri@csir-forig.org.gh*), Acheampong, E. (*Kwame Nkrumah University of Science And Technology, Ghana; ekachie@yahoo.com*), Opuni-Frimpong, E. (*Forestry Research Institute of Ghana, Ghana; eofrimpon@csir-forig.org.gh.*).

Farm forestry as an agroforestry practice has become a viable option in ameliorating climate change and forest degradation and also enriching the rural poor. The integration of woody perennials managed for a range of purposes within tropical farming systems can be seen as an ever-rewarding venture looking at it from the social, economic, and environmental points of view. This paper overviews the benefits, challenges, and potentials of farm forestry from the Ghanaian smallholder farmer perspective with reference to African mahogany as a woody perennial in the system. The work examines an instance where tree components are to be maintained for carbon sequestration. Here farmers are paid for the carbon sequestration service being rendered by their planted trees. Also, this study looks at a scenario where tree components are to be harvested for timber at stumpage prices at the end of their rotational period. In both cases, input and output data for food crops are incorporated to ascertain profit margins at a 10% discount rate using a net present value approach over a 40-year period. Farm forestry was found to be economically rewarding. The paper further recommends national policies to consider the system for overall sustainable development.

Intercropping with *Pongamia pinnata* for higher productivity and soil fertility. Divya, M.P., Natesan, C.S. (*Forest College and Research Institute, India; divsara05@yahoo.com; rasincs@yahoo.com.in*), Henry, P. (*TNAU, India; philip.tnau@gmail.com*).

Pongamia pinnata is widely distributed in tropical India. It is reported that *Pongamia* oil is the best for biodiesel when compared to any other non-edible oil used in biodiesel industry. This tree is hardy and comes up well in poor soil under dryland conditions. Hence, this experiment was conducted with the following objectives: (i) to find out the suitable intercrops for *Pongamia* based agroforestry system, and (ii) to assess the soil fertility status under *Pongamia* based agroforestry system. Cowpea, blackgram, redgram, soybean, greengram, grain amaranth, groundnut, and sunflower were raised as intercrops under *Pongamia* for 5 years. The results showed there was a significant difference in available N, P, and K due to intercrops and *Pongami;,* and revealed that cowpea, groundnut, and blackgram were found to be suitable intercrops for a *Pongamia*-based agroforestry system for higher productivity and soil fertility.

Carbon dynamics and other interactions in a pine-based silvopastoral system, a pine plantation, and a natural prairie established on degraded volcanic soils in Chilean Patagonia. Dube, F. (*University of Concepción, Chile; fdube@udec.cl*), Gordon, A. (*University of Guelph, Canada; agordon@uoguelph.ca*), Thevathasan, N. (*University of Guelph, Canada; nthevath@uoguelph.ca*), Zagal, E., Stolpe, N., Espinosa, M. (*University of Concepción, Chile; ezagal@udec.cl; nstolpe@udec.cl; mespinos@udec.cl*).

According to the United Nations, the use of agroforestry systems on degraded lands could capture 820–2200 × 10^6 t C $year^{-1}$ over a 50-year period. The objective of this study is to investigate the potential to sequester C in a *Pinus ponderosa*-based silvopastoral system arranged in strips, a plantation, and natural prairie in Patagonia. Tree and pasture biomass were inventoried and C contents

determined by dried combustion. Needle fall was recollected once a month, and decomposition of needle, grass roots, and cattle feces measured using the litterbag technique. Lignin and nutrient contents in the needle litter were determined as well as C in soil leachates and respired CO_2. Preliminary results show that decomposition rates were related to soil temperature and moisture contents. Soil respiration was highest in the prairie and lowest in the plantation. The C contents in grass and tree biomass in the silvopastoral system exceeded that of the pasture and the plantation, respectively. Determination of SOC at 0–40 cm depth shows that the silvopastoral system had the highest C contents, and there was more C in soil than corresponding plant biomass. The silvopastoral system appears as an interesting alternative for C sequestration, erosion control, and plant growth.

Social benefits of agroforestry associated with the role of women in small communities: case study in Brazil. Hermoso Barroso, L.; Ziantoni, V.; Angelo, A.C. (*Federal University of Parana, Brazil; letiziahermoso@gmail.com; vziantoni@gmail.com; alessandro.angelo@ufpr.br*).

The study was carried out on various agroforestry properties of "Barra do Turvo" (24°45′21″S-48°30′18″O), a municipality with the lowest social indicators in the south of Brazil that suffers from the lack of adequate economic alternatives for sustainable development. The study evaluated the economic and social impacts on women from 10 years of agroforestry development activities. Our results were obtained by living in these communities and by participatory investigation (40 families) between February and December 2008. The women in this study had an average age of 35 years, were largely illiterate, and had two to three children. The social benefits of agroforestry were of direct benefit to the women of the community as they fostered their contribution to the family income, thus giving them greater decision opportunities and more independence economically and in the family. Their spare time increased, and their nutrition and health improved, which had a positive effect on the school achievements of their children. A greater unity as "community" was achieved and cooperatives of women in organic agriculture and handicrafts were established. All in all, agroforestry brought more gender equity to the community, maintained the sustainability of the system, and also offered the women greater decision power.

Smallholder rubber farm in Riau, Indonesia: its contributions to rural livelihood, biodiversity conservation, and climate change mitigation. Muhammad, A. (*Riau University, Indonesia, biodiversity_riau@yahoo.com*), Kono, Y. (*Kyoto University, Japan; kono@cseas.kyoto-u.ac.jp*).

We studied two types of smallholder rubber (*Hevea braziliensis*) farm in Riau (Sumatra, Indonesia): rubber garden and rubber forest. Our survey of more than 120 farms showed the necessity to reconsider the rubber forestry system as a production-embedded agroforestry system. Tree densities of rubber garden and rubber forest were between 367 and 1,686 trees ha^{-1} with the average of 541.3 tree ha^{-1} and between 312 and 1,894 trees ha^{-1} with the average of 926.6 tree ha^{-1}, respectively, of which the productive ones numbered averagely 343.2 trees ha^{-1} and 251.6 trees ha^{-1}, respectively. The farm size was between 0.5 and 6 ha, mostly between 1.0 and 2.5 ha. The farmer's monthly income from latex production varied between 0.5 and 2.5 million rupiahs (approx. 50 to 250 USD) and there was no significant difference between both farm types. The contributions of rubber farm to biodiversity conservation and climate change mitigation depended on the stand type and density. Being a self-regenerating (hence denser) stand, rubber forest was more supportive of the persistence of native flora and fauna and more superior in accumulating biomass than the rubber garden, thus conforming better to the need to mitigate climate change through carbon sequestration and storage.

Aggregate formation and soil carbon sequestration under tree-based systems in various agroecological regions. Nair, V.D., Nair, P.K. (*University of Florida, USA; vdn@ufl.edu; pknair@ufl.edu*).

Environmental factors such as soil type, climate, plant species, and landscape position play an important role in soil aggregate formation and carbon (C) sequestration. We examined C storage in soil fractions (2000–250 μm, 250–53 μm, <53 μm) under various tree-based land-use systems in different agroecological conditions. They included sole stands of trees, agroforestry systems, and natural forests; alfisols, inceptisols, oxisols, spodosols, and ultisols; and humid, subhumid, and semiarid tropics, and subhumid Mediterranean climates. The total soil organic carbon (SOC) to 1 m depth in the various systems ranged from 30 Mg ha^{-1} in the alfisols of the West African Sahel to 300 Mg ha^{-1} in shaded cacao systems on oxisols of the humid tropics. All land-use systems had higher protected C (in <53 μm soil particles) in lower soil profiles across ecological regions. In alfisols and sandy soils, SOC stability was related to silt and clay content. Occlusion of C in larger-sized aggregates and its binding with metal oxides appeared to be a mechanism for protection of C in oxisols. The results show the variability of C sequestration among different soil types, and the importance of trees in stabilization of soil C under lower soil profiles.

Reserve Barkossi conversion in agroforestry parklands. Pereki, H. (*Laboratoire de Botanique et Ecologie Végétale, Togo; perekih@yahoo.fr*), Folega, F. (*Beijing Forest University, China; ffolega@yahoo.fr*), Batawila, K., Wala, K., Akapagana, K. (*Laboratoire de Botanique et Ecologie Végétale, Togo; batawila@tg.refer.org; kpwala@yahoo.fr; kakpagan@tg.refer.org*).

The Barkoissi Reserve is a forest reserve in zone I of northern Togo consisting mostly of savannas. So far, not many international studies have investigated this reserve on a scientific basis. Due to anthropisation, the reserve has almost entirely been converted into agroforestry parklands, and constitutes a place for collection of fuel wood, bark, and roots. These parklands are dominated by *Vitellaria paradoxa*, *Parkia biglobosa,* and *Borrasus aethiopum*. The study follows the phytosociological approach according to Braun-Blanquet in combination with field observations. Samples of species have been taken in a sector with more or less natural forest cover. Ethnobotanical surveys in discussion groups have revealed that the share of income from the reserve in farm household income is substantial. Certain species with strong added value such as *B. aethiopum* are grown in nurseries.

Biodiversity conservation in coffee-based agroforestry systems and livelihood enhancement: a novel approach from Western Ghats. Sathish, B.N., Kushalappa, C.G. (*College of Forestry, India; satibn@gmail.com;* kushalcg@gmail.com), Viswanath, S. (*Institute of Wood Science and Technology, India; sviswanath@icfre.org*).

Expansion of coffee cultivation is one of the causes of deforestation and biodiversity loss. However, shade-grown coffee has been promoted as a means for preserving biodiversity in the tropics. Shade coffee has been ambitiously promoted by conservationists

and the scientific organizations as a means for preserving biodiversity in tropics by providing incentives through certification process. In this context the present study was conducted in the coffee agroforests in the Western Ghats region of Kodagu: one of the largest producers of coffee in the world. Coffee agroforests in this region were assessed for their biodiversity value in terms of tree diversity under different shade-tree management regimes. Coffee productivity and quality also were assessed under different shade-tree management regimes. It was found that canopy with native trees species was influencing positively on productivity of coffee (in the past 10 years) and on coffee quality (both physical traits and cup quality) of sun coffee or coffee grown under *Grewillia robusta*. This proven positive influence of native tree species on coffee quality and productivity will be used for certification to get premium price for the coffee grown under biodiversity-rich shade-tree managements regimes.

Soil carbon sequestration in Attapady Valley of Nilgiri Biosphere Reserve, Western Ghats, India. Viswanath, S. (*Indian Council for Forestry Research and Education, India; sviswanath@icfre.org*), Sameer, P.A (*AVT McCormick, India; sameeradam@rediffmail.com*), Nair, K.M. (*NBSS & LUP, India; nairkmn@yahoo.com*).

The impacts of extensive land use changes in Attapady Valley over the past century on soil carbon sequestration were estimated by mapping soil organic carbon (SOC) up to 1 meter depth under four prominent land use systems. The SOC stock depletion was in the order of barren land > seasonal agriculture land > agroforestry> forestland. Barren lands, which constituted 56.3% of the study area, accounted for 34.6% of the total SOC stock at the top 100 cm; undisturbed forest (15.14%) accounted for 33.20% of SOC; agroforestry (12.98%) held 18.02% of SOC; and agriculture landscapes (15.04%) held 14.09% of SOC. Major depletion of SOC was in the top 30 cm of soil and estimated to be 1.16 kg m^{-2} on conversion to agroforestry, and 3.52 kg m^{-2} and 4.71 kg m^{-2} on conversion to agriculture and barren lands respectively. Forest soils had carbon reserves 3.2 times greater than barren land. Nearly 0.019 Pg of C is estimated to be fixed as SOC, whereas deforestation caused depletion of 0.025 Pg from this potential carbon stock. It is estimated that through reforestation, 0.044 Pg C can be potentially fixed, which could contribute significantly to the soil carbon stock.

Posters

Biodiversity-friendly coffee from agroforestry in South Bandung Forest Management Unit. Bahunta, L. (*Perum Perhutani, Indonesia; lbahunta@hotmail.com*), Siregar, I., Yunanto, T. (*Bogor Agricultural University, Indonesia; izsiregar@yahoo.com; genom_tedi@yahoo.com*).

Forest encroachment in the South Bandung Forest Management Unit (FMU) has drastically changed both forest biodiversity and landscapes. In 2003, around 15,000 ha of protective forest was encroached, mainly for vegetable production. The habitat created has no conservation benefits for watershed functions, soil fertility, biodiversity, and carbon stocks. Since 2003 attempts have been made by the FMU to change the disadvantegous condition through co-management approaches in which farmers' knowledge and agroforestry sciences were carefully blended. Considering "tradeoffs" between different effects of management styles, the final choice suggested coffee agroforestry using shade-tolerant coffee species to be implemented in the FMU. This softpower approach has been very effective in reducing the encroachment whereby 840 ha (2009) are left out of 15,000 ha (2003) to be handled. On the other hand, total forest areas that are co-managed in coffee agroforestry increased from 70 ha (2003) to 2,000 ha in 2009. In terms of economic benefit, this agroforestry system has contributed significantly to the sharing portion for forest farmers' groups amounting to IDR 2.4 billion (2009). Shaping up existing agroforestry co-management is continuosly done through facilitation schemes, especially for biodiversity friendly coffee, labelling within the framework of a forest certification program.

The socio-economic effects of agroforestry and its role in the conservation of natural resources of Iran. Ghanbari, S. (*University of Tehran, Iran; ghanbarisajad@gmail.com*).

The supply of raw materials for wood industries is facing serious problems due to the lack of harvestable forests. This shortage imposes high costs for wood products in the economy. Agroforestry is an important way to provide these materials, to reduce dependency on imports, and to increase employment. This research examines the species used, the cultivable regions, and the methods of agroforestry development in Iran. The results showed that in agroforestry, rapid-growing native species, such as *Populus* spp., and exotics, such as *Eucalyptus* spp. and *Paulownia* spp., are often used. These species are used in the different regions of the country; poplar in the north, west and northwest; *Eucalyptus* and *Paulownia* in the north; and *Eucalyptus* in the south. Although these species have high yields in terms of wood cultivation from agroforestry systems, farmers plant less of these species in large areas because of the lack of support by the government. Therefore, the government must adopt incentive policies that assist in developing agroforestry practices by granting facilities, giving farms, and guaranteeing product markets. Cooperation between the government and the people can result in supplying the wood requirements of the country, preventing dependency on wood imports, and increasing employment.

Characteristics of leaf photosynthesis and root respiration of *Panax ginseng* grown in forest. Jeon, S.R., Han, S.S, Sa, J.Y., Yi J.S. (*Kangwon National University, Republic of Korea; ds2szm@gmail.com; sshan@kangwon.ac.kr; sajy1208@hanmail.net; jasonyi@kangwon.ac.kr*).

Forest-grown ginseng (FGG) is recommended as one of the non-timber forest products in Korea. It catches public attention more and more, because field-cultivated ginseng (FCG) has many problems, including residual agricultural chemicals, while FGG is cultivated without such chemicals and some fertilizers. This is an investigation to find a suitable forest floor conditions in terms of light and temperature for cultivation of ginseng in the forest area by physiological responses of FGG leaves and roots. Ten ginseng plants were selected from a 4-year-old plantation. FGG were grown in the *Quercus-Larix* mixed forest floor. Leaf photosynthesis and root respiration were investigated and analyzed. The light compensation point was 15.2 $\mu mol^{-2}s^{-1}$; the light saturation point was 400 $\mu mol^{-2}s^{-1}$; and the maximum net photosynthetic rate was 3.7 $\mu molCO_2m^{-2}s^{-1}$ at 25 °C and 1,200 $\mu molm^{-2}s^{-1}$. The root respiration rates were exponentially increased by increasing temperature, but were very low values less than 15 °C. This research results suggest that *P. ginseng* should be grown a cool area and shady forest area of which the average temperature ranges around 25 °C to less than 30 °C maximum during the daytime.

Agroforestry for ecosystem services and environmental benefits. Jose, S. (*University of Florida, USA; sjose@ufl.edu*).

Modern agricultural practices have allowed for a dramatic increase in crop and livestock production; however, it has come at the expense of environmental degradation. Agroforestry, the intentional incorporation of trees, agricultural crops, and/or animals into a single land-use system, is one way to reduce the negative impacts of modern agriculture. Agroforestry systems are believed to provide a number of ecosystem services; however, until recently evidence in the agroforestry literature supporting these perceived benefits has been lacking. This poster brings together a series of papers from around the globe to address recent findings on the ecosystem services and environmental benefits provided by agroforestry. Specifically, it examines four major ecosystem services and environmental benefits provided by agroforestry: (1) carbon sequestration, (2) biodiversity conservation, (3) soil enrichment, and (4) air and water quality. Past and present evidence from both the tropical and temperate regions of the world clearly indicates that agroforestry, as part of a multifunctional working landscape, can be a viable land-use option that, in addition to alleviating poverty, offers a number of ecosystem services and environmental benefits. This realization should help promote agroforestry and its role as an integral part of a multifunctional working landscape the world over.

A two-year study of root growth of *Panax ginseng* in forests. Lee H.S., An, C.H., Kim, C.W., Bagus, I., Park, Y.G., Kang, H. J., Choi, Y.E., Yi, J.S. (*Kangwon National University, Republic of Korea; lvangood@nate.com; soaurora@naver.com; forester@nate.com; tectonagrandis@msn.com; zxcmnbv7@nate.com; gywls0406@nate.com; yechoi@kangwon.ac.kr; jasonyi@kangwon.ac.kr*).

Panax ginseng (ginseng) is an important forest product in Korea, its roots widely used as food and medicinal material. Three kinds of forest stands—oak, pine, and larch—were chosen for the comparison of root growth in ginseng. Soil pH, soil nutrients (K, Na, Ca, and Mg) and soil organic matter were analyzed using standard methods. The oak forest site was a 30-year-old stand on a SW-facing slope, with an average tree DBH, height and stem density of 21.6 cm, 14–15 m, and 1,000 trees/ha, respectively. The 35-year-old pine forest was on a NE-facing slope with an average DBH, height and density of 22.2 cm, 12–13 m and 1,100 trees/ha, respectively. The 45-year-old larch forest was on a NE-facing slope, with an average DBH, height and density of 23.1 cm, 14–15 m, and 900 trees/ha. Two-year-old ginseng roots were longest when grown under pine forest (12.23 mm), and shortest under larch (3.27 mm). Root diameters were 12.23 mm in pine, and 1.22 mm in larch. Average fresh root weights were 0.50 g in pine, and 0.17g in larch forest. High calcium ion concentration (2.27 cmol/kg) in pine forest seemed to be related with the better root growth of ginseng.

Water relations parameters of the leaves of three *Ligularia* species. Lee, K.C., Jeon, S.R., Sa, J.Y., Han, S.S. (*Kangwon National University, Republic of Korea; dlrud112@naver.com; sshan@kangwon.ac.kr*).

This study was conducted to diagnose drought-tolerance and to find an adequate cultivation environment of *Ligularia fischeri, L. stenocephala,* and *L. fischeri* var. *spiciformi*s by using pressure-volume curves. The original bulk osmotic pressure at maximum turgor Ψo^{sat} was –0.8MPa in *L. fischeri* and *L. stenocephala*, This value is lower than that of –0.7MPa in *L. fischeri* var. *spiciformis*. It also appears that the osmotic pressure at incipient plasmolysis Ψo^{tlp} was –0.9MPa in *L. fischeri* and *L. stenocephala*, This value is lower than that of –0.8MPa in *L. fischeri* var. *spiciformis*. Maximum bulk modulus of elasticity E_{max} was 29.0MPa *in L. fischeri* and *L. stenocephala*, which was about 2 times higher than that of 14.5MPa in *L. fischeri* var. *spiciformis*. The relative water content showed a similar value, at incipient plasmolysis RWC^{tlp} was 95% in *L. fischeri*, 93% in *L. stenocephala*, and 94% in *L. fischeri* var. *spiciformis*. Therefore, the drought tolerance of *L. fischeri* and *L. stenocephala* was higher than that of *L. fischeri* var. *spiciformis.* This study showed that *Ligularia* species leaf is a low drought-tolerant with relatively high water content, and that an adequate cultivation environment is comparatively moist forest.

Contribution of indigenous agroforestry systems in biodiversity conservation and ecosystem functioning: experiences on four contrasting systems from Bangladesh. Mukul, S.A. (*Centre for Research on Land-use Sustainability, Germany; sharif_a_mukul@yahoo.com*), Saha, N. (*Shahjalal University of Science and Technology, Bangladesh, nsaha@yahoo.co.in*).

In recent years the multipurpose role of agroforestry in conservation of biodiversity and ecosystem functioning has been widely recognized, particularly in developing countries. We conducted an exploratory study on four contrasting indigenous agroforestry systems in north-eastern Bangladesh: betel-vine (*Piper betel*)-based *Khaisa* agroforestry, lemon (*Citrus limon*) horticulture-based, pineapple (*Ananas comosus*)-based *Tripura* agroforestry, and short-rotation shifting cultivation practiced by *Garo* indigenous community, to realize their biodiversity conservation and ecosystem functioning potentials. The functional diversity of plants, planted-wild crop ratio, cultural management, conservation values, and ecosystem benefits of each agroforestry system were evaluated through a series of systematic survey and standard procedures. The study revealed that betel-vine-based agroforestry is the most environmentally and ecologically feasible land-use system in the area supporting higher plant and wildlife diversity and providing greater ecosystem benefits, which sometimes seem even better than the indigenous forest cover. Intensification of management practices and extensive use of agro-chemical for higher yield in few of these agroforestry systems, however, threatens local ecosystems. The study concluded that for scientific improvement, greater recognition, and wider application of a few of these indigenous agroforestry systems will certainly bring positive outcomes for sustainable land-use in the country.

Neem-based agroforestry system for enhancing the productivity of drylands. Muthusamy Palani D., Natesan C.S. (*Forest College and Research Institute Mettupalayam, India; divsara05@yahoo.com; rasincs@yahoo.co.in*), Henry P. (*TNAU, India; philip.tnau@gmail.com*).

In India, the productivity of drylands is getting reduced by erratic and uncertain rainfall. The adoption of a neem-based agroforestry system is a viable option for increasing the productivity of drylands because neem is a best suited tree for drylands. The versatility of this tree is that it survives in very extreme climates and grows in a variety of soil types. In India, neem trees are found growing scattered in the fields surrounded by crops that appear to be quite unaffected and also on the boundaries of the fields to meet local demands for timber, fodder, and fuel. Results of the compatibility study revealed that there was least reduction in growth and yield of intercrops due to effect of neem trees. Among intercrops raised, cowpea and horsegram were found to be highly compatible and more beneficial in boosting the growth of neem trees. The neem-based agroforestry system

improved soil fertility also in terms of available soil N, P, K, Ca, and Mg. The allelopathic study showed that neem was less toxic in terms of its allelopathic effect. Hence, considering all these factors, neem-based agroforestry systems are found to be economically viable for enhancing the productivity of drylands.

Multiple benefits of alley cropping practice in former pumice-mined land rehabilitation in Indonesia. Narendra, B.H. (*Ministry of Forestry, Indonesia; budihadin@yahoo.co.id*).

The district of Lombok Timur in the eastern part of Lombok Island, Indonesia, has been recognized for its pumice mining. The mining adversely loses the top soil to water run-off, thereby decreasing soil fertility and limiting the crops to be planted. Moreover, the low rainfall in the area further constrains people from farming reclaimed pumice-mined lands. Rehabilitation of pumice-mined land is rarely done because of the lack of technology effective enough to make it productive again. Based on a completely nested randomized design trial starting in 2004, using some leguminous tree species as hedgerows and green manure sources as additional input, alley cropping quantitatively showed the ability to improve the soil properties of former pumice-mined lands. Multiple benefits were also obtained during application of the system, such as high-growth-rate teak as the main tree species, high amounts of green manure, high quality forage, and high crop harvests. More importantly, the trial demonstrated the capability of the alley cropping system to rehabilitate degraded lands whose resources have been depleted by mining.

The alternative preferred species to be planted in community forest with *Paraserianthes falcataria* in multi-culture system in West Java, Indonesia. Permadi P. (*Forestry Research and Development Agency, Indonesia; permadi@indo.net.id*), Rachman E. (*Ciamis Forestry Reserch Institute, Indonesia; enceprachman@yahoo.com*).

Sengon (*Paraseriantes falcataria*) is commonly planted in community forests in Ciamis district of West Java, Indonesia, along with other timber species such as mahogany, *Maesopsis* spp., and *Mangletia* spp. The community forest in Ciamis district plays an important role in the economy, producing about 450.000 m^3 yearly. Some 80% of this is *sengon* wood, grown as a plantation forest in a monoculture system susceptible to pests and diseases. Multi-culture forest planting needs to applied, as well as choosing other species, which should be technically applicable, economically feasible, and socially acceptable. Three steps can help choose the species: questioning the wood industries and farmers about species that have similar properties to sengon and are acceptable by themarket; collecting information about species that are pest and disease resistant; and collecting information about sylviculture techniques of selected species. In this research we applied those steps to four proposed species—Suren (*Toona sureni*), Manglid (*Mangletia glauca*), gmelina (*Gmelina arborea*), and kemiri (*Aleurites moluccana*). Results showed that *Tona sureni* is the preferred species to be planted with sengon, since it is pest and disease resistant, fast-growing, and aceptable by the market. Our findings are valuable for developing a community forest with multiculture system.

Productivity and wood quality of farm teak under different management practices. Shukla S.R., Viswanath S. (*Institute of Wood Science and Technology, India; srshukla@icfre.org; sviswanath@icfre.org*).

Productivity and wood quality parameters are reported for 12-year-old teak (*Tectona grandis*) grown on farms under three management practices in the same locality, as unmanaged block (UMB), partially-managed line (PML) and intensively managed block (IMB) plantations. Mean annual increments (MAI) of 0.016, 0.006 and 0.020 m^3/tree/year was recorded in IMB, UMB and PML respectively. Overall growth performance of IMB and PML appear to be comparable and much higher than UMB grown in the same locality. Among three types of management practices, wood quality parameters of UMB were comparatively better than IMB and PML, though all the three were inferior compared to the standard forest teak. Higher values of different wood properties of UMB may be attributed to slower growth as evidenced by smaller girth. Since mechanical properties of IMB and PML were lower compared to UMB, exploitation at this stage may not be advisable. Mechanical properties are expected to improve with age or maturity; hence, harvesting of UMB may also be delayed for few years to obtain better productivity and optimum economic returns. Due to favorable wood quality parameters UMB may be considered for commercial exploitation provided thinning is undertaken for reducing competition and enhancing volume in subsequent years.

C-14 Management impacts on forest hydrology, biogeochemistry and water quality

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Nutrient budgets of forest ecosystems in terms of clean water production. Özhan, S., Gökbulak, F., Hızal, A., Şengönül, K., Serengil, Y. (*University of İstanbul, Turkey; sulozhan@istanbul.edu.tr; fgokbulak@istanbul.edu.tr; ahizal@istanbul.edu.tr; sengonul@istanbul.edu.tr; yserengil@yahoo.com*), Özcan, M. (*University of Duzce, Turkey; mehmetozcan38@yahoo.com*).

Water demand has continuously been increasing due to population growth, industrial development, and rise of living standards in many countries. Therefore, people have been struggling and studying to provide sufficient water. In this context, studies are done on forest hydrology owing to forest effects on hydrological and hydrochemical cycles. This paper presents results of a paired watershed project initiated to study effects of forest thinning on stream water regime, quantity, and quality in an oak-beach mixed forest ecosystem in Istanbul. Stream flow measurements were made through automatic water level recorders and precipitation was measured by recording gauges. Streamwater was sampled on a weekly basis in two watersheds and the samples were analyzed according to APHA-AWWA-WPCF standard methods. In terms of concentrations, input of cations Na^+, K^+, H^+, NH_4^+, Mg^{+2}, Fe^{+2}, and Al^{+3}; and anions NO_3^-, PO_4^-, Cl^-, and SO_4^{-2} for precipitation were strongly lower than those for stream waters of three forested watersheds. In contrast to concentration, when inputs and outputs were compared on a mass basis from per unit area, input values of precipitation were higher than output values of stream flow for the same chemicals**.**

Ecological monitoring to predict human disturbance in urban watersheds. Serengil, Y., İnan, M., Özcan, M., Kılıç, Ü., Yurtseven, I., Çokoyoğlu, S., Uygur, B. (*Istanbul University, Turkey; serengil@istanbul.edu.tr; inan@istanbul.edu.tr; ozcan@istanbul.edu.tr; ukilic@istanbul.edu.tr; ibrahimy@istanbul.edu.tr; cokoyoglu83@hotmail.com; uygur@gmail.com*).

More than 15 watersheds and reservoirs supply water to Istanbul's population of more than 12 million. Many of these watersheds are under pressure of urbanization. Increase in percentage of impervious areas, channel alteration, riparian degradation, and water quality deterioration are typical impacts related to human activities in the urban and periurban watersheds of the city. In this study we selected three significant watersheds (Sazlıdere, Alibeyköy, and Kağıthane) and performed ecohydrologic surveys on the stream cross sections of their subwatersheds. Our objective was to find relationships among the attributes determined during the surveys of the stream cross sections and the human impact levels of subwatersheds over them. In stream cross sections we measured both hydraulic and ecologic parameters such as bankfull discharge level, flood depth, riparian width, soil hydraulic conductance, and many more. We studied 35 subwatersheds, enough to establish linear regression equations. With these equations, municipalities can predict the human impact level of a watershed by surveying the stream cross section below it or vice versa.

Statistical indicators for trends in stream acidification: impact of silvicultural management practices. Sucker, C., von Wilpert, K. (*Forest Research Institute Baden-Wuerttemberg, Germany*; *carina.sucker@forst.bwl.de; klaus.wilpert@forst.bwl.de*).

Forested catchments are considered to guarantee a high quality of surface and drinking water. However, during recent decades, anthropogenic deposition has led to a continuous acidification of forest soils which has negative effects on stream water quality. The acidification processes can be influenced by silvicultural management practices. The aim of our research is to determine trends of stream acidification depending on management practices, deposition trends and site conditions on the basis of statistical analyses. These should allow for a comparatively quick and straightforward evaluation of the effectiveness of the forest measures in catchments where no intensive field observations of soil and water chemistry are available. The analyses are carried out over a broad group of approximately 100 water catchments in Germany where various forest management measures have been applied. The analysis allows a valid prognosis on how application of these measures to other areas would be effective. I will present the results both of the time series analyses of the stream water data and multivariate regression statistics, which help to identify the contribution of influencing factors on water quality.

The effects of whole-tree harvesting on nutrients and heavy metals leaching in forested peatlands. Ukonmaanaho, L., Starr, M., Kantola, M., Nieminen, T.M., Nieminen, M., Piispanen, J. (*Finnish Forest Research Institute, Finland, liisa.ukonmaanaho@metla.fi; mike.starr@helsinki.fi; marjatta.kantola@metla.fi; tiina.nieminen@metla.fi; mika.nieminen@metla.fi; juha.piispanen@metla.fi*), Mäkilä, M., Loukola-Ruskeeniemi, K. (*Geological Survey of Finland, Finland;, markku.makila@gtk.fi; kirsti.loukola-ruskeeniemi@gtk.fi*), Lauren, A. (*Finnish Forest Research Institute, Finland; ari.lauren@metla.fi*).

According to current Finnish energy policy, logging residues will have to be used in addition to stemwood to meet targets for bioenergy production. In Finland, 4.9 million ha of peatlands have been drained for forestry purposes, and much of it will be harvested within 10 to 30 years. This biomass would provide a major source of bioenergy, especially if whole-tree harvesting (WTH) were practised. However, the impacts of WTH on biogeochemical cycles and leaching to surface waters are largely unknown, especially in the case of drained peatland forests. Our aim is to investigate the potential risk of harvesting of drained peatland forests, both stem-only (SOH) and WTH, on the mobilization and leaching of nutrients and trace metals to surface water. The study has been carried out in nine small drained peatland catchments. Five of the catchments are underlain by granitic bedrock, four by black shale. In 2007 study plots were established. In 2009, two of the catchments were subjected to SOH, four to WTH, and the remaining three left unharvested. Preliminary results indicate that there are differences in drainage water quality before and after harvesting (both SOH and WTH) as well as between the two bedrock types.

Budgeting nitrogen fluxes in a temperate hardwood forest: uncertainties and changes in sources and sinks. Yanai, R.D. (*SUNY College of Environmental Science and Forestry, USA; rdyanai@syr.edu*), Hamburg, S.P. (*Environmental Defense, USA; steven_hamburg@brown.edu*), Vadeboncouer, M.A. (*University of New Hampshire, USA; matt.vad@unh.edu*), Arthur, M.A. (*University of Kentucky, USA; marthur@uky.edu*).

Predicting the long-term consequences of anthropogenic N deposition on forest health and water quality depends on understanding N sources and sinks. Until now, forest nutrient budgets have not propagated the uncertainty in ecosystem calculations. We examined changes in N pools and fluxes at the Hubbard Brook Experimental Forest in the northeastern USA, where atmospheric N deposition averages ~10 hg/ha/yr. Surprisingly, streamwater export of N has declined from ~5 hg/ha/yr to ~2 hg/ha/yr over the 50 years of record. We included the uncertainty in biomass equations and tissue concentrations in estimating forest N content, using a Monte Carlo approach. The N stored in living biomass is now declining slightly (+2.4 ± 0.5 kg N/ha/yr). The forest floor is no longer thought to be accumulating N (in fact, the C:N ratio is increasing; $p = 0.05$), but uncertainty in this sink is high (−2 ± 22 kg N/ha/yr). The mineral soil is a very large pool (4,340 kg N/ha) with poorly known change over time. If the atmospheric N additions are not accumulating in the soil, denitrification could represent a major source of greenhouse gases (~1 Mg CO2eq/ha/yr). Analysis of uncertainties is essential to interpreting ecosystem budgets and understanding how best to improve them.

Analysis of landslide occurrence affected by forest tending. Youn, H.J., Woo, C.S., Lee, C.W (*Korea Forest Research Institute, Republic of Korea; yount@forest.go.kr; woocs77@gmail.com; leecw@ forest.go.kr*).

In general, forest tending work contributes to preventing landslides by enhancing forest health. In order to quantify beneficial effects of forest tending, landslide occurrences in forest tending areas and those in non-forest tending areas were compared and examined. Landslides had hit hard in Inje and Pyeongchang county, Gangwon province, following Typhoon 'Bilis' on July 15, 2006. Data on forest tending of *Pinus koraiensis* and *Larix leptolepis* stands were acquired from the Inje National Forest Station, Bukbu regional forest service. According to analysis results, tending practices increased the rate of landslide occurrence at the beginning but decreased it gradually with time. The analysis also found that the difference in landslide frequency was slight by age class in the non-forest tending area, while it decreased rapidly as age class increased in the forest tending area. It is estimated

that the recommended tree planting density after forest tending to prevent landslides is 700–900 trees per hectare. In conclusion, forest tending work increases landslide occurrences temporarily at the beginning, but eventually curbs landslides by promoting root growth over time.

Posters

Historical change in sediment yield in Lake Toro catchment, Kushiro-mire, northern Japan over the past 300 years. Ahn, Y.S. (*Korea Forest Research Institute, Republic of Korea; ysahn@forest.go.kr*), Nakamura, F. (*Hokkaido University, Japan; nakaf@for.agr.hokudai.ac.jp*), Choi, H.T., Jeong, Y.H. (*Korea Forest Research Institute, Republic of Korea; choih@forest.go.kr; green@forest.go.kr*).

Environmental degradation—including shallowing and deterioration of aquatic habitat, and water pollution—has arisen from the inflow of fine sediment to Lake Toro in northern Japan. The gradual environmental degradation of the lake is due to agricultural development, which has introduced both fine sediment and sediment-associated nutrients into the lake. We have reconstructed the history of sediment yield to the Lake Toro catchment in Kushiro Mire over the past 300 years and have examined trends with reference to land-use development. Twenty-eight lake sediment core samples were obtained and dated using Cs-137 and tephrochronology. The lake sedimentation and sediment yield were determined by Cs-137 (in 1963) and two tephra layers (Ko-c2 in 1694 and Ta-a in 1739). The total sediment mass in the lake was 1,787 ton/year in 1694–1739 and 1,640 ton/year in 1739–1963. The total sediment mass after 1963 increased to 3,855 ton/year. Compared with the average sediment mass of 1,714 ton/year prior to 1963, sediment production and delivery accelerated after 1963. The average sediment yields for initial development periods of catchments were 13.0–14.1 ton/km^2/year until 1963 and increased to 30.5 ton/km^2/year after 1963 because of the conversion of floodplain and upland forests to cultivated lands.

Rainfall interception in three Tamaulipan thornscrub species and an *Eucalyptus* plantation. Cantú-Silva, I., Yáñez-Diaz, M. I., González-Rodríguez, H., Uvalle-Sauceda, J.I. (*Universidad Autonoma Nuevo Leon, Mexico; icantu@fcf.uanl.mx; mainnes61@hotmail.com; humberto@fcf.uanl.mx; joseuvalle@yahoo.com*).

Measurements of interception losses in three scrub species and a *Eucalyptus* plantation were carried out from 18 April to 30 December 2009 in Linares, Nuevo Leon. Analysis of 26 rainfall events, which totaled 457 mm, showed that net precipitation for *Prosopis glandulosa*, *Eucalyptus* spp., *Ebenopsis ebano,* and *Helietta parvifolia* represented 94, 95, 79, and 92% respectively of total gross precipitation during the study period. Linear regression analysis between gross precipitation and interception in the four canopy types investigated showed values of correlation from r = 0,785 (*E. ebano*) to r = 0.36 (*Eucalyptus*). Interception losses of canopy were estimated at 10, 11, 23, and 16% for *P. glandulosa*, *Eucalyptus* spp., *E. ebano,* and *H. parvifolia*, respectively. The results indicate that the percentage of interception loss decreased as follows: *Ebenopsis ebano*> *Helietta parvifolia*> *Eucalyptus* spp.> *Prosopis glandulosa*. The higher interception loss in *E. ebano* and *H. parvifolia* can occur because the canopy of these species is thicker and its storage capacity is greater than that of *Eucalyptus* and *Prosopis*. However, the architectural features of the canopy and foliage type are different among the species studied and may influence the interception loss.

Vulnerability assessment of the Daguitan Watershed in region 8, Philippines. Nasayao, E., Germano, E., Lacandazo, S. (*Department of Environment and Natural Resources, Philippines; bertnasayao@yahoo.com; emma_germano04@yahoo.com; rino_2766@yahoo.com*).

Daguitan Watershed is a major watershed in the northern part of Leyte Island, occupying an area of 28,385 hectares, encompassing six municipalities and one city; 124 barangays are within the watershed. Land uses are timberland, agricultural land, coastal zone, and geothermal reservation. From the standpoint of ecology, the watershed has a disturbed environment, and changes to the forest landscape strongly suggest continuing destruction of the ecosystem. The watershed also is vulnerable to earthquake hazard due to its location along the Sinistral Philippine Fault, a major geological structure that bisects Leyte Island. For Daguitan Watershed to sustainably exhibit its protective and productive values, its vulnerabilities had to be assessed so that sound management policies and practices could be instituted. Although the watershed was assessed as medium in terms of its vulnerability to floods, it is still vulnerable to this hazard because of the presence of low-lying agricultural communities. Other hazards such as loss of biodiversity and landslides, although they do not pose serious threats at the moment, could potentially result in a confluence of factors that could worsen flooding if mitigating measures are not well-planned and executed.

Water quality in Bunder Forest area, Gunungkidul Regency, Yogyakarta Special Province, Indonesia. Nisa, K. (*Lambung Mangkurat University, Indonesia; nisa_kh@telkom.net*).

One of the interesting factors for nature tourism area development is quality of water resources. This research was carried out in Bunder Forest area, squares 19th and 22nd. The objective was to study the quality of water resources that are available in Bunder Forest. Both field and laboratory observations were done and analyzed to examine chemical and physical characteristics of the water. Water bacteriology was also analyzed to compare with standard of good water quality. Water quality of the Oyo River is in good quality and classified as B level, except for the value of BOD 5.2 mg/l at the point C, COD16 mg/l and 24 mg/l at points A and C, which are higher than that of the tolerable maximum value. For groundwater, NO_3 (11,12 mg/l) and coli bacterial content (110) are higher than that of the tolerable maximum values, which are NO_3 (10 mg/l) and coli bacterial content (0 mg/l). For the purposes of drinking, water must be purified first.

Solute preferential transport in a dark coniferous forest ecosystem of Gongga Mountai. Niu, J., Yu, X., Zhang, Z. (*Beijing Forestry University, China; niujianzhi@gmail.com; yuxinxiao@bjfu.edu.cn; zhqzhang@bjfu.edu.cn*).

We selected a dark coniferous forest ecosystem of Gongga Mountain in the upper reaches of the Yangtze River as our research area to study preferential flow and solute preferential transport, by adding the tracers KNO_3 and KBr to the self-made soil column equipment in different ways to examine density and volume changes of inflows and outflows of a mass input (impulse input) and a stable, well-distributed input (step input). The results showed that this is a typical area of preferential flow and solute preferential transport, a process that can be classified into five parts. A great amount of solute was transported at high speed as

the result of preferential flow in the soil and caused the density of the solute in both deep water and in groundwater to rise rapidly, which definitely increased pollution deep in the soil. In addition, by using the water droplet penetration time (WDPT) test, we showed that the surface water-holding time is largely over 5 seconds among different soil levels across four development stages at the beginning of rainfall, which proves that the soil within the research filed is characterized by soil water repellency.

Evaluation of the availability of water in the soil of *Pinus taeda* stands of different densities in Telemaco Borba, Parana, Brazil. Pachechenik, P.E., Soares, R.V., Chaves, D.M., Batista, A.C. (*Universidade Federal do Paraná, Brazil; p_pache@uol.com.br; rvsoares@ufpr.br; dmcahves@klabin.com.br; batistaufpr@ufpr.br*).

The Brazilian forest industry preserves 1.6 million hectares of native forests and contributes 4.5% to the gross domestic product, although it is considered a cause of negative environmental impacts, especially with regard to soil water availability. To evaluate the impact of industry activity on the availability of water in the soil, an experiment was set up in a stand of 6-year-old *Pinus taeda* with a density of 1,666 trees (3 × 2 m spacing). The stand, belonging to the Klabin Florestal company, was randomly divided into four blocks with five treatment situations (T0 to T4), whereby T0 corresponded to complete clearance, T1 to 100% of the original planting, and the others to 75%, 50%, and 25% of the original density, respectively. The influence of density on interception of rain was monitored by measuring precipitation using rain gauges installed in the treatment areas. The infiltration of water into the soil was evaluated by means of sample series taken in five depths up to 1 m throughout 1 year (January to December 2009). Preliminary results show that the treatment type T2 received the highest rain water supply to the soil and showed the highest water storage.

Impact of extreme monsoon rainfalls on the hydrologic transport of sediments and lead (Pb) in a mountainous watershed. Park, J.H., Jo, K.W., Chun, K.W. (*Kangwon National University; Republic of Korea; jihyungpark@kangwon.ac.kr; siera3@hanmail.net; kwchun@@kangwon.ac.kr*).

Intensifying monsoon rainfall as a consequence of climate change can increase the risk of soil erosion and off-site impacts in steep mountainous terrain. To obtain insights into environmental impacts of changing climate and land use in mountainous watersheds, we compared short-term variability in concentrations of suspended sediments and Pb in a forest stream and a downstream agricultural stream during monsoon rainfall events. Concentrations of Pb, particularly in the particulate phase, rapidly increased during the peak of each storm. While the concurrent increases in sediment and Pb concentrations corresponded to rainfall intensity in the forest stream, the highest peak concentrations of Pb were observed during the smallest event in the agricultural stream, presumably due to depletion of easily erodible soils in agricultural fields during large events with longer duration. Comparison of Pb isotope ratios in three sediment size fractions with those of various soils showed that silt and sand fractions comprising the bulk of sediments in both streams were primarily derived from streambank and arable lands. The results suggest that rainfall-induced increases in soil erosion from mountain forests, intact or converted to agricultural lands, can result in a large export of Pb otherwise stored in soils.

Soil macropore properties of subalpine forest in the upper reaches of Minjiang River, China. Xue, J., Wu, Y. (*Nanjing Forestry University, China; jhxue@njfu.com.cn; yongbowu74@yahoo.com.cn*).

It is well-recognized that soil macropores affect the transfer of water, gas, solutions, and microorganisms in the soil. There is rising evidence that macropores have much impact on the surface runoff and the conservation of soil and water. In this study, the Poiseulle formula method was used to study the radius range and quantity of soil macropores in three types of forest communities in the upper reaches of Minjiang River, southwest China, for the purpose of discovering the mechanism of water conservation and runoff regulation process in different forests. The three types of forest are *Abies faxonian*, *Quercus aquifolioide,* and shrub-bamboo. The results indicated that the radius of the soil macropores under different vegetations ranged from 0.2 mm to 2.4 mm, the mean value is 0.68 mm, and the standard deviation is 0.096.There is difference in various soil profiles: soil macropores occur more frequently in upper soil layers, while less so in the lower soil profile. The range of soil macropores in four forest communities varied from 134 to 1,261 per dm^2. The mean value was 566 per dm^2 while the variation coefficient was 59.6%.

Litter storage and its water-holding properties in three types of subalpine forest communities. Xue, J., Wu, Y.**,** Hao, Q. (*Nanjing Forestry University, China; jhxue@njfu.com.cn; yongbowu74@yahoo.com.cn; 57262894@qq.com*).

In this paper, the authors have investigated the dynamic changes of three types of typical subalpine forest communities such as *Quercus aquifolioide* forest, shrub-bamboo forest, and *Abies faxonian* forest, for the purpose of quantifying the ecohydrological effects of the subalpine forest. The results showed that litter accumulation of the three types of forest varied from 10.00t·hm^{-2} to 25.20t·hm^{-2}, the ranks being: *A. faxoniana* forest>*Q. aquifolioides*> shrub-bamboo forest in both May and July, and *Q. aquifolioides*>*A. faxoniana* forest>shrub-bamboo forest in September. The annual litterfall of *Q. aquifolioides* forest is 391.5kg·hm^{-2} and 1,019.6 kg·hm^{-2}, more than *A. faxoniana* forest and shrub bamboo forest respectively. The maximum water-holding capacities in three layers of litter in three forests were showed as humus layer>ferment layer>litter layer. The obviously saturated water-holding capacity of litter was found in all three types of forest, and ranked as *A. faxoniana* forest> *Q. aquifolioides*>shrub-bamboo forest. There existed either a logarithmic or exponential relationship between water-holding capacity or water-absorption velocity of litter and immerse time. The maximum velocity occurred during the first 5 immersing minutes, then decreased gradually, and fell to zero after 24 h.

General Posters: Forest Environmental Services

Reinforcement effects of tree roots on slope stability. Cha, D.S. (*Kangwon National University, Republic of Korea; dscha@kangwon.ac.kr*), Oh, J.H. (*Korea Forest Reseach Institute, Republic of Korea; jhoh@forest.go.kr*), Hwang, J.S. (*Kangwon National University, Republic of Korea; jinny3879@kangwon.ac.kr*).

This study was carried out to find soil reinforcement effects of tree roots. Tensile strength of tree root, which is an important factor when calculating increased shear strength value for slope stability analysis, was estimated by tree species. Five arbor

species—*Alnus japonica, Quercus mongolica, Larix leptolepis, Pinus koraiensis, P. densiflora*—were selected and tested by universal testing machine. With increasing root diameters, tensile resistance was increased; it can be concluded that root diameter and tensile resistance have direct correlation. On the assumption that the composition of a root is uniform, average tensile strength, calculated by tensile resistance and root area, was estimated by tree species. Results showed that *Alnus japonica* was the highest, at 235.07 kgf/cm^2, and average tensile strength of *Q. mongolica, P. koraiensis, P. densiflora,* and *L. leptolepis* were 228.10 kgf/cm^2, 184.75 kgf/cm^2, 176.25 kgf/cm^2, and 172.78 kgf/cm^2, respectively. Increased soil shear strength values estimated by average tensile strength were 0.141 kgf/cm^2 (*A. japonica*), 0.137 kgf/cm^2 (*Q. mongolica*), 0.111 kgf/cm^2 (*P. koraiensis*), 0.106 kgf/cm^2 (*P. densiflora*), and 0.104 kgf/cm^2 (*L. leptolepis*).

Boreal forest soils change criteria under logging in Komi Republic, Russia. Dymov, A., Lapteva, E. (*Institute of Biology, Komi Scientific Centre, Russian Academy of Sciences, Russian Federation; dymov_a@mail.ru; dymov_a@mail.ru*).

Boreal forest is one of the most significant biosphere components in terms of water regulation, soil protection, soil conservation, and climate regulation functions. The Komi Republic is one of the richest forest resource regions in the European part of Russia, with 30 million ha of forest cover area. During the 20th century, especially the second half, large areas of native forests of the Komi Republic were cut. It is necessary to conduct detailed investigations on soils and reveal the mechanisms of soil changes in connection with the corresponding anthropogenic impacts, particularly how direction and depth of transformation of soils are affected by timber cutting, type of soils, primordial extent moistening, and degree development grass cover on cut-areas. We investigated two cronosequences formed after cutting spruce and pine forests growing on sand underlain by loam and loam sediments. We will discuss morphological changes; physicochemical properties of investigated soils; and some characteristics of soil organic matter: water soluble forms, hydrophobic properties, content and changes of humic and fulvic acids, and changes of carbon stocks after boreal coniferous forest cutting.

Wind tunnel test for determination of drag coefficients for artificial plants. Hong, Y.J., Ahn, S.J., Kim, D.Y., Im, S.J. (*Seoul National University, Republic of Korea; wow8803@naver.com; freeas81@hanmail.net; hendrix7@snu.ac.kr; junie@snu.ac.kr*).

Vegetation can significantly reduce wind erosion by absorbing the force of the wind and decreasing the wind velocity at near ground level. Canopy structure characteristics, plant arrangements, and the number of plants occupying a given area could determine its aerodynamic roughness, which is usually expressed in terms of drag coefficient. In this study, the drag coefficients of three artificial plants with different leaf shapes and leaf area densities were determined using the wind tunnel test. Three samples of each artificial plant were selected for measuring leaf characteristics. Wind velocity, static pressure, and air temperature at a given blowing wind velocity (1–5m/s) were measured at different heights on both windward and leeward sides using a pitot tube and a hot-wire anemometer in a wind tunnel. The drag coefficients obtained for the three artificial plants were significantly different at p-value of 0.05. This suggests that the effects of shape and size of leaf on wind drag force are significant for tested artificial plants. This study results can provide fundamental information for the study of questioning how to improve control of wind erosion by vegetation.

A design model for forest landscapes around expressways in South Korea. Jang, H.J. (Kangwon National University, Republic of Korea; jhj317@kangwon.ac.kr), Kim, J.J. (Korea Forest Research Institute, Republic of Korea; jjkim@forest.go.kr), Lee, G.G. (Kangwon National University, Republic of Korea; gglee@kangwoan.ac.kr).

Most South Koreans have used expressways whose surroundings and backgrounds are almost formed with large and small mountainous forest landscapes. Since about 64% of the land has mountainous topography with temperate forest areas, people see or watch a variety of forest landscapes from most scenic points on the expressways while driving. The Korea Forest Service has been focusing on the necessity of managing outstanding forest landscapes out of the sceneries from the load lanes. Therefore, the Korea Forest Service has recently developed a design model to manage forest landscapes around expressways and conducted a pilot project as a case study on Jung-Ang expressway between the areas of Hoengseong and Chuncheon in Kangwon-do, Korea. This article shows the research processes and results on how the model was developed and how the results were obtained through a pilot project. The Korea Forest Service has a future plan to provide the standard design guideline for all relevant local governments through additional pre-tests and research with the design model that was conducted as the result from this study.

Evaluation of the forest recreational function using the potentiality and suitability of the forest recreational function. Kim, J.K., Woo, J.C. (*Kangwon National University, Republic of Korea; o-yellow00@kangwon.ac.kr; jcwoo@kangwon.ac.kr*).

Visitors of the recreation forest are steadily increasing. Thus, to manage the forest effectively and meet the increasing demand for forest recreation, suitability evaluation with respect to the factors of the forest recreation function is required. In this study the evaluation factors of forest recreation function were divided two groups: the potentiality of external factors, and suitability of internal factors. Potential factors were divided as follows: accessibility, location, landscape, and induction factors, with 17 detailed factors. Suitability factors included stand structure, forest structure, and human impact, with 10 detailed factors. Then the forest recreation function was estimated through a questionnaire of forest experts. The priority of the potentiality of external factors was in the following order: location, accessibility, induction factors, and landscape. The most important factors for each of these are regional characteristics related to distance to the highway, historical and cultural heritage, and land use type. The priority of suitability of internal factors was in the following order: stand structure, human impact and forest structure. In the case of stand structure, the most important factor was species diversity; for human impact, the forest road density; and for forest structure, the vertical structure.

Sustainable forest management on the basis of timber availability evaluation by example from Krasnoyarsk province, Russia. Laletin, A.A., Sokolov, V.A. (*V.N. Sukachev Institute of Forests, Russian Federation; slal@mail.ru; vsokolov@forest.akadem.ru*), Laletin, A.P. (*Friends of the Siberian Forests, Russian Federation; sibforest@akadem.ru*), Laletina, I.D. (*Siberian Federal University, Russian Federation; innasib@mail.ru*).

A crisis of providing for the needs of Krasnoyarsk province for wood resources suggests failure of the current model of forest management. In many traditionally timber producing regions of Russia, including Krasnoyarsk province, the proportion of economically available wood decreases all the time, while the calculated wood-cutting area is significantly underused. To shift forest use on a permanent basis, it is recommended that wood stocks be evaluated, taking into consideration economic availability. The target of economic availability determination is to reveal wood resources that are the most effective for development based on market prices for wood production, costs for reforestation, and transportation of the products. Timber stock in the region covers 7,795.6 million m^3, of which 4,912.6 million m^3 (or 63%) are mature and over mature forests. The size of the calculated economically available wood-cutting area in the forests of Krasnoyarsk province is: 25,774.9 thousand m^3, including 20,315.6 thousand m^3 of coniferous and 5,459.3 thousand m^3 of deciduous stands. From 1961 to 2007, the area covered with forests in Krasnoyarsk province decreased by 0.7%, and area covered with coniferous trees decreased by 6%. For the past 50 years the qualitative composition of the Krasnoyarsk province forests is worsening constantly.

A 3D-based simulation method for scenic beauty evaluation of a forest recreation area. Lin, C., Lin, Y.D., Hung, S.H. (*National Chiayi University, China-Taipei; chinsu@mail.ncyu.edu.tw; ydlin@mail.ncyu.edu.tw; s0911438@mail.ncyu.edu.tw*).

Forests enrich worldwide natural recreation and ecotourism. Enjoyment of forest views and mountain hiking are becoming major activities of tourists in natural recreation areas. Scenic management is therefore an important work of the recreation area, and it is expected that a kernel issue of forest recreation management will be to understand the expectations of nature tourists with respect to scenic beauty of forests. A questionnaire analysis based on a 3-dimentional simulation technique was designed to meet this end. A 58-year-old plantation of sugi and red cypress across from a railway in the Alishan Forest Recreation Area was selected for this study. Stand density and spatial pattern of trees—which were first determined by computer-simulated thinning intensity accompanied by the ground survey data—were applied for simulation analysis. Then a method of scenic beauty evaluation (SBE) with a psychophysical paradigm model was applied to examine tourists' tendency to adore forest scenic beauty. Results showed that the most favorite scenic beauty is the one determined by low density thinning, such as 20% removal.

Assessment of the landslide hazard area based on GIS and administrative data. Park, D.H., Lee, J.S., Lee, J.A., Cho, Y.H. (*Kangwon National University, Republic of Korea; dhrdmlrltk@naver.com; jslee72@kangwon.ac.kr; lja0210@naver.com; yh8749@naver.com*).

This study aimed to construct a landslide hazard map based on the forest geographic information system (FGIS) database, and also to analyze the spatial distribution of landslide areas. The subject area of this study was part of the forests in Gangwon prefecture, and the main types of forests were *Pinus densiflora*, *P. koreaiansis*, and oak (*Quercus* spp.). The characteristics of landslide-prone areas were analyzed with the GIS information and administration data, and then landslide hazard maps were constructed by the SAW method. Geographic factors (slope, forest type, soil, and rainfall) were used as the crucial factors to construct two types of landslide hazard map, which was classified into 10 classes and then compared with ground-truth data to assess accuracy. Hazard maps using the forest service standard had an accuracy of 4.8% in the top 10% of the study area. The accuracy of the hazard map based on the improved standard was 11.5%. Performance of the advanced hazard map was higher than the basic hazard map when the difference between the landslide occurrence rates was examined. For example, the advanced model in the top 5classes of the study area showed highest performance when the difference is 20%.

Using choice experiment to estimate public value of forest in Korea. Yoo, J.C., Kim, M.O., Kong, K.S. (*Chungbuk National University, Republic of Korea; jcyoo@chungbuk.ac.kr; kmiok96@naver.com; kskong@chungbuk.ac.kr*).

The purpose of this study was to estimate forest public functions, which cannot be evaluated in the market. This kind of function has a possibility for market failure, so if we don't support the forest public function with policy, it will decrease. Conditional logit model was used; and expert interviews, focus groups interviews, and pilot surveys were implemented for design efficiency. Nine forest public functions at four levels were selected as attributes of forest public functions: storage and purification function of water, the reduction of soil sediment, prevention of landslides, capture of CO_2, formation of living environments, recreational opportunities, ecosystem protection, beautiful landscapes, and tax payments. Attributes levels of forest public functions are 10% decrease, same as present, 10% increase, and 20% increase. Some 508 citizens were selected using stratified sampling methods. Direct interview methods were used. Implicit values of the attributive levels have been calculated into tax money costs per household by conditional logit. The highest preferences for forest public functions were formation of living environment, storage and purification of water, and capture of CO_2.

Theme D: Asia's Forests for the Future

D-01 Recreation management in protected areas: Asian perspectives

Organizer: Tsuchiya Toshiyuki, *Tokyo University of Agriculture and Technology Japan, toshit@cc.tuat.ac.jp.*

The relationship between urban forest visitors' motivation and their behavior in Nopporo Forest, Hokkaido, Japan. Aikoh, T., Tani, A., Kaise, M., Abe, R. (*Hokkaido University, Japan; tetsu@res.agr.hokudai.ac.jp; a-tani@res.agr.hokudai.ac.jp; mao@res.agr.hokudai.ac.jp; reina@res.agr.hokudai.ac.jp*).

A rapidly aging society accelerates the demand of recreation in nearby natural areas. Urban forests offer opportunities for daily exercise and natural experiences to urban residents, making a great contribution to maintaining people's health and relaxing the stress from crowded urban life. Increasing demands of recreation in urban forests and varying activities cause crowded situations and some conflicts among visitors. This study explored visitors' behavior and attitudes in Nopporo Forest, which is located in a suburban area of Sapporo city, Hokkaido, Japan. We conducted long-term visitor monitoring and on-site interviews of visitors at several trailheads. The results of monitoring showed that more visitors entered at accessible trailheads throughout the year; on the other hand, fewer visitors entered at remote trailheads. Most of respondents were more than 50 years old, and live less than a 30-minute walk from the forest. Although enjoying nature and exercise were the highest motivations on the average, motivations of each visitor were varied depending on their activities and behavior. The difference of their motivations also affected their choices of trailheads and route. Visitors chose the trailhead and route that seemed to be suitable for their motivations.

A case study to assess the scenic quality of mountain forests using GIS. Han, H., Song, J., Chung, J. (*Seoul National University, Republic of Korea; pack1@snu.ac.kr; readjean@hanmail.net; jschung@snu.ac.kr*).

The objective of this study was to develop GIS-based methodologies to assess the scenic quality of mountain forests. The scenic quality assessment needs the inventory process for identifying scenery resources, the analysis process for analyzing detailed scenery attributes, and the evaluation process for quantifying the scenic quality. These procedures were applied to a case study in the area of Mt. Sambong in South Korea. Initially, the study site was divided into smaller landscape units based on topographic conditions using GIS. Then, the natural and artificial landscape inventory was identified and mapped using GIS. Next, the landscape visibility and the level of sensitivity were measured using GIS to quantify the relative importance of the features and their visual impacts on the scenic quality of the landscape unit. The scenic attractiveness of the landscape unit was also analyzed to estimate the scenic importance. The attractiveness was estimated as the function of the quality and quantity of various landscape resources as well as the intrinsic beauty of the whole scenery influenced by harmony and diversity of resources. Finally, scenic quality was determined as the function of the quantified parameters, and the results were validated by experts in the field.

Perceived sustainability impacts of ecotourism activities through a co-management approach at Lawachara National Park in Bangladesh. Islam, Md. (*Khulna University, Bangladesh; wasiulislam7@yahoo.com*), Elands, B., Duim, V. (*Wageningen University, the Netherlands; birgit.elands@wur.nl; rene.vanderduim@wur.nl*).

The Nishorgo Support Project was undertaken between 2003 and 2008 as a pilot project at five protected areas of Bangladesh to introduce co-management approaches for the first time in Bangladesh. Lawachara National Park is one of these protected areas where ecotourism has been identified as one of the 'alternative income generation' strategies. Because impacts of co-management on ecotourism at the park have not been studied, our work aims to analyze the contributions of the co-management approach to generate ecotourism benefits using 'prism of sustainability' as a theoretical framework. Various methods were used to evaluate perceptions of the key stakeholders. Results show that 57% of local people are aware of the co-management approach. About 58% of total respondents perceive ecotourism benefits as contributions of the co-management approach. Institutional ecotourism benefits were perceived as the most satisfying impacts resulting from the application of co-management. It suggests the appropriateness and applicability of ecotourism interventions at Lawachara National Park and its fringe communities to ensure institutional benefits to local people through the application of the co-management approach.

Utilization of forest environmental services through religious tourism management at Alas Purwo National Park, East Java, Indonesia. Satyasari, I. (*Bogor Agricultural University, Indonesia; asia.ika.ifsa@gmail.com*).

Forests might not only provide natural resources but for certain people they might also give religious inspiration. Alas Purwo National Park (APNP) is one of the conservation areas in Indonesia for religious purposes. The local people of Banyuwangi, East Java, believe that Alas Purwo is one of the oldest forests in Java; therefore, study on religious tourism management at National Park is needed to understand the relationship between religious tourism and conservation efforts. Alas Purwo National Park is divided into two management areas, Tegaldlimo and Muncar. Religious tourism is more focused at Tegaldlimo. Several spots at Tegaldlimo are used for religious tourism: Basori cave, the great temple of Giri Salaka, Isatana cave, Mayangkara cave, and Parang Ireng site. Based on interviews and observations conducted during 1–7 March 2009 and based on APNP's report, religious tourism has been done well in APNP. This type of tourism is synergic with the triple basic lines of conservation. Visitors believe that nature is the source of inspiration; therefore, they have to conserve nature well without any disturbance. The APNP has developed a system for religious tourism management, which is appropriately implemented.

Verifying governance system of world heritage areas from an aspect of common-pool resources: a case study of Yakushima Island, Japan. Shibasaki, S. (*Iwate University, Japan; shiba@iwate-u.ac.jp*).

Recently many tourists have come to visit world natural heritages in Asian countries. Tourism conducted in these sites can give economic benefits to local communities and the travel enterprises, while a dramatic inflow of visitors may lead to overuse issues,

that is, the "tragedy of the commons." This research aims to clarify the robustness of the management system in Yakushima Island, which was designated as a world natural heritage site in 1993. Each maintenance project conducted for visitor management was checked by comparing eight design principles that characterize robust common-pool resources. The number of visitors to Yakushima has been growing four-fold within 20 years, and tourism has becomes an essential industry in the island. Public authorities have implemented various projects to mitigate potential overuse issues after the designation. Fund-raising schemes, establishment of coordination institutions, and local rules for sustainable use of specific sites can be exemplified respectively. However, local residents who were not engaged in tourism industries were not satisfied with the management system of Yakushima because they felt that most projects were implemented without listening to their opinion fully. To make current situations better, introductions of graduated sanctions and fair systems to promote fair public involvement are important.

Visitor preferences for a low-risk option: a new guided-tour in Shiretoko National Park, Japan. Shoji, Y., Shiina, H., Kubo, T., Aikoh, T. (*Hokkaido University, Japan; yshoji@for.agr.hokudai.ac.jp; shiina1213@gmail.com; tkb9@ec.hokudai.ac.jp; tetsu@res.agr.hokudai.ac.jp*).

The purpose of this study is to examine visitor preferences for a new guided-tour that is under consideration in Shiretoko National Park, Japan, applying the contingent valuation method. Shiretoko national park is one of the most primitive areas in Japan; thus, its quality recreation settings attract many visitors. However, the park is also one of the foremost brown bear habitats; visitors are always exposed to the risk of encountering bears. Furthermore, park managers frequently close trails on account of bear appearances; visitors lose opportunities to use the trails in such situations. Consequently, the compulsory guided-tour directed by trained guides is proposed. It can contribute toward improving visitors' benefits by reducing the risk of encountering bears and reducing the uncertainty of recreation opportunity, but visitor preferences for the low-risk option is still unknown. The result shows that the mean willingness to pay for taking the tour was JPY 972 and the median one was JPY 2,826, and this finding suggested that 20–30% of visitors are assumed to prefer the tour. In addition, visitor preferences for the tour are not homogenous. The risk-taking visitors regarding encountering bears and the risk-averse visitors regarding the uncertain recreation opportunity have higher willingness to pay.

Social network structure in Rebun lady-slipper (*Cypripedium macranthos* var. *rebunense*) conservation. Yamaki, K. (*Forestry and Forest Products Research Institute, Japan; yamaki@ffpri.affrc.go.jp*), Shoji, Y. (*Hokkaido University, Japan; yshoji@for.agr.hokudai.ac.jp*), Hayashi, M. (*Forestry and Forest Products Research Institute, Japan; masahaya@ffpri.affrc.go.jp*).

Social networking is one of the key factors to consider for successful collaborative natural resource management. This research examined the current status of the social network of Rebun lady-slipper (*Cypripedium macranthos* var. *rebunense*) conservation activities using social network analysis (SNA). Rebun lady-slipper is an endangered species that lives only in Rebun Island, northern Japan. Since its beautiful faint yellow flowers inspired illegal digging, the population has dwindled. The pretty flowers are also considered as an important tourism resource for Rebun Island. Conservation activities involve many actors in several public organizations and NPOs. Rebun lady-slipper conservation meetings, which are the core framework of the conservation activities, are set up under the Endangered Species Act. Sharing scientific knowledge among the actors is necessary to keep activities progressing. The analysis showed that there were no direct ties between researchers and other meeting members, suggesting that scientific knowledge is not well-shared among the members. The analysis also revealed that there were no ties between the conservation sector and tourism sector, indicating that partnership is insufficient between the two different sectors.

Posters

New management strategy for forest ecotourism with application of a national trust system. Chun, J. (*Seoul National University, Republic of Korea; andrew78@snu.ac.kr*), Seol, M. (*University of Washington, USA; mistral@u.washington.edu*), Lee, E. (*Seoul National University, Republic of Korea; norannamu@snu.ac.kr*).

After the "Quebec Declaration on Ecotourism" in 2002, ecotourism has been considered a sure alternative to existing nature tourism. For its successful implementation, many local governments in Korea have used protected areas, hoping to protect the natural environment effectively and improve profitability at the same time. Ecotourism in Korea, however, has many problems such as low profitability, promotion and marketing problems, lack of government's institutional support, absence of systematic consultative group, etc. In this point of view, this research suggests a new forest ecotourism management system that can solve upper-level problems with application of a national trust system. The Korean government enacted the National Trust Law in 2006 and established the National Trust System for enforcement. Forest areas such as 'Baekdudaegan' and DMZ are the main target areas of the National Trust System. The National Trust Law can protect natural resources permanently through its authority and promotion of ecotourism, which means that the National Trust System and ecotourism have the same philosophy. The National Trust System also has various institutional and systematic instruments that can solve problems inside ecotourism. So this research argues that the Korean government can make applicable strategies through application of the National Trust System.

A master plan for a national eco-forest trail in South Korea. Kim, M., Lee, G., Lee, H., Lee, J. (*Kangwon National University, Republic of Korea; msk004@kangwon.ac.kr; gglee@kangwoan.ac.kr; lhj628@kangwon.ac.kr; faith@kangwon.ac.kr*).

The Korean government has developed the "National Eco-Cultural Trail" to enable trail trekking all across the country on foot. The trails were largely classified into three types, one of which is National Eco-Forest Trail (NEFT)s. NEFTs were designed as line-type corridors including pathways, trekking roads, and on-foot-local roads that connect surroundings of main mountainous ridges and forest areas, which cover 64% of the land in Korea. This study focused on drawing the regions for making NEFTs, designing support-roads connecting NEFTs to each other, and encouraging a total of 1,000 km of NECTs by 2012 as a national plan. By utilizing the results of this study, the Ministry of Environment (MOE) in Korea could select 331 km for NEFTs through the assessment process established by the Committee of National Eco-cultural Trails in 2008. The 331 km of NEFTs in 2008 were selected by using guidelines suggested by this study. Support-road networks were developed through GIS analysis on trekking suitability as national eco-cultural resources, and the data for analysis were obtained from national GIS by MOE, Korea

Forest Service, and the Ministry of Culture, Sports and Tourism. The government has been planning on constant support for this project until at least 2012.

Nature-based recreation in Germany and in Korea. Lee, J., Bürger-Arndt, R. (*Georg August University Goettingen, Germany; foersterlee@gmail.com; rbuerge@gwdg.de*).

The occident and orient have very different culture and history. Because of differing understandings of nature, they also contrast highly with regard to how they use nature. Their recreational offerings reflect the exact expectations of recreation users; therefore, the different recreational use types of both eastern and western countries can be recognize through this study. To review recreational offerings, services, and infrastructure, a complete search of the websites of all German nature parks and Korean recreation forests was conducted. The result is compared per category of offerings. In addition to hiking, most of the German nature parks offer biking and horse-riding activities, whereas walking and fitness trails were mostly offered in Korea. Nature educational trails were offered by two-thirds of German nature parks compared to one-fourth of recreation forests in Korea. The demand of recreation users for infrastructures is very high; therefore almost all Korean recreation forests have toilets, kitchens, and water and shower rooms. Koreans exhibit soft recreation, and their environmental education program is less compared to that of German nature parks, but the infrastructure plays a very important role in nature recreation of Koreans.

Trail management of ecosystem and landscape conservation area in Seoul. Lee, S., Oh, C. (*Dongguk University, Republic of Korea; woorinuri@empal.com; ecology@dongguk.edu*).

Ecosystem and landscape conservation areas use with recreation sites in Seoul, and so the areas are vulnerable to human activities. But the population density of Seoul is very high, so it is very difficult to satisfy both nature conservation and use of recreation in the areas. Our study sites are Mt. Chunggye and Mt. Bong, which were designated as ecosystem and landscape conservation areas. The areas are used as hiking sites by many citizens. In this study, we analyzed plant community structures and trail conditions. We found that plant communities have been disturbed by excessive use of citizens. Especially, the edges of the conservation areas were disturbed very much. The trails have been extended, and it is a main cause of damage in the areas. In conclusion, for sustainable conservation and management, it is necessary to separate the conservation areas into core zones and buffer zones. And trails must be made in the buffer zones for nature conservation. Also, it is necessary to manage trails and the areas with volunteers, to promote the importance of the areas to citizens.

Comparative study of national park management in Japan and United Kingdom, with special reference on environmental governance. Tsuchiya, T. (*Tokyo University of Agriculture and Technology, Japan; toshit@cc.tuat.ac.jp*).

The National Parks and Conservation Association in United States published a book called Greenline Parks in 1984. They defined a new concept of natural park, "Greenline Park," as follows. "A large, scenic landscape area which is protected by law and regulation from being overtaken by unplanned development to the extent that it retains its natural, scenic, or historic attributes; the protections for such a landscape are cooperatively arranged and managed by citizens and agencies on the local, state, and federal levels." But actually this was not a new concept because a national park system with this concept was born in Japan in 1931, and in England and Wales in 1949 separately. In this presentation, management systems of "Greenline Park" in two typical countries are examined and compared from intensive field research. In both cases, nature conservation and regional development in a sustainable manner are encouraged simultaneously under collaboration by local communities, NGOs, and governments. In conclusion, we show the possibility of "Greenline Parks" that can become one of the key concepts for promoting local environmental governance in Asian countries.

D-02 Biology, ecology and management of *Pinus koraiensis* in East Asia

Organizer: Jae-Seon Yi, *Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr.*

The effective method of forming the Korean pine forests. Alexeenko, A. (*Far East Forestry Research Institute, Russian Federation; Alexeenko.alex@gmail.com*).

The north border of the *Pinus koraiensi*s area is located in the Russian Far East. *P. koraiensi*s forests cover up to 2.92 million hectares. The area of the forests containing *P. koraiensi*s stands is about 5.8 million hectares. Natural forests prevail and selective cutting is practiced. However, big squares of coppice forests are accumulating. For a long time such forests were reconstructed by planting saplings under the shadow or in corridors. Now there are 235 thousand hectares of reconstructed forests. Unfortunately, the volume of cleaning cuttings (thinning) is insufficient. In 2004–2005, we did experimental thinning in different types of reconstructed oak forests, using silvicides for accelerating the formation of mixed stands. Glifosad was selectively injected in the stamps of *Quercus, Betula*, and *Populus. Tilia* and *Acer* trees were preserved as bee plants. The second examination in 2009 showed high effectiveness: 85–99% of injected trees have been dried up; growth of Korean pine saplings increased by 30–100%; the growth of preserved stand reaches 6 m^3 per year. Labor inputs of the silvicides method are 9–30 times lower than those of the usual cleaning cutting.

Twelve-year growth monitoring of *Pinus koraiensis* plantation by thinning intensity in Korea. Choi, J.K., Lee, B.K., Choi, I.H. (*Kangwon National University, Republic of Korea; jungkee@kangwon.ac.kr; bkmaster@kangwon.ac.kr; inchoi@kangwon.ac.kr*).

This paper presents the growth response of 19-year-old Korean white pine plantations in Korea after the first thinning of different intensities. Two thinning sites were established to investigate the thinning effect. Four treatments of each site were tested: 59%, 32%, 28%, and 0% of basal area removed (site 1); and 53%, 25%, 20%, and 0% of basal area removed (site 2). The results showed significant difference depending on the thinning intensities in terms of diameter growth. The height growth had no difference in thinning. The candidate trees of large size greater than 25 cm DBH were 31% of total trees in a heavy thinning plot,

compared to 2% in a control plot. The growth of single tree volume showed highly significant effect in the heavy thinning plots as well. The crown competition factor approached 250% in control plots, compared to 150% in heavy thinning plots. Through five extracted cores of dominant trees in each plot in the two sites, in heavy thinning plots, no effects of growth were found in 1–2 years after thinning; high growth appeared until 10 years; the growth decreased thereafter.

Abundance and growth of naturally regenerated *Pinus koraiensis* in the *Quercus mongolica* forest, South Korea. Chung, S. H., Kim, J.H. (*Kangwon National University, Republic of Korea; chsh@kangwon.ac.kr; kimjh@kangwon.ac.kr*), Lee, W.S. (*WSL Research Institute, Republic of Korea; dendrolee@hamail.net*).

The aim of this study was to analyze the distribution and growth of naturally regenerated Korean pine (*Pinus koraiensis*) whose seeds were dispersed, mainly by rodents, into *Quercus mongolica* forests. The data were collected in 103 10-m × 10-m sample plots in Gangwon-do and Gyeonggi-do, Korea. Individuals of Korean pine regenerating in each plot were counted and measured for height, collar diameter, and age. Environmental data were also collected in each plot. The results showed that average density of Korean pine regeneration was 8,805 stems per hectare in the study area. With increasing age of regenerating individuals, the number of stems was decreased, indicating that the mortality rate was gradually increased by limited amount of resources and competition among them. Regenerating *P. koraiensis* were found in the *Q. mongolica* as far as 1,130 m away from the seed-source stand. The distribution and abundance of Korean pine regeneration were hardly influenced by the aspect and slope gradient. The mean annual increment (MAI) was relatively good up to 15 years of age, but decreased beyond this age. The growth of regenerating trees was better in young *Q. mongolica* stands than in mature stands.

Population structure of *Pinus koraiensis* in understory of *Quercus* forests in northern Korea. Ito, S., Soen, N. (*University of Miyazaki, Japan; s.ito@cc.miyazaki-u.ac.jp; agf806u@student.miyazaki-u.ac.jp*), Yi, M.J., Jeong, M.J. (*Kangwon National University, Korea; mjyi@kangwon.ac.kr; sky4887@hanmail.net*).

Natural forests of Korean pine (*Pinus koraiensis* S. et Z.) have been replaced with artificial plantations in Korea, which resulted in raised costs and ecological disadvantages. Recently, Korean pine seedlings invading into oak forests around Korean pine plantations are often observed in northern Korea. We investigated the population structure of Korean pine invaded into oak forests to clarify their invasion process and sapling growth under the canopy of broadleaved trees. Age structure of Korean pine in understory of secondary forests dominated by *Quercus mongolica* indicated continuous recruitment of this species for several decades. In these stands, Korean pine seedlings were established beneath the crown of taller saplings of the same species, but scarcely found beneath the crown of broadleaved saplings. Height growth of Korean pine saplings was severely suppressed beneath the understory crown of broadleaved saplings. This suggested that dense crown of broadleaved saplings, probably due to the locally sparse canopy cover of *Quercus* spp., have a substantial effect to inhibit establishment and growth of Korean pine saplings. Thus, canopy manipulation as well as control of understory broadleaved trees seemed to be the key for successful establishment of Korean pine in oak forests.

Undisturbed *Pinus koraiensis*–broadleaved forest in the Bikin River valley as a base for preservation of forest ecosystems and a model for sustainable forest management. Lepeshkin, E.A., Smirnov, D.Y. (*WWF Russia, Russian Federation; elepeshkin@amur.wwf.ru; dsmirnov@amur.wwf.ru*).

Mixed Korean pine-broadleaved forests were under heavy exploitation during the 20th century in the Russian Far East. Today the presence of such forests, formed mainly by *Pinus koraiensis* in the Primorsky region, is at least 2.2 times less than 60 years ago. The most valuable and typical forest ecosystems for Sikhote-Aline are mixed Korean pine-broadleaved forests, now left mainly in "nut-harvesting zones" (NHZ). The Bikin NHZ, within the water belt of the Bikin River, covers 461,500 ha. This area is one of the last intact, large-scale watersheds in the Northern Hemisphere. The area is important as a prime habitat for the endangered Amur tiger (*Panthera tigris altaica*) and for sustaining traditional lifestyles of indigenous people. About 600 tonnes of Korean pine nuts can be harvested sustainably from an accessible area. The Bikin NHZ is estimated to contain a minimum of 48.1 million tonnes of carbon mass (equivalent to 176.53 million tonnes of CO_2) in the standing phytomass. On-going projects based on NTFP harvesting, hunting, fishing, and ecotourism development have an international status. Climate and biological relevance of the area as well as its scientific values and research possibilities are the most important issues under consideration.

The characteristics of coarse woody debris in a mixed broadleaved–Korean pine forest in the Xiaoxing'an Mountains, China. Liu, Y., Guangze, J. (*Northeast Forestry University, China; liuyanyan07@126.com; taxus@126.com*), Kim, J.H. (*Kangwon National University*, *Republic of Korea*; *kimjh@kangwon.ac.kr*), Li, F. (*Northeast Forestry University, China; fengrili@126.com*).

The species composition, diameter at breast height (DBH) class, existing form, and decay class of coarse woody debris (CWD) were studied in a large permanent plot (9 hm^2) of a typical mixed broadleaved-Korean pine forest in the Xiaoxing'an Mountains. All CWDs with DBH ≥2 cm were tagged, mapped, and measured with species identified. Important findings include: a total of 3,418 CWD were recorded, among which the species of 864 CWD individuals were not able to be identified due to serious decay. The CWD density, basal area, and volume were 380 $n \cdot hm^{-2}$, 15.80 $m^2 \cdot hm^{-2}$ and 91.11 $m^3 \cdot hm^{-2}$, respectively. *Acer ukurunduense* (28 $n \cdot hm^{-2}$) and *Betula costata* (27 $n \cdot hm^{-2}$) were the major broadleaved species, while *Pinus koraiensis* and *Abies nephrolepis* were the major coniferous species. The density of different types of CWDs decreased with increases of DBH class, and followed the inverse J-shape. The CWD existing forms were mainly composed of standing dead, breakage at rootstock, and breakage at trunk. The decay classes of CWD focus on decay classes II and III, except for the CWD of coniferous species with decay class V; others decreased with increase of DBH class.

The regeneration of *Pinus koraiensis* in mixed broadleaved–Korean pine forest in Liangshui Natural Reserve, China. Piao, T.F. (*Kangwon National University, Republic of Korea; piaotiefeng@hotmail.com*), Jin, G.Z. (*Northeast Forestry University, China; taxus@126.com*), Kim, J.H. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr*).

The mixed broadleaved–Korean pine (*Pinus koraiensis*) forest was one of the major forest types in northeast region of China, once extensively distributed as a climax forest type. To study regeneration and other characteristics of this kind of forest, a 9-ha

permanent experimental plot was established in 2005 in Liangshui Natural Reserve, which was set to conserve the old-growth mixed broadleaved-Korean pine forest. The major tree species in the study area were *Pinus koraiensis*, *Picea koraiensis*, *Abies nephrolepis*, *Tilia amurensis*, *Acer mono*, *Fraxinus mandshurica*, *Ulmus laciniata*, *Betula costata*, etc. As the dominant tree species, Korean pine can regenerate well under canopy conditions of less than 800 m^2 of gap size. However, under closed canopy, Korean pine suffered from a high mortality during the seedling stage and low growth rate during the sapling stage, mainly due to the over accumulation of organic matter on the forest floor and to the lack of available sunlight. In addition, average number of fallen seeds of the pine was recorded at 2.5 per m^2, presumably a small amount owing to excessive cone-picking by local people and animals, which also resulted in the poor occurrence of Korean pine seedlings in the understory.

A study of stand structure and growth in *Pinus koraiensis* plantations. Shin, J.W., Choi, J.K., Choi, I.H. (*Kangwon National University, Republic of Korea; jwshin@kangwon.ac.kr; jungkee@kangwon.ac.kr; inchoi@kangwon.ac.kr*).

This study is intended to investigate the process of stand structure and growth for *Pinus koraiensis* plantations that had 7 continuous inventory data collections in permanent experimental plots during 1981–2009. Various size distributions (diameter distribution, height distribution, and crown diameter distribution) were made at each inventory year. They typically had the normal distribution of an even-aged stand. The more the stand age increased, the more the diameter distribution gradually spread out into a wide bell-shape with less density of trees. The height distribution shifted clearly to the right due to fast height growth. The crown diameter distribution also followed a normal distribution in which crown diameter had narrow and overlapped width because of irregular growth and crown closure. Natural mortality was also investigated during 10–17 of stand age. Its annual mortality rate was less than 0.5%. As crown closure increased densely in the stand, the rate of natural mortality increased. The long-width and short-width of crown diameter showed no difference until year 17 of stand age. Crown diameter had high correlation with DBH (r = 0.75–0.88). Average periodic annual growth was investigated as 0.74 cm/yr of diameter growth, 52.4 cm/yr of height growth, and 21.3 cm/yr of crown growth.

Dynamics of Korean pine stands in mixed forests. Ukhvatkina, O.N., Omelko, A.M. (*Institute of Biology and Soil Science, Russian Federation; ukhv_olga@rambler.ru; alexomelko@gmail.com*).

In mixed, dark, conifer-broadleaved Korean pine forests, trees of Korean pine locate in groups, forming a mosaic pattern. Key animals, which distribute pine nuts in such forests, are nutcrackers, squirrels, and chipmunks. Nut stores are located uniformly, but further undergrowth survival depends on upper canopy state. In better light conditions, probability of undergrowth survival is relatively higher, and Korean pine undergrowth forms local concentrations. During further growth, the pine needs better light conditions, so local groups become more distinct. In poor light conditions (under dense canopy), Korean pine undergrowth grows very slowly and then dies. In case of partial release undergrowth, they quickly increase growth rate. Usually at this time, yellow birch undergrowth, which has similar light condition requirements, appears in Korean pine groups. As a result the mixed "patches" composed of Korean pine and yellow birch arise in the upper layer. Dendrochronological data show great release on a sample plot from 50 years ago. Korean pine trees can respond to partial releases during their whole life, probably because the trees locate far from each other and are influenced by different microsite conditions. In general most Korean pine trees react to releases that can be distinguished on sample plots.

Crown shapes for easy cone collection of *Pinus koraiensis* trees. Yi, J. (*Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr*).

It is necessary to lower tree height for easy cone collection. Seed orchard trees, of which the main stem was simply cut at the height of 1 m or 2 m, produced 1.4 to 2.2 times more seeds than un-cut seed orchard trees, respectively. Stem-pruning has no influence on the general seed component and fatty acid composition. Based on these results, four crown shapes are suggested. Central leader type is a natural crown shape. Modified leader type is a central leader type improved for better sunlight and low height, with the first healthy, strong branch attached less than 1 m above the soil and 4–5 nodes in total remain, of which 3–4 branches are maintained for each whorl. Vase form is a short stem with 3 to 4 branches at the same height (more than 1 m above soil) or remaining node. Open central natural type is an improved vase form with 4 to 5 alternative but very close nodes, of which 1–2 branches are maintained for each whorl. Combined central type includes the crown of modified leader type, vase form, or open central natural type above a 4- to 8-m long, single stem.

Photosynthetic plasticity of *Pinus koraiensis* seedlings based on assessment of current year and 1-year-old needles exposed to different light intensities. Zhu, J., Wang, K., Yan, Q., Sun, Y. (*Chinese Academy of Sciences, China; jiaojunzhu@iae.ac.cn; wangkai_2005@hotmail.com; yqliae@yahoo.com.cn; rongyisun@163.com*), Sun, O.J. (*Beijing Forestry University, China; sunjianx@bjfu.edu.cn*).

There are contradictory views on light requirements of *Pinus koraiensis* for seedling growth and establishment. To understand how *P. korainesis* adapts to different light regimes and determine which light level is suitable for its growth, seasonal variations in several photosynthetic variables and leaf traits in current year and 1-year-old needles of 6-year-old seedlings grown at 15%, 30%, 60%, and 100% natural irradiances were observed. Light-saturated photosynthetic rate did not differ between seedlings at 100% and 60% treatments, while there was significant (P<0.05) reduction at 30% and 15% treatments in both current and 1-year-old needles. Dark respiration rate (R_d), light saturation point (LSP), light compensation point (LCP), leaf mass area (LMA), leaf N content, and leaf chlorophyll (Chl) contents were significantly correlated with light levels (P<0.05). Results suggest that *P. koraiensis* seedlings mainly vary leaf traits (LMA, N, and Chl contents) and regulate R_d, LSP, and LCP, which can adjust the ability of capturing light, decrease respiration consumption, and vary the range of light utilization to adapt to different light conditions. Therefore, *P. koraiensis* seedlings are better adapted to 60% natural irradiance and exhibit a considerable photosynthetic plasticity, which allows them to grow from full natural irradiance to underneath the canopy.

Posters

Combining ability of volume growth from 27 full-sib families of *Pinus koraiensis* in Korea. Cheon, B.H., Han, S.U., Woo, K.S., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; cbhmk1302@forest.go.kr; sanguhan@forest.go.kr; woo9431@forest.go.kr; jskim20@forest.go.kr*).

The main aim of this study was to select superior combinations from a control pollinated progeny test of *Pinus koraiensis.* Control pollination was made by disconnected half diallel mating design with 10 female and 9 male parents, and the progeny trial was established with 27 combinations in Suwon in 1996. At age of 16, individual volume growth was measured, and general (GCA) and specific (SCA) combining abilities were estimated. ANOVA showed that there was a significant difference of volume growth among the combinations. Combinations of 01116 × 0184, 0184 × 023, and 021 × 01116 were identified as superior combinations for volume growth; and 0129 × 0184, 0178 × 01116, and 0196 × 013 were recognized as inferior combinations. General combining ability showed that 0184 and 0217 combinations were good combiners, but 0178 and 0129 were lower. Specific combining ability showed that 0157 × 013 and 01116 × 0184 were good combiners and 0129 × 0184 and 0178 × 01116 were poor combiners in years. Superior GCA combiners of volume growth were also good SCA combiners. Good combinations in GCA and or SCA would be used as breeding materials in the future generation.

Analysis of diameter growth characteristics of major species using national forest resource inventory in the Gangwon-do Forests. Choi, J.K., Lee, W.A., Park J.T., Shin, J.W. (*Kangwon National University, Republic of Korea; jungkee@kangwon.ac.kr; wona87@gmail.com; p850226@kangwon.ac.kr; jwshin@kangwon.ac.kr*), Lee, W.K. (*Korea University, Republic of Korea; leewk@korea.ac.kr*), Lee, Y.J. (*Kongju National University, Republic of Korea; leeyj@kongju.ac.kr*), Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; shkimfri@forest.or.kr*), Jung, D.J. (*National Forestry Cooperatives Federation; Republic of Korea; cdj3663@nfcf.or.kr*).

This study was carried out to analyze annual diameter growth characteristics for 11 major tree species using the Gangwon province data of the National Forest Resources Inventory in 2007. The annual diameter growth of coniferous species was 5.02 mm, 4.70 mm, and 3.90 mm in Korean white pine, Japanese larch, and Korean red pine. In growth of deciduous trees, dogwood, basswood, and cork oak had 3.55 mm, 3.48 mm and 3.01 mm, respectively. The average diameter growth for coniferous species, deciduous species, and *Quercus* species was 4.54 mm, 3.03 mm, and 2.82 mm, respectively. Average of the annual diameter growth for all species was 3.38 mm. Looking at diameter growth and age, the growth rate decreased for all species as age increased. Age class 2 (10–20 years old) had the highest annual diameter rate (average 5.14 mm) for all species. Regarding trees per hectare and diameter growth, the diameter tended to decrease as the trees per hectare increased for most species, especially Korean white pine, cork oak, and basswood. Finally age had the highest value (average -0.336) in the correlation coefficient between measurement factor and growth rate regardless of species.

Estimation of expected and realized genetic gains from progeny tests of *Pinus koraiensis* plus trees. Han, S.U., Woo, K.S., Oh, C.Y., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; sanguhan@forest.go.kr; woo9431@forest.go.kr; chang05@forest.go.kr; jskim20@forest.go.kr*).

Pinus koraiensis is native to Korea, and was widely planted from 1970 to the 1990s in Korea because of its high value for both timber and edible nuts. *P. koraiensis* is one of the major planting species, occupying about 12% of the total artificial plantation area in recent 5 years in Korea. In 1983, open-pollinated seeds were collected from 21 plus trees and nurtured for 5 years. The seedlings were planted in three sites—Chuncheon, Gunpo, and Cheongwon—in 1988 in a randomized block design with four replications. Height (H) and DBH (D) were measured in 2009, and volume was calculated as the following: $V = H \times D^2$. The volume of Chuncheon was the greatest, followed by Cheongwon and Gunpo. Families of Kyeonggi51, Kwangwon21, and Kyeonggi58 showed good growth performance, but families of Kyeonggi63, Kyeonggi62, and Kwangwon82 showed poor growth performance. Site and family were statistically significant in the analysis with combined data, but difference was not significant in family × site interaction. The heritability of individuals and families for volume was 0.286 and 0.673, respectively. It was estimated that the expected and realized genetic gains from 10 superior families in growth performance were 7% and 32%, respectively.

Biomass estimates of a primary temperate forest in the Xiaoxing'An Mountains, northeast China. Jin, G. (*Northeast Forestry University, China; taxus@126.com*), Li, R. (*Northeast Forestry University, China; LR0721@126.com*), Li, F. (*Northeast Forestry University, China; fengrili@126.com*), Yang, C. (*Northeast Forestry University, China; yangcp@nefu.edu.cn*).

The biomass of primary temperate forest plays a key role in quantifying the characteristics of the forest ecosystem and forest carbon stocks. In this study, allometry equations were developed and applied to tree census data (*DBH* ≥2 cm living stems) obtained in a 9-ha primary temperate forest plot to estimate biomass and its allocation. We applied a compatible biomass model to develop species-specific allometry equations from the sample trees collected in the primary temperate forest. The resulting equations fit well and enable us to predict biomass by component for each species. Total biomass for the temperate forest was 381.30t/hm^2, of which stems accounted 50.70%; and roots, branches, and foliage were 29.49%, 15.51%, and 4.3%, respectively. The biomass allocation among different DBH classes was concentrated in the middle and larger classes (DBH ≥30 cm), accounting for 82.95%. In contrast, individuals with DBH less than 30 cm dominate the community, accounting for 91.13% of the total, but contribute little to the total biomass (17.05%). For biomass allocation among species, over 90% of the biomass is due to six species only: *Pinus koraiensis* (65.53%), *Abies nephrolepis* (7.73%), *Acer mono* (6.84%), *Betula costata* (5.17%), *Tilia amurensis* (3.99%), and *Fraxinus mandshurica* (2.13%).

The development of a successive generation scheme for *Pinus koraiensis* plantation. Kim, J.H., Chung, S.H. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr; chsh@kangwon.ac.kr*), Yang, H.M. (*Korea Forest Research Institute, Republic of Korea; ycology@korea.kr*), Piao, T.F. (*Kangwon National University, Republic of Korea; piaotiefeng@hotmail.com*), Jung, S.S. (*Korea National Arboretum, Republic of Korea; tricyrtis@forest.go.kr*).

Korean pine (*Pinus koraiensis*) has been widely planted for several decades in South Korea, having contributed to afforestation to restore the country's land. The establishment of Korean pine forests has commonly and effectively been done with monoculture, chiefly for the benefits of simplicity of management and predictability of yield. However, any forthcoming actions in the treatment of Korean pine forests need to be based on an understanding of natural structure and function. Ecologically sound silvicultural systems should be developed for present Korean pine forests as well as other coniferous plantations. We could benchmark the lesson from the dynamics and processes of natural Korean pine forests in northeast China, where the mixed broadleaved-Korean pine forest type remains. Advisable succeeding generations could be multi-species, multi-layer, and uneven-aged stands, taking advantage of the forest successional process. Several alternatives of the silvicultural system would be suggested to realize this ecological management scheme in Korean pine plantations. Alternative 1 is clearcutting in patches for conversion of other species to make patch mixture; alternative 2 is partial cutting (or heavy thinning) for the growth of understory to make two-storied stands; and alternative 3 is shelterwood cutting with more than three times to make uneven-aged stands.

The occurrence of regenerating seedlings in different thinning treatments in *Pinus koraiensis* plantations. Lee, H.S., Kim, J.H. (*Kangwon National University, Republic of Korea; gngnt35@nate.com; kimjh@kangwon.ac.kr*), Yang, H.M. (*Korea Forest Research Institute, Republic of Korea; ycology@korea.kr*), Jin, G. Z. (*Northeast Forestry University, China; taxus@126.com*), Piao, T.F. (*Kangwon National University, Republic of Korea; piaotiefeng@hotmail.com*).

Presuming to stimulate the growth of understory by controlling stand density, the study was conducted to examine the occurrence of regenerating seedlings for different thinning treatments in *Pinus koraiensis* plantations. In 2007, thinning practices were implemented in he age classes III and V of Korean pine plantations for the purpose of timber quality improvement (A-32% of thinning), biodiversity enhancement (B-64% of thinning), forest gap (C-50% of thinning), and no thinning for control (N). In each treatment site, data of seedlings were collected from nested plots in the permanent plot. The results indicated that, in stand age class III, the highest number of Korean pine seedlings was recorded in the site of treatment A, followed by that of B, C, and N. On the other hand, in stand age class V, the site of treatment B had the highest number of pine seedlings, followed by that of N, C, and A. Even though recent thinning practices had little influence on the occurrence of the pine seedlings in the stands of age class V, the practice made the stand of age class III produce a significantly large amount of seedlings.

Significant correlation of total nitrogen content in seedlings with fast-growing traits in *Pinus koraiensis*. Lee, W.Y., Park, E. J., Han, S.U., Cheon, B.H., Noh, E.W. (*Korea Forest Research Institute, Republic of Korea; lwy20@forest.go.kr; pahkej@forest.go.kr; sanguhan@forest.go.kr; cbhmk1302@forest.go.kr; ewnoh@forest.go.kr*).

In this study, a comparative study was conducted on genetic correlation between 12 plus trees (35-year-old) and their open-pollinated 1-year-old seedlings for early selection in *Pinus koraiensis* with fast-growing traits. Interfamily differences of 1-year-old seedlings on the basis of height (cm), total weight (g DW), and shoot and hypocotyl weight (g DW) were significantly correlated with the height, DBH, and volume of 35-year-old trees. Ring widths of 35-year-old trees also showed significant correlation with the value of $\delta^{13}C$ (‰) and total nitrogen content, and C/N ratio in their xylem. Interestingly the growth performances in the adult trees were significantly associated with the nitrogen contents and C/N ratio but not with the $\delta^{13}C$ value in the cotyledonary needles of seedlings, indicating that there may be differences in the physiological adaptation of *P. koraiensis* seedlings to environmental conditions. In conclusion, our results showed that the nitrogen content in 1-year-old seedlings was an important factor in determining the fast-growing trait in adult trees, suggesting that such a parameter may be useful to shorten the breeding cycle of *P. koraiensis* through early selection.

Influence of topography on coarse woody debris in a mixed broadleaved–Korean pine forest in Xiaoxing'an Mountains, China. Liu, Y., Jin, G., Li, F. (*Northeast Forestry University, China; liuyanyan07@126.com; taxus@126.com; fengrili@126.com*), Kim, J.H. (*Kangwon National University*, *Korea*; *kimjh@kangwon.ac.kr*).

The relationship between coarse woody debris (CWD) number, existing form, decay class, and topographic traits was studied in a large permanent plot (9 hm^2) of a typical mixed broadleaved–Korean pine forest in Xiaoxing'an Mountains. CWD density and basal area (BA) increased with the topographic position rising; the density, BA, and volume of CWD decreased from north to south slope. A x^2-test showed that topography significantly affected CWD density. CWD was likely to occur on ridge, north slope, and slope degree of 16°–25°.The CWD was mainly composed of uprooted blow-down, breakage at rootstock, and breakage at trunk depending on topography. The density, BA, and volume of uprooted blow-down decreased from valley to ridge, but the density of other existing forms showed an opposite pattern; the density of snags decreased from north to south slope. The falling direction of CWD was not correlated with the aspect ($p > 0.05$) or wind direction ($p < 0.001$). The decay classes of CWD were largely distributed with a peak on the decay class 2 and 3, suggesting that the input and output of CWD was largely balanced in the mixed broadleaved–Korean pine forest.

Comparison of photosynthetic characteristics between introduced and native pines grown at four irradiance regimes in Northeastern China. Sun, Y.R., Zhu, J.J. (*Chinese Academy of Sciences, China; rongyisun@163.com; jiaojunzhu@iae.ac.cn*), Sun, O.J. (*Beijing Forestry University, China; sunjianx@bjfu.edu.cn*), Yu, L.Z. (*Chinese Academy of Sciences, China; ylzylp@163.com*).

The prolific amount of growth in introduced trees may be attainted by higher net photosynthesis (A_N) or other physiological traits. The hypothesis that leaf-level photosynthetic capacities were greater in introduced pines as compared with the native pines in the Northeast of China was tested. Ecophysiological traits between *Pinus koraiensis* and *P. resinosa* seedlings were compared in a greenhouse study to better understand their differences and the physiological response of these species to four light regimes. The introduced pine, *P. resinosa*, had significantly higher A_N on a leaf area through all the day than the native pine, *P. koraiensis*. All the photosynthetic parameters getting from the *A/Q* and *A*/Ci curves for *P. resinosa* were greater than *P. koraiensis* in full sunlight treatment. Using discriminant analysis and stepwise-discriminant analysis, the Mahalanobis squared distances between them were 9.51 ($P = 0.0218$) and 7.82 ($P = 0.0005$) respectively. The mean net photosynthetic rate (A_{mean}), light compensation point (*LCP*), light saturation point (*LSP*), light-saturation of net photosynthesis (A_{max}), and maximum rate of Rubisco-mediated carboxylation (V_{cmax}) were the most powerful for distinguishing between the pines.

Biomass allocation in *Pinus koraiensis* seedlings in three forest stands. Sun, Y.R., Zhu, J.J., Yan, Q.L., Yu, L.Z. (*Chinese Academy of Sciences, China; rongyisun@163.com; jiaojunzhu@iae.ac.cn; yanqiaoling1978@126.com; ylzylp@163.com*).

Because light environment is a limiting factor in Korean pine (*Pinus koraiensis*) regeneration, continued problems in its regeneration have led to a need for more basic information on responses of Korean pine seedlings to light environment. In the present study, biomass allocation of Korean pine seedlings (about 9-years old) was compared in three actual stands (*Larix* stand, broadleaved stand, and Korean stand). Results indicated that Korean pine seedling biomass allocation responded plastically to light availability. The needle, stem, root, and total biomass of seedlings growing under the broadleaved stand showed the highest value of all, and they were the lowest in the Korean pine stand. But seedlings growing under the *Larix* stand and the broadleaved stand exhibited similar biomass allocation patterns: 41% to 43% of total biomass was allocated in needle, 35% to 36% in stem, 21% to 23% in root, and 76% to 79% in aboveground. However, 56% of total biomass was allocated in stem for seedlings in the Korean pine stand. Results from this study suggested that light quality and light period strongly affect biomass allocation of Korean pine seedlings, and the need for distinguishing the responses of seedlings to light compositions.

Short-term responses of understory vegetation after different thinning treatments in Korean pine (*Pinus koraiensis*) stands. Yang, H.M., Shin, J.H. (*Korea Forest Research Institute, Republic of Korea; ycology@forest.go.kr; kecology@forest.go.kr*), Kim, J.H. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr*).

Recognizing the importance of ecological management to enhance biodiversity in planted forests, a long-term study was started to determine if different silvicultural treatments can enhance biodiversity on Korean pine plantations in South Korea. In this study, we described the short-term responses of understory vegetation in species diversity, coverage, and species composition after different thinning treatments in the long-term sites. We applied three different thinning treatments (66%, 49%, and 38%) with control to 12 management units, and surveyed vegetation in herb and shrub layers before treatment and during two growing seasons after treatment completion. Many understory vegetation traits were significantly changed after thinning, and the changes were often proportional to thinning intensity. In the herb layer, species richness and coverage were continuously increased from the first growing season, while species evenness was increased in the second growing season. Species richness and coverage in the shrub layer increased in the first growing season but decreased in the second growing season. Species composition changed dramatically during the first growing season due to invasion and flourishing of exotic species and non-local native species. Our study showed that the thinning treatments had effects on understory vegetation and that the shot-term responses were different among treatments.

Effects of water and fertilizer coupling on fine root morphology in a Korean pine plantation. Yu, L.Z. (*Chinese Academy of Sciences*, *China; ylzylp@163.com*).

Fine roots are the major organs to absorb water and nutrients in soil. The first effects of soil moisture and nutrient availability on plants are through fine roots. Korean pine (*Pinus koraiensis*) is the main timber species in eastern montane regions of Liaoning Province. In this study, the effects of fertilization, water control, and the coupling of fertilization and water control on fine-root morphology (including diameter, length, and specific root length) were explored for different orders of fine roots of a Korean pine plantation. Results showed that there were significant increases in diameter for 1st-3rd order roots by applying fertilizers and coupling of water and fertilizer. However, after controlling water, the diameter of fine roots did not enhance significantly. The length for 1st order roots significantly declined after both the fertilization and water control treatments, but there was no significant decrease in root length under the treatment of water and fertilizer coupling. The specific root length of all orders of fine roots significantly decreased after water control treatment, but significantly increased by applying the coupling of water and fertilizer. There were no significant effects of fertilization on the specific root length of pine fine roots at all levels.

D-03 Rehabilitating forest ecosystems in Asia under extreme environmental conditions

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Status and growth performances of mangrove species in a fragmented forest of Chakoria Sundarbans in Bangladesh. Hossain, M. (*Chittagong University, Bangladesh; mkhossain2009@gmail.com*), Islam, M. (*Office of the Deputy Commissioner, Netrokhona, Bangladesh; nazrulm@yahoo.com*).

The study was carried out in Chokoria Sundarbans, the second largest Sundarban mangrove forest in Bangladesh with a view to assess the status and growth performances of mangrove plantations in this degraded mangrove forest. In Forest Department-raised mangrove plantations, the MAI in diameter and height for *Sonneratia apetala* were 0.51–0.88 cm and 0.47–0.64 m respectively, whereas the values for *Avicennia officinalis* were 0.52–0.95 cm and 0.38–0.49 m respectively. Two NGOs—OISCA (Organization for Industrial, Spiritual and Cultural Advancement) and UBINIG (Unnayan Bikolper Niti Nirdharani Gobeshona Protisthan)—raised plantations where the MAI in diameter and height of *S. apetala* were 0.71–0.87 cm and 0.45–0.64 m respectively. The corresponding values of *A. officinalis* were 0.79–0.91 cm and 0.33–0.58 m. The height and diameter growth of both the species planted by OISCA and UBINIG showed no significant ($P < 0.05$) differences. The efforts towards afforestation are urgent to combat climate change vulnerabilities in these coastal areas of Bangladesh to safeguard coastal livelihoods.

Rehabilitation of a degraded forest ecosystem in Zagros region of western Iran with *Amygdalus scoparia* Spach. Iranmanesh, Y., Jalai, G.A., Gojani, H.J., Talebi, M., Salarian, A. (*Research Center of Agricultural and Natural Resources, Iran; y_iranmanesh@yahoo.com; Gholamlij@yahoo.com; jahanbazy_hassan@yahoo.com; mahmoodtalebi@yahoo.com; aref.salarian@yahoo.com*).

Zagros forests in western Iran, with an area of 5 million ha, account for almost 40% of the country's forests. The forests are currently considered degraded because of socio-economic problems. Therefore, use of native species, especially pioneer species, is necessary to rehabilitate of degraded forests. This research was conducted with *Amygdalus scoparia* Spach in Chaharmahal and Bakhtiari provinces in western Iran. At the first step, the ecological demands of *A. scoparia* and the soil and physiographic needs of this species were surveyed. Then we planted seeds of *Amygdalus scoparia* at 1- × 1-m distance. After 20 years, quantitative characteristics were measured. The results indicated that one of the most important affecting factors in wild almond distribution is geographical aspect. Also this species was often seen on alkaline soils. The results of plantation study show that annual height growth of *A. scoparia* was 8.5 cm. Also, the average annual diameter growth and annual canopy growth were 1.5 mm and 10.5 cm respectively. In this plantation, the average of coppice sprouts of *A. scoparia* were 8. This study shows that, after 20 years, *A.s scoparia* has covered about 80% of soil surface.

Ecological restoration and management of a degraded area for Baekdudaegan conservation. Kim, Y., Youn J.H., Lee, I.K., Chun, J.H., Shin, J.H. (*Korea Forest Research Institute, Republic of Korea*; *youngkul@forest.go.kr; yount@forest.go.kr; iklee@forest.go.kr; chunjh69@forest.go.kr; kecology@forest.go.kr*).

The Baekdudaegan Mountain System (BDMS) is the longest series (1,400 km) of mountain ranges that forms the backbone of the Korean peninsula. Experimental sites were arranged in a cutting slope of forest roads and an abandoned slope mine with the view to conservation of BDMS. The species and coverage rate have been monitored after preparing the sites with different soil conditions and working methods. In the cutting slope of forest roads, hydro-seeding treatment was applied to same species after making soil beds at 0.4 cm (coir net), 3 cm (native ground cover restoration), 10 cm (2-layers seed spray), and 30 cm(geo-fiber) in depth respectively. Three years later, the 30-cm plot has shown the highest coverage, up to 80% with 12 alive species. The 3- and 10-cm plots have shown 75% coverage, and almost zero coverage has been seen in the 0.4-cm plot. Among working methods, the geo-fiber method resulted in an excellent coverage, 95%. In the slope of abandoned mines, hydro-seeding was applied with 30-cm soil covering after laying a geo-membrane, and with two mulching methods that use woodchips and rice straw mats. The coverage has reached 60% in the case of the geo-membrane treatment. The highest coverage is found in the geo-membrane, and rice straw mulching, woodchip mulching plots are followed in order.

Establishment of productive forest on ex-mine sites in Indonesia: lessons learned from the Newmont Minahasa Raya Co, a gold mining company in north Sulawesi, Indonesia. Mansur, I., Putra, C.A.S. (*Bogor Agricultural University, West Java-Indonesia; irdikam@biotrop.org; irdikam@biotrop.org*), Sompie, D. (*Minahasa Raya Co., Indonesia; irdikam@biotrop.org*), Kojansow, J. (*Newmont Minahasa Raya Co., Indonesia; irdikam@biotrop.org*), Pollo, H.N. (*University of Sam Ratulangi, Indonesia; irdikam@biotrop.org*).

Mining operations have been regarded as one important cause of tropical forest destruction in Indonesia. The operation involves the removal of forest cover, followed by stripping of soil and dumping of overburden materials. The overburden materials and soil are then used to re-contour the site after the mining operation is completed. The drastic changes, especially soil fertility and lack of plant shade, have become the main cause of failure in the re-establishment of forests after mining. Species planted were among others commercial timber of local and exotic species, such as *Palaquium obovatum*, *Pterocarpus indicus*, *Tectona grandis*, *Paraserianthes falcataria*, and *Swietenia macrophylla*. This paper will present the results of a long effort to establish a productive forest on a degraded ex-mine site. Evaluation of the survival and growth of trees has been made by laying sampling plots and measuring trees in blocks rehabilitated from year 2000 to 2007. The results show that all selected species could survive and grow well in the ex-mine site, and some species planted in year 2000 have reached commercial size. Therefore, it is concluded that productive highly commercial forests could be established on degraded ex-mine sites.

Different characteristics of xylem water potential of four species (*Ulmus pumila* L., *Larix sibirica* L., *Pinus sylvestris* L., *Caragana arborescens*) seedlings in Mongolia. Park, G., Lee, D., Park, Y. (*Seoul National University, Republic of Korea; hellogracia@gmail.com; leedk@snu.ac.kr; forest_park@hanmail.net*), Batkhuu, N. (*Department of Forestry, National University of Mongolia, Mongolia; bnyamosor@yahoo.com*), Jamsran, T., Enkhchimeg, T. (*Mongolian Academy of Sciences, Mongolia; Tsogtbaatarj@magicnet.mn; enkhii_smile@yahoo.com*).

This study aims to determine the xylem water potential characteristics of four species, namely, *Ulmus pumila*, *Larix sibirica, Caragana arborescens*, and *Pinus sylvestris*, which are the main species for forest restoration in Mongolia at seedling level. *U. pumila*, *L. sibirica*, and *C. arborescens* were sown in 2006, while *P. sylvestris* was sown in 2005 in the greenhouse (Dambadarjaa, Mongolia). Both the relative humidity and temperature in the air had been monitored since June 2008 using HOBO. Plant Ψ was measured at dawn when the relative humidity was at the highest and midday when the relative humidity was at the lowest. Stems with 13–15 cm length (≤0.8 cm diameter) were taken, and Ψ was measured immediately using Scholander pressure chamber (PMS 600, PMS Instruments, Corvallis, Oregon). The results showed that both of the midday xylem water potential and the difference between midday-predawn water potential of *U. pumila* were higher than other species. In conclusion, it is assumed that 2-year-old seedlings of *U. pumila* have advantages in terms of water uptake under similar water conditions.

Evaluating and monitoring early achievements of rehabilitation projects in Mongolia. Park, Y., Lee, D. (*Seoul National University, Republic of Korea; parkyd70@snu.ac.kr; leedk@snu.ac.kr*), Tsogtbaatar, J. (*Institute of GeoEcology, Mongolia; Tsogtbaatarj@magicnet.mn*), Batkhuu, N. (*National University of Mongolia, Mongolia; nbatkhuu@biology.num.edu.mn*), Park, G. (*Seoul National University, Republic of Korea; hellogracia@gmail.com*).

Mongolia is one of the countries in the world which is seriously increasing forest degradation. Thus, numerous activities for forest rehabilitation have been conducted in Mongolia but most of them showed poor results because of natural reasons, such as harsh climate, and lack of understanding of ecological characteristics. This research aimed to evaluate the achievements of rehabilitation projects conducted recently in Mongolia and to identify attributes promoting their success. A total of 16 plantation sites were selected and investigated for survival and growth rate of planted seedlings. Environmental variables of the plantation sites—such as altitude, aspect, the distance from natural forest, grazing intensity, and soil properties—were measured to identify

the attributes promoting the survival rate of planted seedlings. Water is one of the limiting factors affecting seedling survival in Mongolia, and it is desirable to establish plantation sites near the natural stand, because the nearby natural stand can serve as a barrier from wind and can provide a water supply under water-limited conditions. Prevention of grazing and fire is also an important factor; it is advantageous to use fencing and fire protection strips when establishing plantations.

Stabilizing shifting sand dunes in South Gobi of Mongolia. Tsogtbaatar J. (*Mongolian Academy of Sciences, Mongolia; tsogtbaatarj@magicnet.mn*), Khaulenbek A. (*Institute of geoEcology, Mongolia; khaulenbek@yahoo.com*), Park D. (*Korea Forest Research Institute, Republic f Korea; pdk5920@forest.go.kr*), Mandakh N. (*GeoEcology Institute, Mongolia; maaggi@yahoo.com*).

Based on research conducted in 2004–2005 at Moltsog els, Omnogobi aimag, Mongolia we can reach to the following conclusions: (1) For windblown sands, the dense checkerboard pattern using stones can accumulate approximately 5–6 cm depth of sand. Research results conducted over the last two years demonstrate that such kinds of dense barriers have to placed on slopes of less than 5–10 degrees to be effective. Moreover, it is particularly effective for preventing sand shifting in corners of sand dunes rather than on the windward side of a slope. (2) The capability of sand accumulation of the net barrier is not so dependent on hill slope, hence it can be used on windward sides of sand dunes. The other types such as stone and clay barriers are more efficient for protection of leeward sections of dunes. The height parameter for mechanical barriers is important, thus according to the short-term results we recommend to establish stone barriers with heights of 15–17 cm, clay with 20 cm, and net barriers more than 20 cm. (3) The survival rate of transplanted trees varies between 50–60%. Research shows that tree survival rapidly goes down in a second year after transplantation, which proves that the seedling does not have sufficient biological capacity to acclimatize effectively without maintenance. Thus, experiments using bio-fertilizers to support tree growth need to be investigated.

Posters

The effects of coppicing and manure treatment on the phytoremediation efficiency. Byun, J.K., Park, B.B., Sung, J.H., Shin, J.H., Kim, W.S. (*Korea Forest Research Institute, Republic of Korea; bjk2754@forest.go.kr; bbpark@forest.go.kr; jhs033@forest.go.kr; kecology@forest.go.kr; just.redoak@gmail.com*).

Phytoremediation has been attractive to remove pollutants from the environment because it is a cheap and environmentally sound method. Coppicing has been used to increase biomass production in deciduous temperate forests, but rarely applied to phytoremediation. We measured the effects of coppicing and manure treatment on the efficiency of phytoremediation. We conducted coppicing and four levels of manure fertilization on *Fraxinus rhynchophylla* saplings in pots and treated landfill leachate for 21 weeks. Aboveground biomass was significantly increased as manure treatment increased in water-only treated pots ($P < 0.05$), but there was no significant increases in leachate-treated pots. Because coppicing increased the proportion of foliage out of above-ground biomass by 10%, the effects of phytoremediation by coppicing should be more increased since element concentrations in foliage are usually higher than other tissues. For example, coppicing treatment increased uptake of N by 21%, uptake of Na by 31%, and uptake of Ca by 25% compared to control. This study suggests coppicing with manure treatment can improve the efficiency of phytoremediation when foliage is fully matured even though species selection for phytoremediation is very important.

An attempt to rehabilitate a degraded tropical rain forest in Borneo: the biological results and the social benefits of the IKEA investment, an analysis after 10 years. Falck, J. (*Swedish University of Agricultural Sciences, Sweden; Jan.Falck@ssko.slu.se*), Alloysius, D. (*Sabah Foundation, Malaysia; Dalloysius@yahoo.com*), Karlsson, A., Luc V. (*Swedish University of Agricultural Sciences, Sweden; Anders. Karlsson@ssko.slu.se; Viveca.Luc@slu.se*), Yup, S. (*Sabah Foundation, Malaysia; yapsauwai@gmail.com*).

In 1983 the tropical rain forest of Borneo suffered from a severe drought, followed by wildfires destroying a million ha of rain forests. In 1998 the board of IKEA decided to invest in an attempt to rehabilitate a degraded forest in Sabah and to do it in a cooperation with Sabah Foundation. The aim of the project was to improve biodiversity. Investments were made in labour salaries and in infrastructure, such as roads, family houses, field camps, and a nursery. Mainly these seedlings belonged to the *Dipterocarpaceae* family and fruit trees species. In the rehabilitation concept, line and gap cluster planting were tested, and each planting point was supported with weeding, shade adjustment, and beating up during 10 years. In 2009 an inventory was made. The results of the first-year operation show that 57% of planted spots had a healthy tree. The mean DBH of trees in gap cluster compared to line plantation was 4.1 cm and 5.2 cm, and the mean height was 5.8 m and 6.7 m. There were notable differences in survival and growth between planted tree species. The project is ongoing. Today 9,600 ha is rehabilitated and the cost was 690 USD per ha.

The fate of the tropical rain forest of Borneo and a search for methods for rehabilitation and timber extraction improvements. Falck, J., Karlsson, A. (*Swedish University of Agricultural Sciences, Sweden; Jan.Falck@ssko.slu.se; anders.karlsson@ssko.slu.se*), Yap, S.W. (*yapsauwai@gmail.com*), Forshed, O. (*Swedish University of Agricultural Sciences, Sweden; Olle.Forshed@ssko.slu.se*).

At one time the entire island of Borneo was forested, dominated by biodiversity-rich Dipterocarp forests. However, after the arrival of Europeans during the colonial era, a process of land use change was initiated, one that accelerated after the Second World War. Extraction of tropical timber using single-tree selection methods was followed in many regions by land clearing for production of rice and vegetables for local use and for cacao, rubber, pepper, woodchips, and today palm oil for export. In Sabah alone, 1.4 million ha is now covered with oil palms. In Sabah 3.6 million ha is covered with forest out of originally 7 million ha. This forest is, outside forest reserves, mainly a logging-degraded secondary forest. In an attempt to secure a future forest land cover in Sabah and its biodiversity values, IKEA of Sweden has invested in research in forest rehabilitation, including line and gap plantations in secondary *Macaranga* forests, with a mix of native species, mainly belonging to the family Dipterocarpaceae. Another way to save the forest of Borneo is to make timber production profitable compared to other land uses. In 1992 an experiment was established to evaluate a design of a cheap and gentle timber harvesting method.

The performance of three tree species used for restoration planting in the abandoned coal mine, South Korea. Hwang, G. M., Yeom, D.J., Kim J.H. (*Kangwon National University, Republic of Korea; impkm@korea.com; dj.yeom@kangwon.ac.kr; kimjh@kangwon.ac.kr*), Kang, S.K. (*Forest Human Resources Development Institute, Republic of Korea; tree@forest.go.kr*), Jung, S.S. (*Korea National Arboretum, Republic of Korea; tricyrtis@forest.go.kr*)**.**

A comparative study was conducted to evaluate the performance of three tree species (AH: *Alnus hirsuta*, RP: *Robinia pseudoacacia*, BP: *Betula platyphylla* var. *japonica*) used for restoration planting in 1997 for 11 hectares of abandoned coal mine, Jeongseon-Gun, South Korea. In three 10-m × 10-m temporarily established sample plots, experimental data were collected on the residual density, DBH, height, and understory vegetation to evaluate survival rate, basal area, volume for three species, and the potentiality of coal mine stabilization. The results showed that *A. hirsuta* was the best in size with the average height of 7.3 m, DBH of 6.5 cm, basal area of 7.75 m^2 per hectare, and volume of 34.6 m^3 per hectare. On the other hand, *R. pseudoacacia* had highest survival rate of 97.3%, followed by 93.1% of AH and 55.6% of BP, which performed poorest among the three species. It is suggested that the restoration practice was fairly successful with planting of tree species, especially, *A. hirsuta* and *R. pseudoacacia*. In addition, alder and black locust have nitrogen-fixation mechanisms that must be very helpful to improve the site condition for enhancing possibility of the restoration in the area of abandoned coal mine.

Functional aspects of *Acacia mangium* as a fertilizer tree. Inagaki, M. (*Forestry and Forest Products Research Institute, Japan; inagaki@affrc.go.jp*), Kamo, K. (*Forest Science and Technology Institute, Japan; kkamo@sc4.sp-net.ne.jp*).

Acacia mangium is a major tropical and subtropical fast-wood plantation species in Asia and is also planted in other regions. *A. mangium* is a potential candidate for a nurse tree in mixed planting because of its tolerance for and adaptation to severe site conditions. The fertilizing effect of N_2-fixing trees has been investigated in many studies about N; however, the dynamics of other elements have received little attention. In this presentation, we report the nutrient flux in litterfall of *A. mangium*, in comparison with other tropical plantation trees. Litterfall of an old *A. mangium* stand (> 20 years old), measured for 3 years, exceeded more than 200 kg N ha^{-1} yr^{-1} in Borneo, Malaysia. Such large N fluxes were also reported in some tropical leguminous plantations probably due to symbiotic root nodules. However, phosphorus flux was low and the N:P ratio of leaf-fall exceeded 100, which is considerably different from that of other plantation trees growing in the same soil conditions. These suggest that foresters can expect large N flux when planting some plants mixed with *A. mangium*; however, the imbalance of nutrients in litterfall should be taken into account when using *A. mangium* as fertilizer trees.

Regeneration and seedling survival rates in the rehabilitated degraded peatland of badas, Brunei Darussalam. Jali, H.D. (*Universiti Brunei Darussalam, Brunei Darussalam; dulimah.jali@ubd.edu.bn).*

Over the past decade, forest fires have become a common occurrence, increasing in frequency and extent in Southeast Asia. The Badas peat swamp of Brunei Darussalam, which was destroyed during an enormous fire in 1997/1998, was studied. We report the results of rehabilitation and restoration of this burnt peatland in terms of natural regeneration and seedling survival rates. Five hectares of burnt forest were replanted with several indigenous species of timber and non timber species, including *Shorea pachphylla*, *S. platycarpa*, *Dryobalanops rappa*, *Agathis*, *Dyera lowii*, *Calophyllum borneense*, *Eugenia*, *Lithocarpus sudaika*, and *Teminius* spp. Assisted natural succession methods were used in the rehabilitation work. Initial results show survival rates of seedlings are very low and much affected by environmental conditions. Of the timber species, *Agathis* and *S. pachphylla* showed promising growth compared to other timber species. Non-timber species generally showed equal growth rate, although *Teminius* spp. showed the greatest ability to tolerate adverse conditions and competition. Abiotic factors such as water availability and water table fluctuation are the most crucial aspects for establishment of pioneer species and seedling survival. Results suggest that facilitation of natural regeneration may be a feasible, low-cost management option for restoring native forest cover to large areas.

Development of vegetation base to promote tree growth on the slope of an abandoned mine area in Korea. Jeong, Y., Lee, I., Lim, J., Seo, K. (*Korea Forest Research Institute, Republic of Korea; green@forest.go.kr; iklee@forest.go.kr; forefire@forest.go.kr; kwseo@forest.go.kr*).

Physicochemical properties of mine debris in abandoned mine areas are unfavorable to root growth of plants. Therefore, vegetation base materials are essential for vegetation restoration. The purpose of this study is to develop techniques for establishing a vegetation base that costs less, shows high efficiency, and can be applied in abandoned area. The study area was located in Boryung city, Chungnam province. Twelve plots were established (three soil depth × four treatments) in September 2008. Four treatments were: [SM (soil molding)+SIM (soil improved materials)+EI (erosion inhibitor)+PM (peat moss)]; [SM+SIM+PM]; [SM+EI+PM]; and SM. Mean tree height and mean diameter decreased in order of *Indigofera pseudo-tinctoria* > *Lespedeza cyrtobotrya* > *Pinus densiflora*. There was no significant difference among species on soil depths; however, they showed significant difference on treatments within the same soil depth. Soil chemical properties did not show significant difference on soil depth, but showed significant difference among treatments in the same soil depth. Soil chemical properties among treatments were generally higher in SM+EI+PM than other treatments. In conclusion, if we use soil that is mixed with improved material and spray it on the soil molding after mixing four seeds mentioned above, we can reduce soil molding depth.

Development of vegetation base to promote tree growth on the slope of sea dikes in Korea. Jeong, Y., Seo K., Lee, I., Lim, J. (*Korea Forest Research Institute, Republic of Korea; green@forest.go.kr; kwseo@forest.go.kr; iklee@forest.go.kr; forefire@forest.go.kr*).

The purpose of this study was to develop vegetation base to promote tree growth on the slopes of sea dikes. This study was carried out on a slope of the Saemangeum sea dike in Jeollabuk-do. Total experimental area is 0.38 ha. After digging the dredged soil from the surface soil to 1.65 m depth, the drainage materials was filled to 15 cm depth from the bottom and then three different vegetation bases materials were treated to the surface in each plot, respectively. By the vegetation base materials, DS (dredged soil), DS + IM (improved material), and DS + IM + WR (weathered mother rock) were applied. After 7 months, the hydraulic conductivity of DS+IM and DS + IM + WR treatment was more improved than DS to 5.5- and 4.2-fold, respectively. The salinity of all treatments was decreased to below 0.03% (limiting value is approx. 0.05% for plants) after only 1 month.

These results showed that tall trees can safely expand the root system to the 1.5 m depth by those soil treatments. Although its change was steadily, the soil acidity also was decreased in all treatments. We could suggest that vegetation base materials applied in this study can help to promote tree growth on a sea dike.

Development of restoration technology using native plants seed chips for various disturbed slopes. Kim, D. (*Kyungpook National University, Republic of Korea; dgkim96@knu.ac.kr*), Suh, H. (*Taelim. Co., Republic of Korea*).

This study was carried out to develop an environmental friendly restoration technique for various disturbed slopes using native plant seed chips. As a result of the separated seeding using the developed seed chips of native plant combinations, the average germination rate and survival rate of trees, shrubs, and herbs were higher than those of the direct seeding, at 70–79%, 73–80%, and 53–59% or so, respectively. Also, the germination rates and the survival rates of trees, shrubs, and herbs in the separated seeding by the native plant seed chips were 10–15 times higher than those of the direct seeding. Numbers of plants surviving were at least 10 times of that of the simple seeding. The native plant seed chip technique is more efficient on soil slopes compared with stone slopes. The application of the native plant seed chip technique restored the slope to stabilization from the herb-dominant vegetation to woody-dominant vegetation within 3 years, and the landscape also changed from herbs to variously combined herbs and woody vegetation. The technique using native plant seed chips, which can be applicable to various disturbed slopes, is more efficient than conventional restoration techniques with respect to economics and landscape.

Erosion control research contributing rehabilitation works and future tasks in South Korea. Lee, C., Youn, H., Lee C. (*Korea Forest Research Institute, Republic of Korea; chunylee@forest.go.kr, yount@forest.go.kr, 2changwoo@forest.go.kr*).

Since 1900 the forested land has been devastated by cutting trees for fuelwoods, heating, and the Korean War. Erosion control research started in 1922 when the Korea Forest Research Institute (KFRI) was established. Until the 1960s research was focused on selection of proper rapid-growing grasses and trees, fertilizer components, and basic control works in mountainous areas. Broad and huge rehabilitation works started in the 1970s, including special hillside erosion control techniques supported by research results. Those erosion control projects and researches were almost completed in the 1980s. but landslide damages increased suddenly so research moved to address causes of landslides and predictions to reduce damages. In 2006, finally we made a landslide hazard map for the country. Debris flow was happening simultaneously with landslides. We developed a PDA (personal data assistant) application for field surveys of landslide-prone areas and analyzed the data using aerial and satellite photos to predict the hazard. Research projects on debris flow protection, to find out the proper shrubs and grass for preventing desertification and spatial damaged-area rehabilitation, will be continued.

Experiment of direct seeding for reforestation of devastated land. Mizutani, K. (*Forestry and Forest Products Research Institute, Japan; mizutani@ffpri.affrc.go.jp*), Kodani, J. (*Ishikawa Forest Experiment Station, Japan; kodani@pref.ishikawa.lg.jp*), Ishida, Y. (*Ishikawa Forest Experiment Station, Japan; yjishida@pref.ishikawa.lg.jp*).

Direct seeding appears to be a method of reforestation that can be provide greater tolerance against the natural environment and tree diseases than planting because the individual trees are selected from a lot of the seeds grown under severe natural conditions and whose roots have grown well. The author conducted an experiment with direct seeding on two devastated lands. Seeds coated with clay were also used in direct seeding. In the experiment at the copper mine site, six arbor species used for reforestation were sown and the germination and growth of *Pinus thunbergii* Parl. were found to be satisfactory. It appears that reforestation by this species might be possible, if there is no withering of seedlings by erosion, and no grazing damage by deer. In the experiment on the coastal devastated land, it was found that most of the individuals withered in the first year after germination due to the high temperature and dryness of the sandy surface layer in the summer season. Accordingly, we covered the surface using withered branches and needles of *P. thunbergii* Parl., which improved the survival rate. Thus, it might be possible to reforest coastal devastated land with *P. thunbergii* Parl.

Studies on below-ground biomass between two different origins of pine stands. Na, S.J. (*Korea Forest Research Institute, Republic of Korea; joon81u@ynu.ac.kr*), Lee, D.H. (*Yeungnam University, Republic of Korea; dhlee@ynu.ac.kr*), Woo, K.S., Kim C.S. (*Korea Forest Research Institute, Republic of Korea; woo9431@forest.go.kr; jskim20@forest.go.kr*).

This study was conducted to compare below-ground growth characteristics—such as entire root development form, and number, length, weights, and volumes of roots—of *Pinus densiflora* for. *erecta* Uyeki in Dae-gi and Bo-gwang areas, Gangwon province, Republic of Korea. The entire root development form was significantly different between naturally regenerated and planted stands. The central roots in the naturally regenerated stands showed a straight and well-developed shape with a central root more than 50 cm in soil core. However, central roots in the planted stand were largely distributed at the soil depth of 0–20 cm, in which large numbers of spiraling roots were developed. All root characteristics (numbers, length, weights, and volumes) were much better in the planted stand than the naturally regenerated stand at the soil depth of 0–10 cm. But those characteristics were superior in the naturally regenerated stand than the planted stand beyond the soil depth of 10 cm. The root development at a horizontal level was much better in the planted stand than the naturally regenerated stand at 0–20 cm, but at a horizontal level of more than 20 cm, the naturally regenerated stand showed better growth.

Ecological restoration of the destroyed forest in the civilian control zone in Korea. Oh, C., Ban S., Lee. H. (*Dongguk University, Republic of Korea; ecology@dongguk.edu; suhong21@nate.com; hoyleee@hanmail.net*).

The Civilian Control Zone(CCZ) is an area where entrance of civilians has been limited for more than 50 years since the Korean War. The total length of the zone is 248 km from the eastern seashore to the western seashore. The forest of CCZ has been totally kept well through the limit. But there is severe forest destruction in some places because there have been many military activities, military camps, and roadways. Damage from forest fire, which has occurred frequently because of some military activities such as clearing fields using fire, is severe also. The current extent of damage was 175 military camps 125,781 m^2 and roadways 365,000 m^2. Restoration of the damaged places was considered in two parts, military camps and landslide areas of roadways. Slope stabilization construction methods and vegetation restoration methods have been conducted in the restoration of

landslide area. For ecological restoration, construction materials were taken from that area or similar materials if local materials were not available. In vegetation restoration, native herbaceous plants such as *Arundinella hirta, Themeda triandra* var. *japonica, Miscanthus sinensis* var. *purpurascens*, etc., and woody plants such as *Lespedeza cyrtobotrya, Weigela subsessilis, Zanthoxylum schinifolium*, and *Pinus densiflora*, etc. were used.

Comparative studies on growth pattern of *Pinus sylvestris* plantations in northern Mongolia. Park, D. (*Korean Forest Research Institute, Republic of Korea; pdk5920@forest.go.kr*), Jamsran, T., Purevragchaa, B., Ganbaatar B., Bayarsaikhan U. (*Institute of GeoEcology, Mongolia; tsogtbaatarj@magicnet.mn; battulga@ecology.mas.ac.mn; batlaa_85@yahoo.com; udaakh@yahoo.com*).

Because of intensive deforestation in northern Mongolia, reforestation activities were implemented in Tujiin nars forest area of Selenge aimag in 2003–2006. The comparative studies on growth pattern of *Pinus sylvestris* plantations was carried out in selected permanent plots. Sample plots with size 30 × 30 m and 50 × 20 m were established in the relevant locations of reforestation sites. The main goal of this investigation focuses on long-term monitoring of growth patterns and stand development of plantations in Tujiin nars area of Selenge, Mongolia. The following objectives of this investigation were carried out: (1) to identify survival rate and growth pattern of plantations of *P. sylvestris*, and (2) to investigate the growth pattern of planted pine tree seedlings after transplanting in different years. The investigation of growth pattern of plantations of *P. sylvestris* has shown the following outputs: survival rates of the reforestation sites were 87.7%, 81.1%, 82.8%, and 78.6% that were reforested in 2006, 2005, 2004, and 2003 respectively. Height increments of planted seedlings were approximately 4.5 cm for the first year after transplanting, 10.9 cm for the second year, and 31.9 cm the third year onwards.

Comparison of windbreak and sandbreak effect for the reed sand-barrier and plastic net sand-barrier in deserts of China. Park, K.H., Ding G.D., Wu, B., Zhang, Y.Q. (*Beijing Forestry University, China; bear1127@daum.net; dch1999@263.net; wubin@bjfu.edu.cn; zhangyq@bjfu.edu.cn*).

A sand-barrier is a fundamental facility installed on sand dunes before afforestation to protect the plants from sand storms. Being made mainly of plant or soil material from the field, sand-barriers also improve the soil and help the ecosystem recover. In this study, we made grid-formed sand-barriers of 1 m × 1 m, 2 m × 2 m, and 4m×4m, using reed stem and plastic net (PN), to examine the windbreak and sandbreak effects according to materials and sizes. Anemometers were installed on the ground at 0.2 m and 1.0 m height in every grid to measure wind speed, and sand collectors were installed the same positions to measure collecting sand at the upper ground of 48 cm height. The windbreak effect was presented at Reed 1m × 1m > Reed 2m × 2m > PN 1m × 1m > PN 2 m × 2 m > Reed 4 m × 4 m > PN 4 m × 4 m; and the sandbreak effect was presented at PN 1 m × 1 m > PN 2 m × 2 m > Reed 4 m × 4 m > Reed 2 m × 2 m > Reed 1 m × 1 m > PN 4 m × 4 m. From synthesis and analysis of the results of the windbreak and sandbreak effects, we conclude that the materials and sizes of sand-barriers are effective at Reed 1 m × 1 m > Reed 2 m × 2 m > PN 1 m × 1 m > PN 2 m × 2 m > Reed 4 m × 4 m > PN 4 m × 4 m.

A study on vegetation recovery and succession, and soil improvement, under different periods of exclusion in Hulunbeier Sand-Land, China. Park, K.H., Wu, B., Ding, G.D., Zhang Y.Q. (*Beijing Forestry University, China; bear1127@daum.net; wubin@bjfu.edu.cn; dch1999@263.net; zhangyq@bjfu.edu.cn*).

Exclusion is a common measure taken to restore ecological environments in desert regions in China. In this study, non-exclusion, 1-year, 5-year, and 10-year exclusion plots in Hulunbeier sand-land were selected, and distribution of plant communities and soil physical and chemical properties of each of the plots were examined, so that effects of exclusion per period on vegetation recovery and succession processes, and soil improvement, could be found out. As a result of research on plant communities, vegetation succession proceeded through three stages as the period of exclusion in Hulunbeier sand-land increased. In the first stage, annual plant communities, such as *Agriophyllum squarrosum* and *Corispermum stauntonii*, were dominant; in the second stage, renascent arboreal herbs, mainly *Cleistogenes squarrosa* and *Artemisia frigid*, occupied predominantly the vegetation community; and in the third, the vegetation community of a transition type was found where *Agropyron cristatum* and *Cleistogenes squarrosa* were predominant. Results of the research on soil properties showed that after exclusion, the weight of soil per unit volume decreased and the soil got loosened; and that with the duration of exclusion, pH and organic matters increased in the upper layer of soil, contributing to resistance of the soil to wind erosion.

Korean forest governance: an inter-Korean forestry cooperation approach. Park, M., Youn, Y. (*Seoul National University, Republic of Korea; mpark@snu.ac.kr; youn@snu.ac.kr*).

Projects for cooperation between South and North Korea are easily influenced by the change of political environment in Korean Peninsula. A turnover of political power in South Korea and announcements about nuclear weapons from North Korea made many of ongoing projects temporarily stop. In spite of the political obstacles, activities and projects towards forestry cooperation between South and North Korea have continued since 1999, carried out by a network of various actors. The central government of South Korea serves a systematic base for cooperation through facilitating agreements, and providing legal support and financial funds. Actually intergovernmental organizations (IGOs), non-governmental organizations (NGOs) and enterprises work as practical actors in the cooperation projects. Here a close network among the public and private sector allows South and North Korea to cooperate in forest restoration projects. This phenomenon is named as "Korean Forest Governance." It would have been impossible if only the central governments were left to develop such projects by themselves. A network of participation of IGOs, NGOs, and enterprises with governments' coordination could enhance the effectiveness of the cooperation projects for forest restoration in Korean peninsula.

Restoration of degraded gold mining site by recycling tailing waste in the establishment of fast-growing trees: a case study in PT. Aneka Tambang Pongkor, Bogor, Indonesia. Pasaribu, H. (*Ministry of Forestry, Indonesia; hadispsaribu@yahoo.com*), Siregar, C.A. (*FORDA, Indonesia; siregarca@yahoo.co.id*).

Restoration of degraded sites and mine tailings are two critical problems. Studies were designed to evaluate possibility of recycling high Pb tailings as a growth medium for rehabilitating degraded land in gold mining areas through incorporation of

high levels of organic fertilizer, to produce biomass. Field research has shown that organic fertilizer significantly affects growth of four-month, one-year, two-year and three-year-old *Eucalyptus pellita*. The best plant growth was observed in the tailing, dung and solum treatments (1:1:1 by volume). This same treatment slightly improved growth of *Gmelina arborea.* Further research tested *Michelia montana*, and results indicate that mixture of dung and tailings yield growth at 15 months. Based on local allometric equation $Y = 0.1728\ (DBH)^{2.2234}$, eucalypt grown with spacing of 2 m × 2 m is estimated to produce approximately 100 t biomass (183 ton CO_2 eq.) per hectare at age 5 years (diameter and tree height average are 12.2 cm and 14.8 m respectively); and this value may be used as an indicator for successful land rehabilitation of degraded mining sites of which about 1 million ha exist in state forest lands.

Forested farmlands: a real agroforestry symbiosis from shifting cultivation and its evolution towards stable continuous agroforestry in South and Southeast Asia. Rahman, S. (*University of Rajshahi, Bangladesh; sumonsociology@yahoo.com*), Fitriana, Y. (*University of Paul Valéry-Montpellier3, France; yulia.fitriana@etu.univ-montp3.fr*), Walz, K. (*Humboldt- University of Berlin, Germany; walzkah@gmx.net*).

Forests provide multiple benefits to people in a complex temporal scale, especially as a safety net to the poor and also help to increase overall ecological balance. This research was conducted in four areas of South and Southeast Asia: eastern Bangladesh, southern Myanmar, northwest Thailand, and West Java, Indonesia. Data collection methods included observation, FGD, interviews, and a structured survey of farm households. Data were analyzed through qualitative methods, largely following heuristics of causality, and through quantitative economic methods and models such as cost-benefit analysis. Forest culture on farmlands usually starts from the swidden. Seedlings of selected forest species are planted together with rice, and the young trees develop along with the fallow vegetation. Forest culture through swidden cultivation thus is profitable even on small plots. Swidden agriculture may disappear when the silvicultural system has sufficiently matured; in return, the substitution of a productive forest stand that allows a quick intensification of swidden agriculture without drastic changes in practices or dynamics. This intensification can be achieved through a smooth adaptation of practices, avoiding painful revolution of the whole farming system. This adaptation has obviously important social consequences, as it avoids the marginalization and impoverishment of a whole class of farmers.

Keep Asia Green: forest rehabilitation in Iran. Sagheb-Talebi, Kh. (*Research Institute of Forests and Rangelands, Iran; saghebtalebi@rifr-ac.ir*), Yousefi, P. (*Range and Watershed Organization, Iran; peiman_yosefi@yahoo.com*), Kananian, M. (*Azad University, Iran; mkanan.is@gmail.com*).

Iran is a mountainous Middle East country that is known as an arid and semi-arid country. The total natural forest area of Iran is 13.4 million ha, which covers 8% of the total land area. The total man made forest area is 950,000 ha. Anthropogenic pressure, population growth, traditional agriculture, natural disasters, forest management technical problems, and some development plans have led to forest degradation within centuries. The main national policy on forest rehabilitation is to stop degradation factors and to establish plantations—with native tree species within the forest areas, and with fast-growing native or exotic species in suitable non-forest areas. Plantation of multipurpose trees also has been taken into account in this policy. The research sector supports the rehabilitation activities, by carrying out basic and applied research projects for increasing wood production as well as for protection of ecosystems. The participatory approach plays a major role in this policy as well. Future programmes plan to develop participation of all stakeholders in forestry activities and to observe local rights of native people. Expansion of man-made forest area to 12 million ha and expansion of wood farming to 500,000 ha are the perspectives for the next 15 years.

Effects of exotic grass on natural regeneration in degraded dry forest of Sri Lanka. Suduhakuruge, B. (*Forest Department, Sri Lanka; bandumala03@yahoo.com*).

Natural regeneration of degraded forests in Sri Lanka is not well-understood. A possible explanation for the poor natural regeneration is invasion of these forests by exotic grasses. The objective of this work was to compare the effect of above- and below-ground completion of exotic grass on the growth, structure, and composition of naturally regenerated woody species in a degraded dry forest. In each study plot, all the woody species were subjected to one of the three silvicultural treatments: control, complete removal, and low slashing of grass. Firebreaks were established around the study plot to protect from annual fire hazards. All woody individuals >1 cm diameter were tagged and measured for DBH and height once a year. These results indicate that substantial changes in the composition and structure in aboveground vegetation have occurred across the silvicultural treatments. Above- and below-ground removal of grass had a significant effect on height and DBH growth of saplings and trees compared with the low slashing treatment. These results suggest that exotic grass may slow down the conversion of degraded forest back to its former state. Moreover, the results emphasize the importance of establishing firebreaks for promoting natural regeneration of degraded forests.

Effects of drought stress on hydraulic architecture characteristics of camphor seedlings. Xue, J., Wu, Y. (*Nanjing Forestry University, China; jhxue@njfu.com.cn; yongbowu74@yahoo.com.cn*), Wang, D. (*Henan Education College, China; dingwang@126.com*).

Hydraulic architecture characteristics of plants are usually expressed by such parameters as hydraulic conductivity(*Kh*), specific conductivity (*Ks*), leaf specific conductivity(*LSC*), and Huber value(*Hv*). In this article, hydraulic architecture characteristic parameters of camphor seedlings (*Cinnamomum camphora* (L.) Presl.), which is the important tree species in Karst afforestation, was measured and analyzed by a "flushing method" with four treatments (three intensities of soil drought stress treatments and a control treatment in greenhouse). Each treatment had 20 repeated samples. The result showed that Kh, Ks, LSC, and Hv were affected by the stem segment diameter under both non-stress and drought stress conditions. The relationship between the index and the diameter was positive correlation, and could be described in different functions. The hydraulic conductivity, specific conductivity, and leaf specific conductivity of camphor seedlings evidently decreased with increase of intensity of drought stress. However, change of Huber value was not significant under different drought stress conditions. These results indicate that the

transmittal efficiency of branches with wider diameter provided less pressure gradient than the thinner branches The results provide a theoretical basis for vegetation restoration and reconstruction in southwest karst rocky desertification of mountainous region.

Variation in growth response and adaptability of 3-year-old poplar clones at a reclaimed site. Yeo, J.K., Koo, Y.B., Kim, H. C., Woo K.S. (*Korea Forest Research Institute, Republic of Korea; jkyeo@forest.go.kr; ybkoo@forest.go.kr; simixwiz@ynu.ac.kr; woo9431@forest.go.kr*).

Tidal flats as much as 50,801 ha have been reclaimed for agricultural purposes from 1975 to 2004 in Korea. One-year-old rooted cuttings of 10 clones of poplar species, *Populus alba* × *P. glandulosa* (Clivus, 72–30, 72–31, Bongwha1), *P. deltoides* × *P. nigra* (Dorskamp), *P. deltoides* × *P. deltoids* (97–19), *P. euramericana* (Eco28, I-476), *P. nigra* × *P. maximowiczii* (62-2), and *P. koreana* × *P. nigra* var. *italic* (Suwon) were planted at a reclaimed tidal flat in Incheon. Survival rate, growth responses, and visible injuries by insects, diseases, and environmental stresses (e.g., lack of soil nutrients) were investigated for three growing seasons. Average survival rate of all 10 clones declined from 91.3% the first year to 88.3% the third year. At three years after planting, poplar clones Eco28, I-476 and Dorskamp showed the best survival rate, 100%. For height and DBH growth, the poplar clone Dorskamp was the highest, 5.9 m and 5.0 cm, respectively. No serious visible injuries were found in most clones. Clone 97-19 was the most tolerant to various injuries. Clone Dorskamp showed the best adaptability, which was evaluated with survival rate, growth, and various injuries at the coastal reclaimed land, followed by clones 62-2, 72-30, and Eco-28.

Research on effects of application of geocomposite drainage systems in afforestation on coastal saline-alkaline soil in China. Zhao, M., Ding G., Park, K., Liang, W., Wei, L., Guo, Y., Gao, G. (*Beijing Forestry University, China; bubulove99@hotmail.com; dch1999@263.net; bear1127@daum.net; liangwenjun123@163.com; wlw123456789000@163.com; gy861020@sohu.com; 051014109@163.com*).

To strengthen the capacity of forest land in drainage, reduce plant damage from salt, and promote plant growth on coastal saline-alkaline soils, geocomposite drainage systems were applied in *Melia azedarach* L. afforestation in Hebei Province of China. Soil moisture, salinity, and tree growth indices were fixed-position observed in 2009. Data of leaves' net photosynthetic rate, transpiration rate, intercellular and atmospheric CO_2 concentration, etc. were collected using the CIRAS-2 Photosynthesis measurement system. The results show survival rate of *Melia azedarach* L. was increased by 12%. Soil moisture of systems at 24 h after the rain was the same as that of the control at 48 h. Underground water table was 0.33 m lower at 120 h after the rain. Average soil desalination and water moisture rate were 1.44 times and 1.23 times than that of the control. Stomatal aperture and plant transpiration rate of *Melia azedarach* L. were increased, and the use efficiency of soil water, light, and $C0_2$ were increased as well. The research indicates that geocomposite drainage systems significantly accelerated the drainage. Tree growth was promoted by reduction of soil salinity. Physiological response photosynthetic capacity of *Melia azedarach* L. has been strengthened by application of the systems.

D-04 Advances in plantation forest management in Asia

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Response of China's timber industry and trade to globalization. Duan, Y., Liu J. (*Renmin University of China, China; yanfei.Duan@163.com; liujinlong@ruc.edu.cn*).

A new wave of globalization processes has greatly affected China's economy and society in the past 20 years. China's timber industry and trade have been booming since China's joining WTO in 2001, although threatened by global financial crisis in 2008. Regression models developed using national data illustrate that growth of production and trade has slowed since 2004, affected by increasing labor and timber costs, and environmental protection requirements. The case of Jiangsu province shows responses to this slowdown process, which include industrial upgrading, technical innovation, and securing of timber resources through investment in plantations. In response to the global economical downturn, China's domestic economic stimulus measures along with investments by central and local governments in forest plantations and rehabilitation will help to rebuild the natural forest assets and potential resources for the forest industry sector. However, for the sake of preserving jobs, local governments have loosened environmental requirements and the motivation of industry sector to upgrade technology has declined. The regression models also show that global economic downturns can be considered to provide a "snap period" for the slowdown process, although industrial upgrading and innovation and environmental protection measures were neglected.

ValWood: concepts for a combined production of valuable broadleaved trees for wood processing industry and fast-growing tree species for energy. Engler, B., Becker, G., Spiecker, H., Storch, J., Dörr, A., Schütt, C., Makeschin, F., Wolff, M. (*University of Freiburg, Germany; benjamin.engler@fobawi.uni-freiburg.de; fobawi@fobawi.uni-freiburg.de; instww@uni-freiburg.de; johanna.storch@iww.uni-freiburg.de; andreas.doerr@iww.uni-freiburg.de; christian.schuett@iww.uni-freiburg.de; makesch@forst.tu-dresden.de; wolff@forst.tu-dresden.de*).

China's demand for high-quality wood (e.g., for furniture) and wood with less specific quality characteristics for energetic utilization is increasing. Despite China's remarkable reforestation and plans to convert mono-cultural forests into mixed forest stands, these actions are insufficient to meet future wood demands. Reasons can be seen in less silvicultural management during recent decades and less education of forest workers as well as less technical equipment. To overcome this situation a concept of planting valuable trees in lines with distances of 10 to 20 m and rotation times of 50–60 years, together with fast-growing trees in rotation times of less than 8 years in between, is going to be analyzed (ValWood) in Guangxi province, China. Within this concept approved planting and logging techniques (e.g., motor-manual clear cuts) can be combined with new techniques of

silvicultural treatment (e.g., pruning), to produce different assortments of round wood, while a permanent forest stock will provide positive ecological effects. Based on annual growth data, crown widths, and time working studies, different planting patterns (distances, rotation time) will be analyzed, to optimize (1) the annual growth and (2) the net revenue.

Land use management: mapping suitable areas for rubber tree plant, Laos PDR. Kokmila, K. (*Korea University, Laos; khitlaxay@hotmail.com*), Lee, W.K. (*Korea University, Republic of Korea; leewk@korea.ac.kr*).

The Lao government has a policy to promote Laos to become a leader of rubber exporters in the world market by the year 2020. However, previous implementation showed serious problems such as land allocated for investors to lease overlapped the farming land of local people, creating conflict between local people and investors, as well as between local people and local government authorities. In addition, the concession of areas without a previous forestry survey has led to a massive deforestation, which has created a bad impact on the environment. These problems demonstrated that local government lacks the capacity for good land use planning management. The aim of this study is to identify appropriate areas for rubber tree plantations and create land use function maps that can be used for sustainable land use management in local areas. This study used geographic information system (GIS) techniques, with overlay tools and weight overlay to produce suitable maps based on the geography data. The site of the study is in Pakxong District, southern part of Laos. The final result will be the automatic production of maps of land use functions and suitable area boundaries of rubber tree cultivation in the study area.

Environmental costs and environmental management strategies for industrial plantations in China. Li, Z. (*Chinese Academy of Forestry, China; lzy263@263.net.cn*).

The total plantation area in the world takes up 7% of the total forest area, but provides over 50% of industrial timber for the globe. In China, the accelerating industrialization poses great demand for timber, but the supply-demand gap is becoming larger. In such sense, developing industrial plantations is a critical approach to effectively mitigating the conflicts between supply and demand for timber, which is also a strategic measure for the effective protection of natural forests. However, the long-term adoption of a traditional management model for industrial plantations leads to the ignorance of the eco-environment management during plantation development. The paper analyzes different types of environmental costs in industrial plantation management—such as implicit cost, explicit cost, spillover cost, and control cost—on the basis of the necessity of eco-environment management for industrial plantations. It also discusses and proposes eco-environmental management strategies for industrial plantations, including: eco-environmental management planning and design, vegetation management, soil and water conservation, land productivity maintenance, biodiversity conservation, application of chemical and biological agents, forest fire prevention, monitoring and evaluation of detrimental bio-organisms, etc., with the aim to promote the sustainable management of industrial plantations in China.

The study of the optimum density of *Larix principis* plantations. Liang, W., Ding, G., Zhao, M. (*Beijing Forestry University, China; liangwenjun123@163.com; dch1999@263.net; bubulove99@hotmail.com*).

Based on a survey of different densities of *Larix principis* plantations, the thesis adopts the Hegyi model, which uses a single wood competition index model to calculate the competition index and applies a logistic equation to fit the relationship between age and breast-height diameter, in order to calculate the theoretical diameter at chest height of *L. principis*. After the crown width competition index normalized, the relative crown width competition index was obtained. Then we fit the crown width, diameter at chest height, and relative crown width competition index, and substituted the diameter at chest height and crown width competition index back to calculate crown width, checking measured values with predictive values using variance analysis and correlation test. Results suggests that when the competition indices were 0.8, 0.6, 0.4, and 0.2, the model can predict number of trees per hectare and forest management density under different competition indices, by calculating the area of the circle of controlled area of crown under different competition indices. Comparing the measured values and the predicted values, the model can determine whether the density of *L. principis* plantations management is the most reasonable.

Innovative practices for growing an *Acacia*-based plantation resource in Vietnam. Vu Dinh, H., Le Thanh, Q., Nguyen Thanh, B., Pham The, D., Dang Thinh, T. (*Forest Science Sub-Institute of Vietnam, Vietnam; vudinhhuong@yahoo.com; quangfssiv@yahoo.com; nguyenthanhbinh_pvkhln@yahoo.com; thedungvln@yahoo.com.vn; thinhtrieu@hotmail.com*), Nambiar, E.K.S (*CSIRO, Australia;*), Hardwood, C.E., Beadle, C. L. (*CSIRO, Australia; sadu.nambiar@csiro.au; chris.beadle@csiro*).

Acacia plantations will comprise over one third of Vietnam's target of 2 million ha of plantation forest for pulpwood and sawlog production, much of which is being established on degraded soils. Between 2002 and 2012 four projects, three international and one national, are contributing to an examination of key elements of the silvicultural cycle that can lead to sustainable wood and fibre yields, and maintenance of the productive capacity of soils. The main focus has been residue, vegetation, and nutrient management. In 6-year-old second-rotation plantations at harvest, retention of slash residues, strip weed control, and addition of fertiliser increased volume growth by 6–13%, 53%, and up to 21%, respectively. Overall productivity was higher than in the first rotation. Slash retention led to a significant increase in soil organic carbon and total nitrogen compared to no slash and litter retention. More recent research evaluates the benefits of pruning and thinning for the production of high quality sawlogs; significant responses in diameter growth were detected within 12 months of thinning. The potential for wider application of these practices and realisation of their benefits is considered.

Investigation of patch thinning effect on stand structure of a sugi plantation in Zenlen Area, Taiwan. Wang, D.H., Hsieh, H.C., Chung, C.H., Hwong, J.L. (*Taiwan Forestry Research Institute, China-Taipei; dhwang@tfri.gov.tw; micky@tfri.gov.tw; cchsin@tfri.gov.tw; jlhwong@tfri.gov.tw*).

This study was to investigate the effect of thinning on stand structure of a sugi plantation (*Cryptomeria japonica*) in Zenlen Area, Taiwan. In the sugi plantations, 12 plots with the size of 1 ha for each were set to survey the timber inventory. Among them, a randomized block design was adopted for three treatments, with four replications for each treatment in 1 ha. A gap thinning rule was used to remove trees with three levels of thinning intensity in terms of removing 0%, 25%, and 50% of area in a plot. In

each plot, all woody plants are tallied and tagged, species identified, position oriented, and DBH measured. Stand spatial structural index including horizontal and vertical aspect were computed to show the effect of thinning on stand structure. Structure complexity index (SCI) in spatial structure based on the entire 1 ha showed no great difference among plots before thinning; however, SCI dropped after gap thinning, especially for the thinning with 50% in intensity. Moreover, the division of 1 ha size into smaller area (10 x10 m) in calculating SCI increased average SCI for all plots, and the same tendency of thinning effect on SCI among plots was observed as well.

Posters

Nutrient productivity of *Acacia auriculiformis* and *A. mangium* in Mt. Makiling and *Pterocarpus indicus* in La Mesa Watershed, Philippines. Combalicer, M.S. (*Nueva Vizcaya State University, Philippines; marilyn_sabalvaro@yahoo.com*), Lee, D.K. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr*), Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Lee, K.W. (*Seoul National University, Republic of Korea; b20927@nate.com*).

The nutrient productivity of *Acacia auriculiformis* and *A. mangium* in Mt. Makiling and *Pterocarpus indicus* in La Mesa Watershed, Philippines, was measured to determine the trend in their different age classes. Three sampling plots (20 m × 20 m) in each plantation were established to measure the DBH and height of the sampled trees. Litterfall was collected monthly for one year to determine the above-ground net primary productivity. Leaf area index was obtained and leaf samples in the lower, middle, and upper canopy were analyzed for its nutrient content. Soil samples were also collected and analyzed in the laboratory. Results show that the amount of litter was highest (4.72 tons/ha) in the 10-year-old *A. auriculiformis* and lowest (1.39 tons/ha) in the 20-year-old *P. indicus*, whereas understorey biomass was highest (3.02 tons/ha) in the 10-year-old *P. indicus* and lowest (0.81 tons/ha) in the 20-year-old *A. auriculiformis*. Specific leaf area was highest (75.9 cm^2/g) in the middle canopy of the 20-year-old *P. indicus* and lowest (34.2 cm^2/g) in the upper canopy of the 20-year old *A. mangium*. This is attributed to the leaves exposed to shade that grow larger and heavier due to fewer layers of palisade cells.

***Ficus variegata:* a promising fast-growing timber species from tropical rain forests of Indonesia.** Effendi, R., Mindawati, N. (*Center for Plantation Forest Research and Development, Indonesia; riskan51@yahoo.co.id; safari_silvik@yahoo.co.id; ninapulp@yahoo.co.id*).

At present the existing natural forest in Indonesia could not fulfill raw material for wood industries; therefore, the government has been facilitating large-scale plantation forest establishment since 2005. Plantation forests will be the main source of wood industries in the future. This paper aims to give information on future forest tree species. *Ficus variegata* (Moraceae) is a promising timber tree species suitable for commercial plantation forest. It was found after the 1997/1998 forest fire in East Kalimantan. It grows naturally with *Anthocephalus cadamba*, *Octomeles sumatrana*, and *Macaranga* spp. Several advantages include fast growth, it grows on marginal and fertile soils, it is easy to produce seedlings generatively or vegetatively, and the wood can be made plywood. In Kalimantan this species flowers and fruits twice a year, about 3,000,000 seeds in one kg; seeds are semi-recalcitrant. Fresh seed germination is 80%-85% and decreases after 6 months. Seedlings raised in nursery for 3–3.5 months reach 30–35 cm high and are ready to be planted to the field. Survival using the stem cutting technique is 65–70%; after 3.5–4 months seedlings reach about 30 cm and are ready to be planted. About 500 ha have been planted with *F.variegata* in East Kalimantan.

Formation of epicormic shoots and their effects on the growth of teak (*Tectona grandis*) in Java, Indonesia. Faridah, E. (*University of Gadjah Mada, Indonesia; enyfaridah@ugm.ac.id & Tuharno*), Tuharno (*Perum Perhutani, Indonesia; tuharno@yahoo.com*), Indrioko, S. (*University of Gadjah Mada, Indonesia; sindrioko@ugm.ac.id*).

Epicormic shoots often found on teak plantations in Java, Indonesia, have negative effects on the growth those related plants. Shoot formation is influenced by environmental changes such as drought, but genetic factors also play a role. The study aims to identify family variation in the tendency to form epicormic shoot and to examine its effect on seedling growth of teak. The study was conducted on a 6-month teak plantation of 5 ha in total in KPH Kendal, Central Java, Indonesia. Plant materials used were teak plantation. The research was done in completely randomized design using 28 seedlots (clone number 1 to 28), 3 treeplots, and 3 blocks as replication; and 2 silvicultural treatments, that is, with epicormic shoots and without epicormic shoots (shoots being cut). Results showed that some seedlots showed high tendency to form epicormic shoots (83%), while some others showed the lowest (30%). The existence of epicormic shoots negatively affected plant growth; in 2 months, height and stem diameter growth of plants without epicormic shoots were 81.0 cm and 1.29 cm respectively, while those with epicormic shoots were only 69.1 cm and 1.10 cm respectively. Those with low tendency to form epicormic shoots in general showed better growth.

Effects of SCB liquid fertilizer on vitality, growth, and biomass production of fast-growing species: first-year results from an annual production plot. Kim, H.C., Yeo, J.K., Shin, H.N., Koo, Y. B. (*Korea Forest Research Institute, Republic of Korea; simixiz@hanmail.net; jkyeo@forest.go.kr; hannashin@forest.go.kr;ybkoo@forest.go.kr*).

Fifteen clones of poplars, 2 clones of willows, and *Liriodendron tulipifera* were used to evaluate the effects of five treatments such as SCB (slurry composting and biofiltration liquid fertilizer), general liquid fertilizer, chemical fertilizer, ground water, and control (no treatment) on vitality, growth performance, and biomass production. Five cuttings per clone and species were planted in each of three replications. After planting cuttings, a coppice was induced by cutting off stems at 10 cm above the ground. Data were collected during the first growing season and trees were harvested at the end of October. Groundwater-treated cuttings showed the most superior vitality, 95.9%, and control showed the lowest vitality, 92.8%. Trees treated with chemical fertilizer showed the greatest diameter growth (19.6 mm), which was calculated by adding all diameters of stump sprouts, and those treated with SCB and control showed poor diameter growth, 15.9 mm and 16.3 mm, respectively. Biomass production was the greatest in the treatment with chemical fertilizer, 2.0 tons per ha per year, and control was the poorest, 1.4 tons. The results of this study indicate that SCB and general liquid fertilizer developed from livestock wastewater could be used for the short-rotation intensive culture as a fertilizer.

Seasonal variation of sapflow in two poplar species irrigated with swine wastewater. Lee, E.D., Yeo, J.K., Koo, Y.B. (*Korea Forest Research Institute, Republic of Korea; iamddeum@gmail.com; jkyeo@forest.go.kr; ybkoo@forest.go.kr*),Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*).

Swine wastewater is a growing problem around the world because of livestock famers and the trend of modern farming operations to concentrate livestock in small areas. Swine wastewater contains high concentrations of nutrients such as nitrogen and phosphate. This study was used for phytoremediation to remove the swine wastewater. We examined sapflow of a hybrid and a *Populus* species such as *P. alba* × *P. glandulosa* and *P. euramericana*, grown under swine wastewater treatment. Sapflow of *P. euramericana* was 1.8 times higher than that of *P. alba* × *P. glandulosa* for 14 months. Sapflow of *P. euramericana* and *P. alba* × *P. glandulosa* was 4,628 L and 2,538 L during this period, respectively. A positive relationship between sapflow density and solar radiation and temperature had been shown. Mean temperature, relative humidity, and sapflow were strongly associated with each other. However, some data showed a weak relationship between sapflow and precipitation. During the period of less precipitation, sapflow of *P. alba* × *P. glandulosa* had no relationship. There was a decreasing sapflow tendency of the two poplar species during the late October when the mean temperature was decreased. In addition, the data showed high relationship between sapflow and photosynthesis.

Examination of snow damage to planted forests in Japan. Noguchi, T., Kobayashi, M., Tanaka, K. (*Kyoto Prefectural University, Japan; schneeschaden@gmail.com; masakun@kpu.ac.jp; tanakazu@ac.jp*).

Plantations of Japanese cedar and Japanese cypress were promoted aggressively after World War II in Japan. However, many plantations have since been abandoned because of a long-term decline in timber prices, caused by high-volume imports of foreign lumber. Trees in abandoned plantations are spindly with non-uniform width of annual rings, causing weakness in tree trunks. This weakness increases the risk of weather-related damage such as wind and snow damage. Moreover, this weather-related damage has been increasing in line with global climate change in recent years. In fact, serious snow damage occurred in the central part of Kyoto Prefecture in January 2009. The results of topographical analysis by GIS showed that both the snow damage during calm conditions in 2009 and the wind damage caused by Typhoon 23 in 2004 occurred mainly on north-facing slopes. Annual ring analysis showed that the outer rings of snow-damaged trees were extraordinarily narrow. These results suggest that some trees surviving the wind damage caused by Typhoon 23 had cracked along their annual rings (ring shake), and trees weakened in this way then suffered snow damage due to the accretion of heavy snow on their crowns.

Foliar macro-nutrient element comparisons of six eucalypt species in a 24-year-old plantation. Sardabi, H., Assareh, M. H. (*Research Institute of Forests and Rangelands, Iran; sardabi@rifr-ac.ir; assareh@rifr-ac.ir*).

A eucalypt species trial consisting of six species (*Eucalyptus camaldulensis, E. macarthurii, E. maidenii, E. rubida, E. saligna, and E. viminalis*)—which were planted in 1983 under experimental design of randomized complete blocks with four replications at 2- × 2-m spacing and total number of 100 seedlings at each plot—was used for this research. At each plot, three trees were selected randomly, and leaf sampling was made from each tree at 1/3 end of crown height at end of summer. The aim of the study was to investigate the status of N, P, and K nutrient elements in leaves of the six eucalypt species planted on a heavy and slightly acidic forest soil with pseudoglay type at Gilan province of Iran. The results of leaf analysis showed that there was significant difference between the eucalypt species in respect to amount of only N element. The lowest amount of N was found in *E. maidenii*, with no significant differences among the other species. There was significant correlation between K% of eucalypt leaves and three soil characteristics, including P%, K%, and C/N ratio on the one hand and between P% of eucalypt leaves and P% of soil on the other hand.

Promoting forest land rehabilitation through small -scale forest management for timber and NTFPs: a case study in Garut, West Java. Suharti, S. (*Forest and Nature Conservation Research and Development Centre, Indonesia; suharti23@yahoo.co.id*).

More than 60% of the Javanese population with relatively small land holdings (0.3 ha/household)depends on the agricultural sector. They live in densely populated villages surrounded by forest; as a result, pressure on the forest becomes intense. Consequently, incidents of social conflict become frequent and forest conditions have deteriorated. One alternative solution to accommodate rehabilitation of forest function and fulfilling local community needs is cultivation of forest tree stands together with non-timber forest plants simultaneously. The research objective is to study cultivation of *Eucalyptus urophylla* together with *Andropogon zizanoides* (vetiver oil plants) in a small scale private forest in Tanjung Karya Village, Garut, West Java. The participatory approach was used to develop the model; hence, involved farmers could participate actively in all stages of model establishment. Although a light-demanding species, vetiver oil plants could grow well under *E. urophylla* stands until it has been harvested (13 months old). Some farmers sell vetiver raw material product, others process it first to get distillated oil. By integrating tree stands and non-timber forest plants, farmers could improve not only soil conditions but also their incomes significantly.

Modelling forest growth and yield: examples from the Thar desert in Rajasthan, India. Tewari, V. P. (*Institute of Wood Science and Technology, India; vptewari@icfre.org*).

Technologically advanced growth and yield prediction tools can help foresters make more informed management decisions. Efficiency of the forest production system is to be augmented by optimal management decisions, which need quality information on basic parameters of forests. The availability of such information is scanty in India. Therefore, volume functions, site index equations, potential stand density, generalized height-diameter, stem number, and basal area development models in pure even-aged stands of *D. sissoo*, *T. undulata*, and *E. camaldulensis* planted in IGNP area of Rajasthan have been developed. Various volume equations were tried to arrive at the best equation for predicting volume yield in the stands. Some base-age variants and invariant site-index were used and compared for their relative accuracy to assess the productive capacity of the sites. Two different models were compared to describe the natural decrease of stem number. The model including site index as one of the variables performed slightly better than the model without site index. Path invariant algebraic difference form of stand level

models also were compared for basal area prediction. These are crucial for evaluating different silvicultural treatment options. The models were evaluated using different quantitative criteria and were also validated on an independent data set.

Eucalyptus plantation in China: a new industry is arising. Xie, Y. (*China Eucalypt Research Center, China; xieyj@21cn.com*).

Eucalyptus was first introduced to China in 1890, originally planted as an ornamental tree in parks. Today there are 2.8 million hectares of eucalyptus plantation in China, distributed mainly in Guangdong, Guangxi, Hainan, Yunnan, and Fujian provinces. The development of eucalyptus plantations is expanding and will continue to do so in the future. About 300 species of eucalyptus have been introduced and tested in China. Of these, 200 species have survived. However, only about 10 species and their hybrids are commonly used in plantations, including: *Eucalyptus urophylla, E. grandis, E. tereticornis, E. camaldulensis, E. saligna, E. dunnii, E. globulus, E. maideni*, *E. smithii, E. pellita, E. torelliana*, and *E. cloeziana*. Research of eucalyptus began at 1970s with the earliest studies focusing on eucalyptus cultivation. The first co-operative research group, organized in 1973, grew into a national eucalypt society in 1990 with more than 500 hundred members in China today. The main research institutes on eucalyptus include: China Eucalypt Research Center, the Research Institute of Tropical Forest, Guangxi Research Institute of Forest, and Leizhou Forestry Bureau Institute.

D-05 Managing Asian bamboo forest in a changing world

Organizers: Yueqin Shen, *Zhejiang Forestry University, China; shenyueqin-zj@163.com*; Yaoqi Zhang, *Auburn University, USA, Yaoqi.zhang@auburn.edu;* Shashi Kant, *University of Toronto, Canada, shashi.kant@utoronto.ca.*

Soil and water conservation in moso bamboo forest in the low hills of the Chaohu Lake area in China. Gao, J., Pen, Z. (*International Center for Bamboo and Rattan, China; gaojian@icbr.ac.cn*).

Chaohu lake is one of five famous freshwater lakes in China. However, pollution and soil and water erosion are both serious. Surface runoff, soil fertility, water storage capacity, and organic-matter of soil were investigated. The results showed that surface runoff in moso bamboo forest was 52.6% and 30.5% less than that in masson pine forest and Chinese fir forest respectively. Soil fertility and water storage capacity of earth in moso bamboo forest were 5.62 t/hm^2 and 3.25 t/hm^2 more than that in masson pine forest and Chinese fir forest respectively; and 6.21 t/hm^2 less than that in moso bamboo and deciduous broad-leaved forest. The mixed forest of broadleaved trees with moso bamboo could increase the organic-matter of soil and improve the effective P of soil as well. It is suggested that mixed forest with moso bamboo is more suitable for soil and water conservation.

Biomass carbon in a sympodial bamboo plantation in south China. Gu, X., Zhou, B., Yuan, J., Wang, X., Li, Z., Cao, Y. (*Research Institute of Subtropical Forestry, China; guxpzj@163.com; boozex@gmail.com; yuan_jinling@eyou.com; rsfyrs@126.com; lizccaf@126.com; fjcyh77@sina.com*), Wen, C. (*Pingyang Forestry Bureau, China; pywch@126.com*), Kong, W., Wang, G. (*Research Institute of Subtropical Forestry, China; yilucanlan@yahoo.com.cn; realinter0000@126.com*), Lu, X. (*Pingyang Forestry Bureau, China; luxiaoqin@126.com*).

Bamboo plantation is one of the fastest developing forest resources in Asia, Latin America, and Africa countries. It functions as a rapid-growing carbon sink due to its fast biomass accumulation. The biomass and carbon storage in *Dendrocalamopsis vario-striata* stands were quantified in Zhejiang of China. Eighteen 400-m^2 plots were randomly established with stand density ranging from 6,925 culm/ha to 12,375 culm/ha; a total of 67 culms were sampled for biomass modeling. Regression analysis indicated that the above-ground and below-ground biomass of bamboo culms with different age increased with increasing diameter of culm at breast height in accordance with a power model. Based on these models, the total biomass of the stand was estimated to be 66.1 (±3.23) t/ha, with the majority (74.5%) lying in above-ground, 17.7% in below-ground, and 7.8% in the dead litter. Accordingly, there was 29.7 (±1.45) Mg C sequestrated in one hectare of the stand. Biomass carbon pool dramatically increased with increasing stand density until it reached about 10,000 culm/ha, beyond which, the biomass carbon would not increase anymore even tend to decrease. The sympodial bamboo *D. vario-striata* could be a good choice for plantation development targeting at carbon sequestration.

A comparison of throughfall and stemflow chemistry in plantations of bamboo and Japanese cedar. Sakai, M, Yokoo, K., Imaya, A., Shigenaga, H. (*Forestry and Forest Products Research Institute, Japan; kmsakai@affrc.go.jp; yokoo-k@pref.kumamoto.lg.jp; imaya@ffpri.affrc.go.jp; shige1@ffpri.affrc.go.jp*).

We conducted a tree census, soil survey, and chemical analyses of throughfall/stemflow in order to assess the effects of bamboo on plantation soils in the southern region of Japan. Precipitation, throughfall, and stemflow were collected in three adjacent forests: madake bamboo (*Phyllostachys bambusoides* Sieb), mosochiku bamboo (*P. pubescens* Mazel), and Japanese cedar (*Cryptomeria japonica*). The volume-weighted mean pH of precipitation was 4.7 and acid rain fell over the forest. Throughfall pH values for madake bamboo, mosochiku bamboo, and Japanese cedar were 5.3, 5.2, and 5.3, respectively. Throughfall pH values for the three forests were higher than precipitation pH. This suggests that pH buffering mechanisms occur in the forest canopy, probably due to neutralization of cations derived from dry basic deposits and basic leachates derived from plant materials. Stemflow pH values for madake bamboo, mosochiku bamboo, and Japanese cedar were 5.0, 4.9, and 4.1, respectively; that is, the stemflow pH values for the bamboo forests were higher than that for the Japanese cedar. In the Japanese cedar, excess SO_4^{2-} derived from air may mainly causes soil acidification. Soil under bamboo faces a small risk of soil acidification.

Bamboo sector reforms and local rural development in Zhejiang Province, China. Shen, Y., Wang, X., Zhu, Z., Zhang, X. (*Zhejiang Forestry University, China; shenyueqin-zj@163.com*).

Bamboo management and the bamboo industry play an important role in rural development. Zhejiang is rich in bamboo resources, with 8 million hm^2, creating and supporting 25 billion RMB Yuan of output value of bamboo industry in 2008. This

study reviews development progress of thebamboo industry in Zhejiang from perspectives of bamboo resources management, processing, and marketing. The contributions of the bamboo industry to the local social economy and environment, and the main driving factors are investigated. Three factors are identified to be critical to the development: (1) forestland tenure reforms, (2) technological advancement, and (3) supplementary policies. The paper in particular investigates the economic performance using payback period, internal rate of return, and net present value of bamboo management, based on a 180-household survey in three counties (Anji, Suichang, and Shaoxing) in Zhejiang. Furthermore, this study analyzes the contributions of the bamboo industry to the local economy using comparative analysis in different periods. The social effect is analyzed by the diversity of household total income and the income from bamboo forest management with Gini coefficient.

Multiplication of mature and juvenile bamboos: intricacies of micropropagation. Yasodha, R. (*Institute of Forest Genetics and Tree Breeding, India; yasodha@icfre.org*).

Planting material demand is growing enormously due to the promotion of bamboo by various national and international agencies around the world. Although fecundity is high in bamboos, its serendipitous nature of flowering limits continuous availability of planting stock. Micropropagation has been identified as suitable alternative for rapid and large-scale plant production. Micropropagation of mature bamboos is associated with difficulties in rooting and transplantation success, crucial steps for large-scale production, which aims at 80–90% transplantation success to achieve price and quality objectives. However, multiplication of non seeding bamboo is restricted to vegetative methods. Juvenile bamboo has the advantage of long gestation period but is untested for productivity. This paper describes various rooting methods and problems associated with mature bamboo multiplication *in-vitro* with special reference to rooting in *Bambusa nutans* and *Dendroclamus giganteus* and suitability of juvenile tissue multiplication in *B. arundinacea* and *D. stictus*. The successful use of carbohydrates and supply of auxin in two steps, high pulse treatment, and extended minimum dosage to improve rooting success is discussed. Additionally, the role of specific carbohydrate sources as regulatory factors in bamboos during various phases of micropropagation will be described, as well as interactions between these carbohydrates and indole-3- butyric acid.

Measurement and evaluation of carbon storage in a bamboo (*Phyllostachys pubescens*) system. Zhou, G., Jiang, P., Wu, J., Liu, E. (*Zhejiang Forestry University, China; zhougm@zjfc.edu.cn; jiangpeikun@zjfc.edu.cn; jswu@zjfc.edu.cn; liuenbin2001@yahoo.com.cn*).

Bamboo (*Phyllostachys pubescens)* is an important non-timber forest product (NTFP) in the forest ecological system of subtropical China, with a high capability of fixing carbon. Measurement of carbon accumulation of yang bamboo was conducted by cutting 10 individual bamboos with different ground diameters at 3-day intervals, totaling 10 sampling dates. Carbon accumulation curves of bamboo with different ground diameters exhibited a "slow-rapid-slow" pattern, and carbon in young bamboos depended mainly on ground diameter and length of time after the shoots sprouted. A model that accurately simulated dynamic changes in carbon storage of young shoots (P = 0.9692, E = 0.0818), and predicted C storage without cutting the bamboo was developed. Carbon storage in different organs of bamboo was: trunks (50.97%) > roots (19.79%) > leaves (4.87%). Total C storage in bamboo ecosystems was 106,362 t ha^{-1}, including 34,231 t ha^{-1} (accounting for 32.18%) in above-ground green vegetation, and 72,131 t ha^{-1} (accounting for 67.82%) in litter and soil organic matter (0–60 cm layer). A modified method to evaluate carbon storage in bamboo systems was developed. It was estimated in the province that the total biomass of bamboo was 15.2 million t. and total C storage in bamboo forests was 7.7 million t.

Posters

The challenges of shifting eco-trends for sustainable bamboo management: pursuing a certified or REDD future? Buckingham, K. (*Oxford University Centre for the Environment, UK; kathleen.buckingham@ouce.ox.ac.uk, kathleenbuckingham@gmail.com*).

The focus of forest governance is driven by trends within policy, supported by donor funding. There has been a recent shift away from a focus on biodiversity conservation and certification towards climate change and REDD (reducing emissions from deforestation and degradation). This paper aims to identify the challenges that arise from shifting eco-trends that co-evolve with concepts of sustainability through social science research conducted in bamboo forests in India and China. By focusing on forest certification and the new agenda of REDD+, the article considers to what extent shifting agendas re-alert us to similar problems under a different guise. Bamboo is a unique plant that falls under the governance of non-timber forest products (NTFP), borrowing heavily from the forestry sector. India's National Bamboo Mission is rebranding bamboo, attempting to move away from the constraints of the forestry sector; however, the bamboo industry is eager to remain up-to-date with current environmental trends and requirements, competing directly within timber markets. It is important to consider the implications of shifting timber market mechanisms for bamboo small holders and the implications for concepts of sustainability.

Suitability of bamboo as a renewable energy resource and effects of bamboo forests on sequestrated carbon in soils. Engler, B., Dietenberger, R. (*University of Freiburg, Germany; benjamin.engler@fobawi.uni-freiburg.de; ralphdietenberger@hotmail.com*), Schönherr, S. (*University of Applied Science Eberswalde, Germany; sschoenherr@fh-eberswalde.de*).

As bamboo is one of the fastest-growing plant species, it is used for several products of a material use, but it is widely not used for energy recovery. To learn about the suitability and potential of bamboo as a renewable energy resource, several bamboo stands in Zhejiang and Guangxi provinces, China, have been researched. Bamboo samples from *Phyllostachys pubescence* and *Bambusa emeiensis* of different culm ages were taken and analyzed for (1) calorific value, (2) ash content, (3) lignin content, (4) chloride content, and (5) moisture content. First results show an increase of the calorific values up to the age of 3–4 years, while it decreases again later on. Mean calorific values are comparable to results known from European tree species. To gain insights on carbon sequestration in bamboo forests, organic carbon was measured in biomass above ground and in soils (SOC). The SOC was analyzed for bamboo forests of variable ages, compared to agricultural land. Results show effects on sequestrated carbon by land use and land use changes through establishing bamboo forests for energy recovery.

Research of the influence of balanced fertilization on bamboo's quality. Guo, X., Niu, D., Lu S. (Jiangxi *Agricultural University, China; gxmjxau@gmail.com; gxmjxau@163.com*).

The study aimed to research the influence of balanced fertilization on bamboo quality. Fengxin, Jing'an, Chibi, the main bamboo producing areas in China, were selected as representing the main production types and site conditions in the south. We tested bamboo nutrients using various methods. Fertilization and reclamation measures improved the average diameter at breast height; shoot nutritional content improved in protein, sugar, fat, VC, fiber, and other indicators, more than the non-fertilization treatment. We also tested wood properties of Moso bamboo after 4 years of continuous fertilization with different N, P, and K in Hubei, Chibi. Generally speaking, with the fertilizer, fiber bending strength was slightly lower than the control; radial bending strength (along the grain), compressive strength, and tensile strength were slightly higher than the control. Results suggest that fertilizer inputs to improve bamboo quality is very important. Fertilization improves shoot content of protein, sugar, fat, VC, fiber, and other nutrients. Bamboo shoots fertilized with N, P, and K play an important role during bamboo shoot development, and fertilization influences bamboo culms. Accordingly, Moso bamboo can be used for different purposes, and different levels of fertilizer can be chosen to maximize economic efficiency.

Harvesting and utilization of bamboo sap in Korea. Kwon, S.D., Park, S.B. (*Korea Forest Research Institute*, *Republic of Korea; kwonsd@forest.go.kr, parksb@forest.go.kr*), Moon, H.S. (*Gyeongsang National University, Republic of Korea; hamon@gnu.kr*).

South Korea's bamboo forest (7,039 ha) are mostly scattered in the southern region. Jeollanam-do Province, located in the southwestern part of the Korean Peninsula, has 3,913ha (56%) of bamboo forest area. Gyeongsangnam-do Province, in the southeastern end of the peninsula, has 1,996 ha (28%) of bamboo forest area. Henon bamboo, giant timber bamboo, and moso bamboo are three main bamboo species in Korea. These bamboos are mostly using for bamboo wares and bamboo charcoal. Some species of bamboo in Korea traditionally have been used as food and medicinal purposes. Among all parts of bamboo, bamboo leaf and shoot are listed in the Korea Food Additives Code of Korea Food and Drug Administration (KFDA) as a food ingredient. To develop special usage of bamboo sap, we investigated a tapping method of sap from hollow stems of bamboo, from different species or ages of bamboos, at different picking times and parts. Amount of sap tapped was checked. Contents of ingredients such as minerals, free sugars, and amino acids were analyzed to find possible use for drinking purposes. From the results of this research, we found that the bamboo is expected to be a good raw material for food and drink.

Preparation of non-wood fibers from Korean bamboo species for the utilization of bamboo in value-added industry. Park, M.S., Jeon, K.S. (*Korea Forest Research Institute, Republic of Korea; fmpms@forest.go.kr; jeonks@forest.go.kr*), Kang, K.Y. (*Dongguk University-Seoul, Republic of Korea; kykang@dongguk.edu*), Yoon, S.L. (*Jinju National University, Republic of Korea; slyoon@jinju.ac.kr*), Park, N.C. (*Korea Forest Research Institute, Republic of Korea; pnch@forest.go.kr*).

Bamboo is the fastest-growing plant on Earth, and its astounding growth rate is highly dependent on local soil and climate conditions. Bamboos are of notable economic and cultural significance in East Asia and Southeast Asia, where they are used extensively as building materials, a food source, and a highly versatile raw product. In this study, three species of Korean bamboo, *Phyllostachys pubescens, P. nigra var. henonis*, and *P. bambusoides*, were evaluated for usability of their chemical components and non-wood fibers in value-added industry. Samples were collected in the early stage of growth and subsequently cooked with no chemicals to prepare dietary fibers. Some morphological and chemical characteristics of each bamboo fibers were compared and analyzed. As the results of this study, the fibers from young *P. pubescens* showed the best quality and suitability as a source of dietary fibers. We also made handsheet from the fibers and examined some physical properties. In conclusion, it is expected that the young bamboo fibers can be used in value-added industry as multipurpose raw materials.

***In-vitro* clonal propagation of five bamboo species.** Roy, S., Haque, J.A.M.A, Hossain, M.K, (*Jahangirnagar University, Bangladesh*; *shkmroy@yahoo.com*).

Bamboo is an integral part of forestry and a major non-wood forest product. The conventional propagation method of bamboo is time-consuming and unprofitable. This paper describes protocols for micropropagation of five bamboo species, namely *Bambusa balcooa*, *B. tulda*, *B. vulgaris*, *B. polymorpha*, and *Dendrocalamus giganteus. In-vitro* multiplication of shoots was achieved by culturing the nodal segments of young branches on a cytokinin-rich liquid medium followed by rooting in an auxin-containing medium. WPM medium was optimum for *B. balcooa* and *B. polymorpha;* MS medium was suitable for high multiplication rate of shoots in *B. tulda* and *B. vulgaris*, respectively**.** In the case of *D. giganteus*, shoot proliferation was highest in WPM Continuous shoot proliferation for a period of 2 years was achieved through sub-culturing every 30 days. Eighty to 95% of the regenerated shoots rooted on half strength MS medium. About 90% regenerated plantlets were successfully transferred to soil where plants grew with vigorous growth. The protocol is feasible for high frequency regeneration, conservation, and bamboo forest restoration, and consequently sustainable uses of these species for poverty alleviation.

Response of soil microbial diversity to *Phyllostachy pubescens* plantation management. Xu, Q., Jiang P., Wang J.,Wang Q., Sun D. (*Zhejiang Forestry University, China; xuqiufang@zjfc.edu.cn; jiangpeikun@zjfc.edu.cn; wjj1981_2001@126.com; parking9@tom.com; sundidi521@126.com*).

Bamboo has been widely planted, and its area is increasing in China. Soil microbial diversity as an important indicator of soil quality is sensitive to change of vegetation and management. The objective of this paper was to find out the effects of three different management types on bamboo plantations—natural, extensive, and intensive management—on soil microbial diversity. The natural bamboo stand in a natural reserve was selected to inspect changes of soil microbial diversity when bamboo invades natural broadleaved forest; no great change in soil microbial diversity was observed with the invasion process. Extensively managed bamboo plantations with different histories were selected for assessment of changes in soil microbial diversity with increasing history of bamboo plantation. Soil bacterial communities showed no great change with growing history of bamboo, but dominant species shifted from some to others, suggesting that bacterial communities would change over time in pure bamboo

plantations. Intensive management generally did not cause great change in soil bacteria communities but some species declined in population and even disappeared. In conclusion, soil microbial communities under bamboo plantation had less diversity than natural forest, and intensive management would lead to changes of microbial diversity in the long term.

A dynamic study of microelements in rhizosphere soils during early growth of *Phyllostachys pubescens*. Zhang, W., Guo, X. (Jiangxi Agricultural University, China; zwy1526@gmail.com; gxmjxau@gmail.com).

This study examined the dynamic change law with respect to macroelement (N, P, K) and microelement (Cu, Zn, Fe, Mn) concentrations in different plant parts during rapid growth stages in unfertilized *Phyllostachys pubescens* stands in the Huangshan area in Anhui Province. The demand for all macroelements was great during the shooting stage, with the maximum demand for K. Concentrations of N, P, and K peaked during the initial growth phase and decreased thereafter. Microelement concentrations in the shoots of *P. pubescens* were in the order of Fe>Zn>Mn>Cu, with peak concentrations of Fe and Zn found in the middle 10 days and the last 10 days of April. The contents of macroelement and microelement in roots, branches, stems, and leaves generally decreased during the growth of young *P. pubescens*, although the absorption peaks for some elements occurred in some plant organs between June and July. Statistically significant correlations were found among many pairs of elements during the early growth stage, particularly between N, K, and other elements.

The splitting process and factors of Moso bamboo culms. Zhong, S., Qin, D., Zhang, S. (*Beijing Forestry University, China; shasha1305@126.com; qindaochun@gmail.com; shuangbaozhang@tom.com*).

To develop splitting-proof technologies for bamboo, a preliminary investigation was conducted into the splitting process and factors of Moso bamboo (*Phyllostachys pubescens*) culms. The 4-year old *P. pubescens* culms were cross-cut into long bamboo tubes, which served as specimens. All the specimens were exposed outdoors from June 21-September 15 in Huangshan area, Anhui. The height position from which the specimen was cut, diameter and thickness of the tube wall, tube length, and node distribution (with or without nodes at the 2 ends of a tube) were selected as influencing factors, and their effects on splitting were studied. The results showed that diameter and thickness of the tube wall decreased gradually with the increase of the height of cutting position. There were linear correlations between diameter and height position, and also between wall thickness and height position. Height position, tube diameter, and wall thickness had significant influences on the splitting extent. Bigger diameter and thicker walls were found to result in more severe splitting, whereas tube length and nodes distribution had no significant influences. It was also found that long splitting mostly occurred symmetrically along the tube diameter, and splitting rate was influenced greatly by air temperature and humidity.

Impacts and adaptation of bamboo industries to global financial crisis: Anji County case study. Zhu, Z., Shen, Y. (*Zhejiang Forestry University, China; zhuzhen8149278@126.com; shenyueqin-zj@163.com*), Dong, D. (*Bureau of Forest in Anji, China; dongdunyi@126.com*).

The financial crisis also significantly affected forest bamboo processing industries in China, leading to closures of numerous bamboo processing enterprises. This study investigates the impacts in Anji County, which has 700, 000 ha of bamboo, and an important bamboo industry. Bamboo processing industries first appeared in mainland China in Anji County. The first processed bamboo product was bamboo mats made by machine at that time, and the industry has developed very fast in the past 20 years. Currently there are 1, 600 bamboo processing enterprises using 150 million bamboo per year and with output value of USD 1.35 billion in 2008. In this paper, 30 bamboo processing enterprises in Anji were surveyed by email, telephone, and personal visit regarding the impacts of the global financial crisis on bamboo processing industries. Our survey results show the average growth ratio of workers' wages and export amounts decreased by 40.37% and 36.58% in 2008 compared to 2007, respectively. To cope with the financial crisis for the processing sector, some adaptation strategies are proposed from the perspective materials, firm location, collaboration between farms and firms, the financing service system, and marketing.

D-06 Challenges and issues of forest management and utilization in Asian countries

Organizers: Sang Seop Lim, *Korea Forest Service, Republic of Korea, sangseoplim@gmail.com*; Im-Young Lee, *Korea Forest Engineers Association, Republic of Korea, iylee@kfea.or.kr*; Shougong Zhang, *Chinese Academy of Forestry, China, shougong.zhang@caf.ac.cn*; Ajith Chandran and Juan Chen, *University of British Columbia, Canada, ajithchandran@yahoo.com, candice10933@yahoo.ca.*

China's six key forestry programs. Chen, J., You, S.J., Wang, G.Y. (*University of British Columbia, Canada; candice10933@yahoo.ca; sjyou9@hotmail.com*; *guangyw@hotmail.com*).

Half a century of over-exploitation of forest resources has had catastrophic consequences, such as an increase in flooding severity in the upper Yangtze River, the degradation of natural forests and associated deforestation, soil erosion, desertification, climate change and loss of biodiversity. In response, the central government has pursued ecological rehabilitation, and China's six key forestry programs (SKFPs) were advanced to address the environmental consequences as a result of the rapid economic expansion in China. The SKFPs cover over 97% of the counties across China and have immense benefits for the local communities, including healthier environment due to the forest protection and land conversion from cropland to forest, and increasing economic income through shifting the focus on raw material extraction to secondary value-added processing. Despite numerous success has been achieved, a range of problems have been generated. For example, the lack of motivations of rural farmers to implement the SKFPs, the conflicts between various stakeholder groups, including the central government, local governments and local farmers, as well as the decreasing forest quality because of the loss of mature forests. As a result, continuous efforts should be taken to make the SKFPs more accommodating to the local context.

Use of plants in healthcare by local communities in and around Rema-Kalenga Wildlife Sanctuary: seeking for new avenues of protected area management in Bangladesh. Chowdhury, M.S.H., Koike, M. (*Shinshu University, Japan; shaheedfeni@yahoo.com; makoike@gipmc.shinshu-u.ac.jp*).

Increased commercialization of economically important medicinal plants has resulted in overharvest, causing many of them to be threatened. The present study was carried out to document the indigenous uses of medicinal plants by local communities in and around Rema-Kalenga Wildlife Sanctuary, Bangladesh. Data collection was predominantly based on qualitative tools to record the species use, identify their relative importance (RI), and assess the informants' consensus factor (Fic) on associated knowledge. We interviewed 140 households of the local community and 5 local herbal practitioners. A total of 44 plant species were in use against 33 ailments under 10 broad disease categories. Five species were found to have high use versatility (RI>1), *Emblica officinale* being the most versatile. Respiratory problems scored the highest Fic value (0.56), involving the use of 30% species recorded. *Terminalia bellerica*, *Sterculia villosa*, *Dillenia pentagyna*, and *T. arjuna* were being harvested commercially. Use by the community, particularly for subsistence consumption, ensured sustainable harvesting, but commercial extraction of some species appeared unsustainable. Buffer-zone-based commercial farming of medicinal plants with a commercial value could serve a dual purpose of assuring sustainable alternative income generation (AIG) for local communities and conserving the natural resources in protected areas.

Conditions for successful implementation of participatory forest management and its impact on forest resource and people's livelihood: some evidence from Nepalese community forestry. Dhakal, M. (*Ministry of Forests and Soil Conservation, Nepal; maheshwar.dhakal@gmail.com*), Misa, M. (*University of Tsukuba, Japan; masuda@sakura.cc.tsukuba.ac.jp*), Paudel, S.K. (*University of British Columbia, Canada; shyam.paudel@gmail.com*).

Among the various participatory forest management modalities applied in the developing countries, Nepalese community forestry by its name and implementation approach has worldwide recognition for organizing local communities and institutions and improving both forest conditions and livelihoods of communities in and around the forests. It has also wider effects, fostering the sharing of forest benefits among member households on equitable basis. However, the question is largely silent among the researchers and policy-makers alike as to what minimum conditions are required for its successful implementation. This study assesses four successfully managed community forests: two from a hilly region having diverse ecological and socio-economic conditions, and two from the lowland region of Nepal. We also analyzed the situations in terms of: institutional stability in decision-making, equity in benefit sharing, and ecological stability in forest conservation and development. The study showed positive results in institutional stability through process decision-making, and in ecological stability through carrying out forest conservation and development activities; it also showed a need for improvement in equity-sharing of forest benefits. The study suggests a need to consider the issue of adding economic value to benefits produced by the forests, focusing on improving the livelihoods of local communities.

How does China's forest product industry secure wooden raw materials under globalization?: An analysis of the timber processing sector in Dalian City. Hirano, Y., Hori, Y. (*Forestry and Forest Product Research Institute, Japan; hiranoy@affrc.go.jp; horijas@affrc.go.jp*), Yamane, M. (*Center for the Conservation of Natural Environment, Japan; yamane.5wxw@pref.kanagawa.jp*).

The goal of this research project is to understand how China secures raw wood materials under their economic development and entry into global market, with a shortage of domestic forest resources. To achieve this goal, we conducted updated case studies to show how timber processing companies in Dalian City (Liaoning Province) mainly export their products to secure timbers and develop their businesses. Over the past 10 years, those companies have developed their businesses but faced several significant challenges from national and global levels, such as drastic cut back of domestic timber supply due to the Natural Forest Protection Program, or the current financial crisis. However, our continuous interviews confirmed that they flexibly dealt with those challenges, since they could quickly find new suppliers of timbers and buyers of their products among global and domestic markets. This flexibility to find the alternatives was also underpinned by their commercial network, which was formed not only by economic but traditional reasons. This result actually underlies the current rise of Chinese companies in the global timber market, and indicates the possibility that they have more worldwide impact on it in the near future.

An assessment of domestic production potential of industrial roundwood in the Republic of Korea. Joo, R.W., Park, D. (*Korea Forest Research Institute, Republic of Korea; joorw@forest.go.kr; pdk5920@forest.go.kr*).

The purpose of this study is to argue that domestic timber production is not expected to grow in proportion to the increase in harvestable growing stock. To verify the argument, the relevant literature was reviewed on the status of forest resources, trends and projections for timber markets, and socio-economic and political factors affecting timber production. Wages in the forestry sector, a highly labor-intensive industry, have been rising rapidly relative to the prices of timbers over the past 40 years, seriously reducing the profitability of forestry. Also, recent demographic trends show an increasingly severe shortage of forestry workers in the future. Thus, timber production potential would not be realized to the actual market supply without marked increase in labor productivity. Forestry in Korea has been and remains a highly subsidized industry, and funding from the government profoundly influences the domestic timber production as well. Recently, however, concerns for sustainable forest management schemes are rapidly growing, so government funds have to be allocated to the production of forest services accordingly. Therefore, strategies for addressing the conflict between timber production and environmental conservation should be developed.

The School of Environmental Conservation and Ecotourism Management in Indonesia. Kang, H.S., Lee, D.K. (*Seoul National University, Republic of Korea; silvi1@snu.ac.kr; leedk@snu.ac.kr*), Basalamah, H. (*Center for Forestry Education and Training, Ministry of Forestry, Indonesia; helmibsl@yahoo.com*), Lee, J.S. (*Korea International Cooperation Agency, Republic of Korea; jslee@koica.go.kr*).

The School of Environmental Conservation and Ecotourism Management (SECEM) is a cooperative capacity-building project between the Korea International Cooperation Agency (KOICA) and the Center for Forestry Education and Training (CFET),

Ministry of Forestry Republic of Indonesia, from 2007 to 2009. The objectives of this project are to improve the capacity and skills of natural resources managers in the fields of forestry, environmental conservation, and ecotourism management; and to strengthen the capacity of SECEM in enhancing the development of the state-of-the-art modules and update education programs include intensive field practices. The five divisions of this project are conservation area management, biodiversity conservation, forest protection and fire management, marine and coastal management, and ecotourism. The target of SECEM trainee is middle level of Ministry of Forestry staffs (minimum echelon IV) who work in the field of conservation area management such as national park and regional office for the nature resources conservation. The first SECEM training course was carried out from October 2008 to April 2009 in CFET Bogor Campus, with field practices at the five national parks; the total participants were 30 persons.

Study of gender equity in community-based forest certification programmes: experiences from Nepal. Lewark, S., George, L. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de; latika_george@yahoo.co.in*), Humphries, S. (*FSC International, Germany; s.humphries@fsc.org*).

The study is aimed at gender equity in a community based forest certification project in Nepal. The research was carried out in the district of Dolakha in Nepal with the Sushpa and Bhitteri forest user groups. Using a mixed method research approach, interviews were conducted with experts and the local people; committee meetings were conducted; and household interviews carried out. Data analysis was done using a convergence model where qualitative and quantitative data were collected and analyzed separately. Then the results were converged to get a better understanding of gender equity with a focus on women´s participation in the pilot phase of the forest certification project and awareness levels of users about forest. The results present a broad spectrum of information on the background and lives of respondents as well as the effects of forest certification on their lives today. The analyzed data include information on the age, caste, occupation of respondents; issues of men and women regarding conditions before and after forest certification; background of forest certification, community forest user groups (CFUGs), non timber forest products (NTFPs), FSC (Forest Stewardship Council) certification of Nepalese forests; forest committee and sub committee meetings.

Key issues and challenges in designing sustainable forest management strategies in India. Ojha, N. (*Regional Centre for Development Cooperation, India; nojhabbsr@yahoo.com*).

Coupled with a clear definition of non-timber forest products (NTFP), the tenurial rights conferred by the Forest Rights Act, 2006, can be trusted to make sustainable management of forests much easier in India. Recognising the carbon storage and sequestration potential of forests, India has given a new impetus to the forestry sector and has more than doubled the forestry budget this year to 83 billion. Huge amounts of money are also being pumped in by overseas donors to increase the green cover in the country. These laudable measures notwithstanding, there are certain developments that cause serious disquiet–none of them more disturbing than the attempts at privatization of common property resources. What is most worrisome is the fact that many such attempts are ordinarily invisible, sugar coated as they are with terms like plantation to check global warming, compensatory afforestation to enhance forest cover, etc. Designing forest interventions is becoming more complex by the day in the light of the fast-changing global scenario. The paper tries to address the key challenges and design some strategies in the forestry sector in the context that forests are not just carbon stores; they have multiple uses.

Deforestation and poverty in North Korea, Mongolia, and the tropical Asian countries. Palo, M., Lehto, E. (*Finland; matti.palo@metla.fi; erkki.lehto@welho.com*).

Our purpose is to promote understanding of the role of poverty and other underlying causes of deforestation in North Korea and Mongolia. When no reliable time series of empirical data were available, 15 tropical Asian countries were included in our modeling of deforestation. The regression model explains 79% of the national variation of relative forest area in these 17 Asian countries. The specification of the model was guided by ecological economics and the availability of data. In our model, the human development index is positively correlated with relative forest area. Increasing poverty is increasing deforestation. Increasing agricultural productivity is decreasing deforestation. Reducing poverty and increasing agricultural productivity thus are instruments against deforestation. GNP per land area is positively correlated with deforestation. Undervaluation of forests makes the opportunity cost of sustainable forestry too high and favors deforestation. When more arable land can be cheaply cleared from forests there is limited motivation to increase agricultural productivity. If competitive market pricing of logs (stumpage) and other forest goods and services could be applied, the increasing impact of deforestation by increasing GNP per land area could be reduced. North Korea and Mongolia match well this explanation along with the 15 tropical Asian countries.

Overview of and changes in today's forest products sector in Japan. Shiba, M., Sakamoto, T., Miura, K. (*Kyoto University, Japan; mshiba@kais.kyoto-u.ac.jp; Jasc60@gmail.com; m.kisato@gmail.com*), Pakhriazad, H.Z. (*University Putra Malaysia, Malaysia; azad@kais.kyoto-u.ac.jp*), Schaller, M. (*Technische Universitaet Muenchen, Germany; schaller@tum.de*).

Currently, there are several issues which are important in the management of Japanese plantation forests. The most significant of these is the lack of silvicultural tending. A number of factors have contributed for this situation; a lack of workforces, reduced profitability of the forestry industry, depressed price of timber and changes in timber demand, and increase in absentee ownership. Consequently forest production activities have stagnated, thus further reducing economic vitality at the village level and fuelling urban migration. A new systematic and sustainable supply of domestic timber products began in 2006, with the long-term planning focusing on market demand and response to needs of consumers. We present examples of ways to build up timber supply chains and logistics, to reduce costs in timber harvest operations, and to distribute and process timber supply in dimensions that respond to market trends. Eleven distinctive regional forest areas as model sites are now pursuing consolidation of operations and management, conclusion of business pacts, and cost-reduction in timber harvesting, distribution, and processing based on agreements linking upstream and downstream businesses. This study highlights the increasing relevance of regional cooperation in developing forest harvesting practices to promote sustainable forest management in mountainous areas.

After colonial forestry: the development and future management of Japanese cedar (*Cryptomeria japonica*) plantations in Taiwan. Wang, P., Wang, D., Lin, J., Chen, L. (*Taiwan Forestry Research Institute, China-Taipei; pjwang@tfri.gov.tw; dhwang@tfri.gov.tw; ljc@tfri.gov.tw; cherry@tfri.gov.tw*).

Japanese cedar (*Cryptomeria japonica*), one of the most important Japanese species, was introduced into Taiwan by Japan's colonization government in the early 1900s. After World War II, the species was planted rapidly and widely due to scholars' suggestions. As a result, Japanese cedar plantations have become the largest woodland with unique species in Taiwan. However, some of them are now in the rotation age, and some of them have an overcrowding problem. Since Japanese cedar is not good for utilization, its price is very low. A bitter controversy exists over whether plantations need to be maintained or to be cut for substituting other useful species. The study aimed to explore the process of the decision-making behind Japanese cedar planting and to provide the suggestions for the ensuing management. The research data come from in-depth interviews with key persons and the examination of literature reviews. According to the process of the species chosen, plantation expansion, and plantation deterioration, all the related events reflect forest management paradigm shifts from colonial forestry, to state forestry, to forest ecological management. Therefore, the evolution of Japanese cedar plantations in Taiwan should be regarded as an adaptive management model.

Economic development and wood products import-export trade of China. Youn, Y.C., Wu, L. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*; *lilybaihe@snu.ac.kr*).

China has maintained a high GDP growth rate in the last 20 years, and its domestic industries are maintaining their growth as well. Since the 1990s, China's economic dependence on foreign trade was more than 30%, and after its access to the WTO in 200, this number increases further. In this paper, we first analyze the wood products import-export trade in China during 1994–2008 and the impact of economic growth on the wood products trade. After presenting an overview of the wood products outflows and inflows in the past 15 years, we discuss the inter-relationship between the outflows and inflows and China's economic structure using input-output tables, and how the economic and environmental policies influence the wood products' trade. In recent years, many countries pay more attention to environmental protection, influencing the forest sector greatly. China's environmental policy has influenced the import and export of wood products of China also. The implications of China's economic growth and environmental policy to sustainable development of forest resources in trade partners will be discussed. Finally, we will give some suggestions to keep China's wood industry growing in a stable and healthy way.

Posters

Collaborative forest management in India: past, present and future. Chandran, A., Singh, M. (*University of British Columbia, Canada; ajithchandran@yahoo.com; monikaxing@gmail.com*).

Forest management in collaboration with community has been happening in India in various forms. In the early 1970s the social forestry scheme, with a series of activities involving communities, lacked the enhanced collaboration that came by with the adoption of joint forest management (JFM) in the 1990s. In JFM the forest department and the community through a community institution often called the forest protection committee (FPC) agreed on a framework for protection of the forest and sharing of produce. While collaborations increased between the forest department and the community, lack of institutional and functional legitimacy to improve rights continue to be roadblocks for effective collaboration. In recent years increased concern over climate change and associated programs like reduced emission from deforestation and degradation (REDD) has brought in an altogether new dimension of forestry that requires further collaboration in the future. This paper looks at these different aspects of community and forest department collaboration. These portray experiences from the past, current situation, and probable future challenges for Indian forest management. The paper draws its content from University of Edinburgh research on JFM conducted in the 1990s, an ongoing CIFOR PEN research; and literature on REDD initiatives in India.

Discussion of collective forest right system changes since the founding of the People's Republic of China. Cui, H., Kong, X. (*Renmin University of China, China; cuihaixing@sohu.com; k-xz@263.net*).

At present, the reform of the collective forest right system has become a center of state and community attention in China. In this paper, according to the type of institutional change, collective forest right system changes are divided into four stages. The process, characteristics, and problems of the collective forest right system changes were analyzed, and the patterns of collective forest right system changes are summarized since the founding of the People's Republic of China. The main conclusions of papers are four aspects. First, the change process of the collective forest right system is the same as the rural property rights system reform; its purpose is to minimize the social costs of system changes. Secondly, the change process of the collective forest right system is decentralization-centralization-decentralization. Thirdly, every change of the collective forest right system is the product of a specific historical context and has an impact on the behavior of forestry management. Fourth, the changing types of collective forest right systems are different at different times.

Major forest types and sustainable forest management in China. Dai, L. (*Chinese Academy of Sciences, China; lmdai@iae.ac.cn*).

Major forest types in China include boreal forest, mixed coniferous broadleaved forest, evergreen broadleaved forest, deciduous broadleaved forest, tropical rain forest, seasonal forest, and bamboo forest. How to manage this wide array of forest resources has challenged forest managers and policy-makers since the founding of the country. From the 1950s to the 1970s, forest management policies in China centered exclusively on timber production; in the 1980s and 1990s, such policies focused both on harvesting and on forest regeneration; and at the start of the 21st century, forestry in China has changed direction to encourage ecological sustainability while balancing land uses, economic growth, and demand for forest products. Results of the latest national forest inventory (1999–2003) revealed that the area and volume of forests in China have increased, and the area of plantation forests is the largest in the world. At the same time, recovering the character and extent of natural forests, meeting the rapidly growing demand for wood products for domestic and international markets, and testing and applying the sustainable forest management criteria and indicators remain important challenges for China.

Timor-Leste forests and woodlands, species productivity, and biodiversity: results from the first National Forest Inventory, 2008/2010. Fonseca, T.F., Marques, C.P., Crespi, A. (*Universidade de Trás-os-Montes e Alto Douro, Portugal; tfonseca@utad.pt; cpmarque@utad.pt; acrespi@utad.pt*), Parresol, B.R. (*U.S. Forest Service, USA; bparresol@fs.fed.us*), Ferreira, M. (*Universidade de Trás-os-Montes e Alto Douro, Portugal; mferreira@utad.pt*), Laranjeira, P. (*MAFF, Timor-Lest; pedrolaranjeira2002@yahoo.com.br*).

The Democratic Republic of Timor-Leste is a country in Southeast Asia, officially recognized as an independent state in 2002. Managing forests of the Democratic Republic of Timor-Leste for the future, according to the sustainable forest management (SFM) principle, requires up to date information on forest resources and on natural and human-driven constraints. Actual and future strategies of forest management authorities will largely depend on current knowledge of growing stock, species diversity, and rural communities needs. The international programme manager of the second rural development programme for Timor Leste (RDPII) has sponsored a reconnaissance inventory to characterize the Timor-Leste forest resources. Results from the first national forest inventory, taken at the districts of Bobonaro and Maliama, are presented. Specific objectives of this presentation are: (1) to present statistical information of forests and other wooded land in the Democratic Republic of Timor-Leste; (2) to characterize species productivity and species biodiversity; and (3) to analyse influential factors and constraints needed to be taken into account for a sustainable forest development in this Asian country.

Tropical timber trade flows in the People's Republic of China. Hu, Y., Shi, K. (*Chinese Academy of Forestry, China; yanjie@caf.ac.cn; shikunshan@yahoo.com.cn*).

The historical transition of timber distribution pattern in China is presented first, including three stages from 1949 to now; then the main parts of timber flows in China, which included timber markets (primary wholesale market, secondary wholesale market, and tertiary retail market); timber transport systems (road transportation, rail transportation, and water transportation); and regulations of timber transport, described individually. The trade flows of tropical timber in China were analyzed step by step, from production and imports of tropical timber, to flows in wood markets, to export of tropical timber products. A coastal port, Zhangjiagang port of Jiangsu province; inland ports of Yunnan province; and Hangzhou market of Zhejiang province were illustrated to show the actual trade flows of tropical timber in China. At the same time, problems in timber trade flows in China were analysed in the end, including lack of co-ordination and co-operation among the different government agencies involved in timber distribution, major stakeholders having little influence on the timber distribution systems, and no reliable data on timber flows due to lack of a reliable information system at a national level.

Outlook for forestry work and demand in Korea. Jung, B.H., Kim, C.S., Kim, K.D. (*Korea Forest Research Institute, Republic of Korea; bhjung@forest.go.kr; k561011@forest.go.kr; kidong@forest.go.kr*).

This research is aimed at forecasting future demand for a forestry workforce in Korea. Data for the employed workers and value added in forestry that are used in this research were obtained of the Bank of Korea. Value-added was based on data of constant prices in 2000 released by the Bank of Korea. The estimate of future demand stretches from 2010 to 2030. Value added in forestry has shown a growing trend due to the increase in forestry activities, including forest management and timber harvest since 2003. Based on this trend, the demand for forest workers is predicted to continuously grow to 25,000 in 2010, 27,000 in 2020, and 28,000 in 2030. However, owing to poor and dangerous working conditions of forest industries, the number of overall employed persons in forestry is likely to go down to 72,000 in 2010, 67,000 in 2020, and 62,000 in 2030, respectively. To make forestry activities more attractive as full-time jobs, it is recommended to develop forest-favorable polices, including extending annual working days and raising wages for forest workers.

Public awareness of forest aesthetic values among East Asians for sustainable forest management. Lim, S.S. (*Korea Forest Service, Republic of Korea; sangseoplim@gmail.com*), Innes, J.L. (*University of British Columbia, Canada; john.innes@ubc.ca*), Xu, L. (*University of British Columbia, China; xu0908@interchange.ubc.ca*), Yoshida, T. (*University of British Columbia, Japan; tyoshida@interchange.ubc.ca*).

Korea, China, and Japan are members of the Montreal Process (MP), and they share more similar natural and cultural conditions than those of the other members. However, there has been little research on the social values of forests in these countries within the framework of sustainable forest management (SFM). This is especially true of aesthetic values, which are regarded as very important in these countries. The MP framework has few aesthetic indicators. To rectify this, we first need to identify similarities and differences in the perception of various forest values between the public in these three countries. This has been done through an e-mail questionnaire to 50 people in each country. The results reveal differences in the importance attached to various forest functions, differences in beliefs about priorities for sustainable forest values, and differences in the level of satisfaction with current forest management practices. This research should contribute to the development of aesthetic indicators in the MP framework. Further work is underway to increase the sample size in each country, and to assess the views of both experts and the general public.

Contribution of community wood toward sustainability of the wood processing industry in Central Java Province. Malik, J., Kartikasari, L. (*Ministry of Forestry, Indonesia; jmalik_2007@yahoo.co.idl; lia.kartikasari@gmail.com*).

Wood industries are experiencing deficits of wood material; consequently, some of them collapse, but they still are included as pillars in Indonesia industry structure. One of the potential wood material sources originates in community wood. A study was conducted in central Java to reveal the outlook for community wood contribution to wood processing industries. We did a desk study of wood production and circulation in a central Java province as well as in-depth interviews with stakeholders related to the industry. The result indicated that community wood contributes about 56% to the wood processing industries in central Java and has been relatively stable for the past 5 years. Meanwhile, the wood supply from outside Java was only 26%, and from the state forest company was 18%. The large contribution of community wood signals that it needs to be paid attention to more seriously, because it has been proven that its contribution is significant toward the persistence of the wood industries. The study also describes how community wood is produced from sustainable forest management, where units of community forest have reached certificates of sustainable forest management.

A study on the North Korea's change of forest policy since the economic crisis in 1990s. Park, K.S., Lee, S.Y., Park, S.Y. (*Korea Forest Research Institute, Republic of Korea; park2637@korea.kr; leeferas@forest.go.kr; leeferas@forest.go.kr*).

North Korea has used the economic effect of forest positively to establish socialist economy systems and restore public facilities that were destroyed after the Japanese colonial period and the Korea War. North Korea has nationalized whole forests and let the government and social structure build and administer the forest. For the first time, North Korea had emphasized wood supply but, on the other hand, support for building and management of forest has been neglected, and recommendations for terraced farms actually accelerated forest destruction. Local agencies have managed forests to prevent destruction, but management has caused loss of central control and could not prevent the huge forest destruction due to an economic crisis from 1990. North Korea has started to alter their traditional timber production-oriented forest management methods into environmental protection-oriented forest management methods. As a result, North Korea established the "Law on the forest of DOR Korea" in 1992 and the "Ministry of Land Environment Protection" in 1996. Furthermore, since 2000, North Korea has asked South Korea and international society to support forest restoration positively.

Impact of forest ownership change on biodiversity conservation in the lowland of Nepal. Poudel, I. (*Ministry of Forests and Soil Conservation, Nepal; poudel.01@gmail.com*), Chou, L.M. (*National University of Singapore, Singapore; dbsclm@nus.edu.sg*), Nepal, S. (*WWF Nepal, Nepal; santosh_nepal@hotmail.com*), Dhakal, M. (*Ministry of Forests and Soil Conservation, Nepal; maheshwar.dhakal@gmail.com*).

Nepal is a pioneer country in the implementation of a community forestry development programme as decentralized forest policy regimes start to develop in the world. Community-managed forests (CFs) and government-managed forests (NFs) are widely adopted systems in the Tarai region, which has diverse socio-political and biophysical contexts. By 2008, one-third (34.6%) of the total forest area was handed over to local communities to manage forest resources through collective efforts in order to conserve biodiversity, reduce poverty, and share benefits among the users. It is crucial to assess whether the ownership change from NFs to CFs has had an effect on overall forest biodiversity. An assessment is made of the diversity and dynamics of tree species in the western Tarai region. Biodiversity indices of tree species were measured using the Shannon-Weaver diversity index (SDI) and the Margalef species richness index (SRI). The results suggest that CFs is superior in terms of SDI to that of NFs, while there was no significant difference in terms of SRI. CFs is the most preferred forest governance system in the lowlands of Nepal. The study also concluded that ownership change from NFs to CFs had positive consequences on biodiversity conservation.

Land use changes assessment using geographic information system. Rahmawaty, R. (*Sumatera Utara University, Indonesia; rahmawaty1974@yahoo.com*), Villanueva, T.R. (*University of the Philippines/Los Banos, Philippines; teodoro_villanueva@yahoo.com*).

This study was conducted to assess land use changes in Besitang Watershed, Langkat, North Sumatra, Indonesia, through the use of a geographic information system (GIS) with transition matrix. It also assessed the relationship of the land use changes related to land use policies and their implementation. Drivers of change were also identified and assessed. The GIS efficiently facilitated the assessment of land use changes through the years by means of map overlays. Remarkable land use changes occurred from 1990–2001; about 25% of the total primary forest was converted to secondary forest, and mangrove forest areas were converted to dry land agriculture by 28% of total mangrove forest. During 2001–2006, the high rate of forest disturbance was from conversion of 91% primary forest to secondary forest, and 26% mangrove forest area was transformed into fish pond. Most of these changes can be traced to poor implementation of land use policies as well as to the demand and pressures from a growing population in the watershed. A driver of change is land conversion in protected areas.

Improvement of forest management in the Asian region for sustainable forest management, as seen in FSC certification. Sugiura, K., Yoshioka, T., Inoue, K. (*Nihon University, Japan; sugiura.katsuaki@nihon-u.ac.jp; yoshioka@brs.nihon-u.ac.jp; inoue.kouki@nihon-u.ac.jp*).

The purpose of this study is to compare the present condition of forest management in Asian countries using evaluation results from Forest Stewardship Council (FSC) certification bodies. The investigation examined certified forests in Asian countries, which account for 2.39 percent of the total certified area (2,761,603 ha), as of 15 September 2009. Materials were taken from the evaluation summaries that each body publicised on their respective web sites. We investigated items of the number and types of items that the FSC certification bodies considered as requiring improvement (RI). In all, the FSC uses 10 principles and 56 criteria to evaluate. Of these, the following 4 principles were cited by the certification bodies as RI in nearly all the countries: Principle 4, 'Community relations and worker's rights'; Principle 6, 'Environmental impacts'; Principle 7, 'Management plan'; and Principle 8, 'Monitoring and assessment'; further, there were differences corresponding to each country with respect to the other items. Thus, while there are differences in what qualifies as RIs in each country, it appears that Principles 4, 6, 7, and 8 are the common weak points and require improvements throughout the Asian region.

China's log trade and timber safety. Wang, L. (*Beijing Forestry University, China; wang_lanhui@hotmail.com*), Xie, S. (*State Forestry Administration, China; ieouin@sina.com*), Liu, J. (*Beijing Forestry University, China; liujunchang@vip.sina.com*).

This paper analyzed the issue of timber safety and log trade of China, from clustering analysis of trade partners of China. The result shows the number of the trade partners in the unstable category accounts for over 68%, which states that the log trade is not stable. Many countries have imposed constraints on log exports, out of the pressure of native resource protection, environment protection, and the forestry processing industry. The countries in the decreasing category are about 8% among the trade partners; those countries are tightening the policy and the average decrease rate is above 20%. This situation urges China to promote her own supply capacity as a large log -mport-dependent country. On the other hand, about 25% of trade partners are increasing log exports to China. Among these countries, 17 countries maintain a stable increase over recent decades, while 10 countries increased rapidly; their annual increase is above 45%. These countries—such as New Zealand, and Papua, New Guinea—provided stable support for the demand from China. It is advisable that China apply different strategies to different categories.

Forest management in northeast China: history, problems, and prospects. Yu, D., Zhou, L., Ding, H., Dai, L. (*Chinese Academy of Sciences, China; yudp2003@iae.ac.cn).*

Studies of the history and current status of forest resources in northeast China are important in discussions of sustainable forest management in the region. Prior to 1998, excessive logging and neglected cultivation led to a series of problems that left exploitable forest reserves in the region almost exhausted. A substantial decrease in the area of natural forests was accompanied by severe disruption of stand structure and serious degradation of overall forest quality and function. In 1998, China shifted the primary focus of forest management from wood production to ecological sustainability, adopting ecological restoration and protection as key management objectives. In the process, China launched the Natural Forest Conversion Program and implemented a new system of classification-based forest management. Since then, timber harvesting levels in northeast China have decreased, and forest area and stocking levels have slowly increased. This paper synthesizes information on forest area, stand characteristics, and stocking levels, and forest policy changes in northeastern China. Following a brief historical overview of forest harvesting and ecological research in northeast China, the paper discusses the current state of forest resources and related problems in forest management in the region, concluding with a proposed management strategy for forest lands in the future.

How does the Natural Forest Protection Program influence China's forest growth? Zhang, K. (*China National Forestry Economics and Development Research Center of State Forestry Administration, China, and Forestry and Forest Products Research Institute, Japan; zhangk@affrc.go.jp, landyou2000@yahoo.com*), Hori, Y. (*Forestry and Forest Products Research Institute, Japan; horijas@affrc.go.jp*), Liu, D.S. (*China National Forestry Economics and Development Research Center of State Forestry Administration, China*; *liudongsheng@forestry.gov.cn*), Tachibana, S., Hirano, Y., Zhang, Y.F. (*Forestry and Forest Products Research Institute, Japan; binn@affrc.go.jp; hiranoy@affrc.go.jp; zhangyf@affrc.go.jp*).

With its economic development, China's demand on timber and wood products grows rapidly. The trends of China's wood demand strongly influence the world's forest resource and wood markets. China's government has changed its policies from timber-oriented utilization to forest protection and ecology restoration since the late 1990s. The Natural Forest Protection Program (NFPP) is the largest program involved in China's key ecological policies. Its major measures—a logging ban on natural forests in west China and decreasing timber production in northeast state-owned forests—are supposed to change China's forest growth and timber market. Until now, little statistical analysis has been done on measures of NFPP and how they influence the forest growth. This paper uses panel data analysis models to explain effects of factors such as forest management, harvest, planting, etc., on changing forest stocks, based on a database of 70 forest/farm samples of state-owned forestry enterprises around China. Results of data analysis are the stock of former year's forest and the measures of the policies, all of which positively affect forest growth; historical forest basis counts a lot; and the forest under protection and management could play more important role.

Comparing long-term effects of different forest management practices on forest ecosystems. Zhao, F., Ding, H., Liu, Z., Xie, X., Wang, Y., Dai, L. (*Chinese Academy of Sciences, China; fuq_zhao@126.com; dingding-518@163.com; lzg8647656@sina.com; xiexiaokui@gmail.com; wy11231027@sina.com; lmdai@126.com*).

Changbai Mountain is one of the most important ecological regions in northeastern China. Because of unreasonable management, forest quality and ecological function have degenerated. We attempted to apply a spatially explicit landscape model, LANDIS, to simulate future forest landscape changes under five management alternatives for exploring the long-time dynamic succession and spatial distribution in a 300-year horizon in Lushuihe forest bureau, which is the typical area in Changbai Mountain. Management alternatives were: (no cutting as control), selective cutting I, selective cutting II, planting after selective cutting I, and planting after selective cutting II. Results of stimulation show: no cutting and plant selective cutting scenarios increase the area of mature and overmature forest on different levels in later succession stage, which is beneficial for increasing forest quality and keeping the integrality of landscape. Comparing plant scenarios to no-plant scenarios, the plant scenarios strategy can increase the area of forestation species, in which the area of planted forest mature and overmature forests is larger than other strategies. Therefore, making use of key species of original broadleaved Korean pine forest to plant forests is beneficial for optimizing forest structure to broadleaved mixed forest landscape, increasing forest quality and landscape restoration.

D-07 The future of forest plantation health in Asia

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Diseases in plantations of *Acacia* and *Eucalyptus* in Asia. Lee, S.S. (*Forest Research Institute Malaysia, Malaysia*; *leess@frim.gov.my*), Wingfield, M. (*University of Pretoria-FABI, South Africa*; *Mike.Wingfield@up.ac.za*).

Expansion of plantations of non-native *Acacia* and *Eucalyptus* has been fueled by increasing industrial opportunities linked to wood products, particularly pulp, and a need to utilize resources other than native mixed tropical hardwood. Diseases represent one of the greatest threats to plantation development in Asia. The most serious problem affecting plantations of *Acacia* is root rot, mainly caused by species of *Ganoderma*. This is most likely a local pathogen that has moved from native hardwood trees. These plantations have also been seriously damaged by introduced pathogens, the most recent of which has been a leaf blight on *A. crassicarpa* caused by *Passalora perplexa*. Early *Eucalyptus* plantations were seriously damaged by *Cylindrocladium* leaf blight, apparently caused by native, soil-borne *Cylindrocladium* spp. Likewise, apparently native *Chrysoporthe cubensis* has caused serious stem canker disease on some *Eucalyptus* spp. However, by far the most serious damage to *Eucalyptus* is caused by the leaf blight pathogen *Kirramyces destructans*, which has spread rapidly throughout Asia. This is an introduced pathogen that clearly illustrates the need for improved quarantine in the region. Plantations in Asia are likely to be deeply influenced by pathogens in the future, and technologies—including selection, breeding, and hybridization—will be increasingly important.

Future prospect on pests and diseases of *Falcataria moluccana* in Indonesian planted forests. Rahayu, S. (*Gadjah Mada University, Indonesia; tatarahayu@yahoo.com*), Lee, S.S. (*Forest Research Institute Malaysia, Malaysia; leess@frim.gov.my*).

Falcataria moluccana is widely planted in several countries in Asia, including Bangladesh, India, Indonesia, Malaysia, and the Philippines. The wood is used for pulp, plywood, veneers, packing cases, chopsticks, and light construction. The plantation area planted to these trees has increased steadily over recent years, parallel with an increase in pest and disease problems. Gall rust disease caused by the rust fungus *Uromycladium tepperianum*, an obligate parasite, is an important disease in the Philippines, Malaysia, and Indonesia. A bagworm outbreak, caused by *Pteroma plagiophleps* (Lepidoptera, Psychidae), attacking 5-year-old plantations, caused the growth of the trees to be reduced. Infestations of *Pestalotia* spp. on seedling are becoming more prominent and important. *Xystrocera festiva* (Coleoptera, Cerambycidae), is becoming more serious as the area planted to *Falcataria* increases. In the future disease and pest problems of these trees may continue to increase, especially due to increases in the planting of *F. moluccana* in Indonesia and Southeast Asia and possible greenhouse gas effects on pest and disease behavior. Thus, establishing collaborative research programmes among Southeast Asian countries for preventing and controlling pests and diseases of *F. moluccana* is an important strategy to be initiated.

Biological control of insect pests in acacia and eucalypt plantations in Indonesia. Tjahjono, B., Gafur, A., Tarigan, M., Nasution, A., Golani, G. (*APRIL Forestry, Indonesia*; *budi_tjahjono@aprilasia.com; abdul_gafur@aprilasia.com; marthin_tarigan@aprilasia.com; aswardi_nasution@aprilasia.com; golani@aprilasia.com*).

Industrial plantation forests of fast-growing species, especially acacias and eucalypts, are being established on a large scale in Indonesia to meet the ever increasing global demands. In the province of Riau alone, by 2009 plantation forests already covered an area of more than 640,000 ha. A number of major insect species have been identified to cause damage in acacia and eucalypt plantations in Sumatra. These include termite *Coptotermes* spp. (Isoptera: Rhinotermitidae); *Helopeltis* spp. (Heteroptera: Miridae); aphids (Homoptera: Aphididae); white flies (Homoptera: Aleyrodidae); *Phyllophaga* spp. (Coleoptera: Melolonthidae); *Xylosandrus* spp. (Coleoptera: Scolytidae); and caterpillars, especially leaf roller *Strepsicrates* sp. and *Archips* sp. (Lepidoptera: Tortricidae), armyworm *Spodoptera litura* (Lepidoptera: Noctuidae), and bag worm *Pteroma* sp. (Lepidoptera: Psychidae). In this presentation we elaborate on these insect pests and their management, especially the use of biological control agents. Currently, we are using the predator *Sycanus* spp. as a biocontrol agent of *Helopeltis* spp. and leaf roller, and nuclear polyhidrosis virus (NPV) as a biocontrol agent of armyworm. We are also isolating and studying the entomopathogenic fungi, especially *Beauveria* sp. and *Metharhizium* spp. To conserve and enrich the parasitoids, we are planting flowering plants such as *Turnera* spp.

Future prospects for forest plantation health in Asia. Wingfield, M. (*University of Pretoria-FABI; mike.wingfield@fabi.up.ac.za*).

Plantations of non-native *Eucalyptus* and *Acacia* species and their hybrids have expanded dramatically in Asian countries over the past 20 years. In many of these countries, diseases and damage due to insect pests have appeared in the early phase of plantation development. These have generally been caused by apparently native insects and fungal pathogens. Their early appearance is at least partly associated with the fact that native woody plants, relatively closely related to the plantation trees, are found in the region. However, it is worrying that a relatively large number of apparently non-native pests and pathogens have appeared unusually early in plantation development in Asia. This could be related to the close proximity of areas where Asian plantation trees are native. However, there is also evidence that various pathogens and pests have moved rapidly among Asian countries. This most likely reflects relatively poor quarantine in the region. Of great concern is the fact that numerous pests and diseases of *Eucalyptus* and *Acacia*, which are frustrating forestry operations elsewhere in the world, are not yet found in Asia. Some of these clearly threaten the future of plantation forestry and every effort must be needed to exclude them from the region.

Current status and future prospects of forest health management in China. Zhou, X. (*Chinese Academy of Forestry, China; cerc.zhou@gmail.com*), Wingfield, M. (*University of Pretoria-FABI, South Africa; mike.wingfield@fabi.up.ac.za*).

Forestry plays an important role in reducing greenhouse gas emissions and stimulating the development of the national economy in China. In this country, there are approximately 195 million ha of forests consisting of conifers and hardwoods, mainly distributed in the northeast and southwest. Pests and pathogens pose a significant threat to this important natural resource, with estimates of damage having increased to more than 12 million ha and an annual financial loss of approximately $13 billion. Five of the most important pests and pathogens accounting for these losses are pine wilt disease, the pine lappet moth, long horn beetles, poplar stem diseases, and larch shoot blight. Various organizations including government departments, universities, research institutes, and commercial companies have, therefore, been working together using integrated pest and pathogen management strategies to reduce their impacts. Biological control, development of pest/pathogen resistant planting stock, and chemical control are the primary approaches to disease management. Collectively, these strategies will contribute towards achieving the goal of increasing the forestry plantation resource in China by 40 million ha by 2020, with a further aim of reducing the impact of global warming.

Posters

Responses of *Dipterocarpus alatus* Roxb. ex G.Don seedlings to the inoculation of *Astraeus odoratus.* Sangwanit, U., Kaewkrajang, T., Puangchit, L. (*Kasetsart University, Thailand; fforuws@ku.ac.th; tarn_67@hotmail.com; fforlwp@ku.ac.th*).

Dipterocarpus alatus Roxb. ex G.Don is a valuable and indigenous tree species growing in the dry dipterocarp and evergreen forests in Thailand. The tree grows very slowly when planted in plantations because of a lack of ectomycorrhizal association on its root system. Therefore, many researchers tried to inoculate the seedlings with some ectomycorrhizal fungal species to find the most suitable species that would promote seedling growth. Two *Astraeus* species, *Astraeus hygrometricus* (Pers.) Morg. and *A. odoratus* C.Phosri, R.Watling, M.P.Marting & A.J.S.Whalley, are reported for the ability to form ectomycorrhizal roots with *D. alatus.* This study demonstrated the responses of *D. alatus* seedlings to the different inoculation techniques using *A. odoratus* in the form of spore suspensions at 10, 25, and 50 ml/seedling, pure mycelium culture 25 ml/seedling and non-inoculated

controls. Results revealed that the seedlings inoculated with *A. odoratus* formed distinctive characteristics and high percentages of ectomycorrhizal roots. Most data from growth measurement of inoculated seedlings were significantly higher than the non-inoculated ones. The inoculation technique using spore suspension of 25 ml/seedling gave the best growth response. Therefore, this technique should be recommended for producing ectomycorrhizal *D. alatus* seedlings in the future.

Heart-rot detection in standing *Larix kaempferi* (Lamb.) Carrière trees in plantations in Pyeongchang, Gangwon-do, Republic of Korea. Shin, J.H., Lee, D.K., Kwon, K.C. (*Seoul National University, Republic of Korea; hun3170@hotmail.com; dklee@snu.ac.kr; kkch30@yahoo.co.kr*), Kim, K.T. (*Sangji University, Republic of Korea; gtkim@sangji.ac.kr*), Lee, K.W., Kim, H.J. (*Seoul National University, Republic of Korea; b20927@nate.com; hjkim0916@gmail.com*).

Transverse stress-wave velocities in standing *Larix kaempferi* trees were measured using the time-of-flight method to detect heart-rot in sampled trees. Measurements were made at 10 cm and 120 cm above the ground on trees at two sites in Pyeongchang, Republic of Korea: (1) first site with 50 measurement trees of approximately 40 years old, and (2) second site with 86 measurement trees of approximately 50 years old. After the measurement, all trees were cut down to inspect the presence or absence of heart-rot. Results of the study show that incidence rate of heart-rot in each site was 18.0% and 72.1%, respectively. Hence, precaution against heart-rot is necessary in Korea. In addition, it was observed that as the diameter of trees increases, measured velocities also increase. Considering this tendency, it is necessary to use predictions using regression equation to discriminate sound wood from decayed wood. The rates of detection varied with the levels of prediction and sites. The rates of detection for heart-rot and sound wood in the first site were about 27.8% and 84.2%, respectively, and in the second site were about 31.9% and 93.4%, respectively, at 89% to 95% level of prediction.

Research on mycorrhizal fungi and plantation in China. Wu, X., Wang, Q., Wang, Y., Dai, L. (*Chinese Academy of Sciences, China; xq_wu2008@163.com; wangqingwei08@mails.gusas.cn; wyforest@126.com; lmdai@126.com*).

Mycorrhizal fungi (MFs) are indispensable components of forest systems. Fungus-root symbiosis stimulates tree growth, and different trees species can be linked underground via a common mycelial network. MFs may also have an indirect stimulative effect on rhizosphere bacteria. Thus, the incorporation of these fungi should be considered when establishing plantations. Some basic data exist regarding the existence and use of MFs for forests in China. In 2008, 82 species of ectomycorrhizal fungi were reported from a mixed forest in Liaoning Province, while in 1997 and 1987, 58 endomycorrhizal fungi species in 5 genera were reported from fruit trees and eucalypt forests in Shandong and southern China. Scientists at the Guangdong Academy of Forestry planted *Pinus elliottii* on soil to which mycorrhizae was added in 1975. Scientists at the Chinese Academy of Forestry have also successfully selected and applied these fungi in plantation establishment. Other researchers have applied MFs to at least 11 kinds of trees in southern China, Beijing, Shanxi, and elsewhere and reported positive effects on tree growth. Despite such progress, further research on the basic mechanisms of symbiosis involving MFs should be an important priority for forestry in China.

D-08 Role of trees outside forests in Asia's changing forestry environment

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Ecological and cultural values of native trees: a case study of *Ficus* trees in South India. Bhaskar, D., Viswanath, S. (*Institute of Wood Science and Technology, India; krupaias@gmail.com; sviswanath@icfre.org*), Purushothaman, S. (*Ashoka Trust for Research in Ecology and the Environment, India; seemap@atree.org*).

Karnataka state of South India, especially Mandya district, harbours a remarkable diversity and abundance of various species of ficus as components of rainfed agrarian systems. These trees provide numerous direct-use benefits (fuel, fodder, shade, and timber) to farmers and also perform crucial ecosystem services such as soil enrichment through litterfall, water conservation, and supporting local biodiversity. In the present study, nutrient addition to soil through ficus litterfall was quantified by collecting litter in specially designed traps of 1 m^2 placed under 10 *Ficus benghalensis* trees in farmer's field for 1 year. Surface litter decomposition and annual release of nutrients (N, P, and K) were studied and the monetary value of nutrients computed using surrogate valuation techniques. Farmers' perceptions on ecological and cultural values of trees were also elicited through detailed household surveys covering 100 farmers from 8 villages in Mandya. Results indicated that native trees such as ficus are more valuable than fast-growing exotic species such as *Eucalyptus tereticornis* and *Casuarina equisetifolia* when ecological and cultural services are also taken into account. The study highlights the need for policy incentives for indigenous systems, which have the potential to offer sustainable livelihood options to rural poor.

Factors influencing adoption of agroforestry among smallholder farmers in Zambia. Kabwe, G., Bigsby, H., Cullen, R. (*Lincoln University, New Zealand; Gillian.Kabwe@lincolnuni.ac.nz; bigsbyh@lincoln.ac.nz; cullenr@lincoln.ac.nz*).

Agroforestry technologies have been extensively researched and introduced to smallholder farmers in Zambia for more than 2 decades. Despite the research and extension effort over this period, not many farmers have adopted these technologies. The purpose of this paper is to determine why agroforestry technologies are not being taken up by examining factors that influence the adoption of agroforestry practices. Based on data obtained from 388 farming households, statistical analysis show an association between adoption of both improved fallows and biomass transfer technologies with knowledge of the technology, availability of seed, and having the appropriate skills. In addition some household characteristics are found to be linked to the incidence of adoption. However, the strength of association between these variables is low, giving an indication that there might be other factors at play limiting agroforestry adoption. It is anticipated that these findings will point to other areas beyond the household and community level that need further exploration in order to understand factors limiting agroforestry adoption.

Community-based forest management: an organizational perspective? Kumar, S. (*Indian Institute of Management-Lucknow, India; sushil@iiml.ac.in*).

In most developing countries, community-based forest management (CBFM) has emerged as a much advocated approach for sustainable forest management, inside and outside the forest areas. However, in spite of a focused policy and administrative efforts, the results of CBFM systems have been mixed. One of the major factors of failure, often neglected in the CBFM literature, has to do with the ability of the state forest departments to embrace and implement the concept of collaborative management. Viewed from the perspective of organizational theory and strategic management, strategies needed for implementing collaborative approaches of forest management differ from the ones currently in vogue in the state forest departments. Building on the framework that the CBFM paradigm demands sharing decision making powers, authority and control between the forest departments and various social players, some of the constraints the forest departments face in adopting and implementing the concept of CBFM, are examined. Understanding of incongruence between the working culture of state forest departments and the decentralized working ethos of CBFM regime may go a long way towards explaining the frequent gaps between policy and practice.

Urban forest structure of Kuala Lumpur. Maruthaveeran, S. (*Forest Research Institute Malaysia, Malaysia; sreetheran@frim.gov.my*).

Tree planting programmes in Malaysia have progressed as planned since in the 1970s. However, the management of the street trees is not well-undertaken due to inadequate information about the trees by the Kuala Lumpur City Hall (DBKL) for the management and maintenance purposes. There has never been a systematic tree survey conducted to inventories the street trees in Kuala Lumpur. With this, a survey was conducted in five major roads in Kuala Lumpur. A total of 2,291 trees by 35 species from 16 families were enumerated. The survey shows that 68.6% of the species were indigenous species and 31.4% were exotic species. Among the three dominant species were *Pterocarpus indicus* (34%), *Pelthophorum pterocarpum* (20%), and *Samanea saman* (18%). The analysis of the species diversity index (SDI) for the street trees in Kuala Lumpur has shown that the SDI was moderately low (SDI = 5.0). Therefore the SDI for Kuala Lumpur could be enhanced by selecting underused species besides being based on both biological/genetic diversity and special characteristic of planting sites. We hope this database would foster a greater appreciation of 'green' elements and promote research, technology and the professional practice of tree planting and landscaping as a whole.

Trees outside of forests: a case study on species composition, structure, and role of homestead forestry in Bangladesh. Muhammed, N., Oesten, G.,Von Detten, R. (*University of Freiburg, Germany; nur.muhammed@ife.uni-freiburg.de; oesten@ife.uni-freiburg.de; r.v.detten@ife.uni-freiburg.de*), Hossain Masum, Md., Hossain, Md., Chakma, S. (*University of Chittagong, Bangladesh; masum5602@yahoo.com; mohitulh@yahoo.com; shiladitya_cu@yahoo.com*).

Rural homesteads in Bangladesh play a major role in timber and fuelwood supply. Homestead forests practicing traditional agroforestry occupy 2,951.40 km^2 (2% of the land area). Homestead forests/village forests in Bangladesh also are rich in terms of yield and species diversity. Home gardens provide about 80% of the total fruits, 65–75% of saw logs, 90% of fuelwood, and 73% of bamboo consumed in Bangladesh. Designated forest area accounts for 15% of the landmass but forests in Bangladesh are deteriorating at an alarming rate. This study, conducted in Mymensingh district, focused on species composition, species diversity, number of trees in homesteads, and trends of tree growing in homesteads. We collected information using a semi structured questionnaire, formal and informal interviews, focus group discussions, and field observations. We found that homestead forestry produces a mixture of economic, aesthetic, environmental, and social goods and services. However, rural dwellers still lack scientific information on species selection and optimal utilization of homestead area to maximize production. It is necessary to work on developing region-specific, well-planned, multi-layered cropping models with proper species list for sustained homestead production, to help mitigate a forthcoming demand-supply gap for biomass energy, timber, fruits, and bamboo uses in Bangladesh.

Posters

Biomass production and carbon sequestration in an irrigated poplar-wheat agro-ecosystem in India. Chauhan, S., Gupta, N., Babuta, R., Yadav, S. (*Punjab Agricultural University, India; chauhanpau@rediffmail.com; naveen_pau@rediffmail.com; ritubabuta@gmail.com; sudhir_ydv@yahoo.com*).

In the irrigated agro-ecosystem, poplar and wheat combination is an important option because of the trees' leafless condition during most of the wheat cropping season. An attempt has been made to assess the productivity as well as the carbon sequestration potential of this mixture. The grain as well as straw yield were significantly lower in poplar block plantations than in the open (14 to 64% and 13 to 66% grain and straw yield, respectively under 1- to 6-year-old plantations). The annual productivity of poplars was recorded maximum after fourth year and later the annual wood increment decreased (42.4, 39.8, and 35.6 m^3/ha/yr after 4^{th}, 5^{th}, and 6^{th} year, respectively). The enrichment of soil through litter and roots enhanced the organic carbon in the surface layer of soil (0–15 cm) under poplar blocks as compared to open fields with wheat crop only. The carbon storage in agroforestry system increased with the age of the plantation and the major contribution came from the timber, roots, and litter (37.30t/ha after 6 years). However, wheat crop yield decreased under poplar but this may be compensated by the poplar trees in terms of biomass, economic returns and the carbon sequestration potential.

Heritage trees of India: ambassadors for global biodiversity. Gupta, A. (*Loreto Convent School, India; anuguptaevs@gmail.com*), Gupta, S. (*Dayanand Public School, India; shivai.gup@gmail.com*), Gupta, H. (*Forest Survey of India, India; hemantgup@gmail.com*).

India has a long tradition of forest management, and examples of cultural wisdom such as sacred forests and tree temples have kept the landscape healthier through many centuries. The heritage trees of India have names that ring with culture and religion with special significance to humans. The most revered living organisms on Earth, e.g. the Bodhi tree, *Ficus religiosa* at Bodh

Gaya; the giant Banyan tree (*Ficus bengalensis*) in Guitibayalu village, Andhra Pradesh, which has broadest canopy in the world (2.1 ha); and the ber tree (*Zizyphus* sp.) at the Sikh Golden Temple of Amritsar; "*Kalpvriksh"* (*Morus*) tree at Joshimath, Uttrakhand serve in many ways as advocates for conservation of biodiversity. As environmental crises mount throughout the world, we need strong advocates for conservation, and heritage trees are the perfect ambassadors for global biodiversity. We have documented, photographed, and profiled 20 individual heritage trees of various species for their history, management, age, spiritual value, ethno-botanical uses, and sizes across various physiographic zones in India. The key to organizing the information is as a representative of its species and consequently a representative of the natural world.

Cost-effective assessment of tree resources outside of forests: community-based strategies for their sustainable management. Omprakash, M.D., Gupta, H.S. (*Indian Institute of Forest Management, India; prakash@iifm.ac.in; hsgupta@iifm.ac.in*).

Tree-based livelihood generation is gaining relatively higher importance in developing nations including India. But their extent and the status of their management with a sustainable development approach to meet the local community needs is not studied very well, hence requiring a cost-effective mechanism for the proper assessment for evolving their sustainable development mechanism through participatory approach. The paper attempts to use scientific methods involving the community participation approach to assess and understand trees outside of forests (ToF) in terms of their extent, distribution pattern, diversity, and socio-economic and cultural values attached to them, in dry regions of central India using GIS and other ecological/social tools. The lesson learnt from the study has helped us standardize a cost-effective method for assessing and planning them. Remotely sensed data (LANDSAT -7, ETM+) is used to quantify the ToF at micro level, whereas large-scale R.S. data (Google) is used for cost effectiveness. Field samples were laid, basing analysis of large-scale R.S. data. Participatory mechanisms were used for qualitative assessment: diversity, ecological, economical, socio-cultural values of ToF. The wisdom of the community and scientific tree management combined together contributed to drawing a sustainable development strategy for TOF resources.

Role of trees outside forests (TOF) as mitigation and adaptation options for meeting challenges of sustainable livelihoods and environmental sustainability in Asia. Saxena, V. (*Ministry of Environment and Forests, India; viveksax1@gmail.com*).

Asia and the Pacific region, with more than half the world's population and 18.6% of the forest area, face the challenges of meeting development and wood products needs of the growing population while developing forest management strategies to cope with conservation, production, restoration, mitigation, and adaptation aspects. Challenges of sustainable livelihoods and environmental sustainability for the region are multidimensional and varied. Trees outside forests (TOF) have emerged as a potential adaptation and mitigation strategy to meet the challenges of climate change, offering protection to natural forests as the fast-growing demand for wood products is met from TOF. TOF is also a potentially effective option for adaptation for sustaining and improving livelihoods of farmers due to decreasing agricultural output. The paper analyses the role of TOF models for mitigation and adaptation options and identification of key barriers in adoption of various models, including successful models from Yamunanagar, Haryana, India. The success of TOF has led to the evolution of markets of more than US$210 million. Adaptation by rural people to the effects of climate change and the importance of linking carbon credits more aggressively with TOF are issues to be addressed in all policy options.

Yield and oil content ideotypes specification in *Jatropha curcas* L. Vallesteros, S.F. (*Nueva Vizcaya State University, Philippines; sfvallesteros@gmail.com*), Carandang, W.M., Palijon, A.M., Cruz, R.V.O. (*University of the Philippines Los Baños; Philippines; wm_carandang@yahoo.com; ampalijon@hotmail.com; rexcruz@yahoo.com*).

Twenty four trees were selected from an experimental plantation to specify an ideotype for *Jatropha curcas* L. based on seed yield and oil content. Variability was large in all morphological traits such as unbranched stem (CV = 46.51%) and number of first order branches (CV = 33.72%). Seed yield was positively and significantly correlated with basal diameter, length of unbranched stem, and crown diameter. Variability was small in fruit and seed traits. Crown diameter appeared to be a predictor of three seed size parameters ($P<0.05$), namely: length, breadth, and thickness. Among the seed traits, seed length was significantly correlated with oil content. The oil content in kernel ranged from 41.40% to 59.26%. The proposed ideotype can be described as a relatively short tree with big and circular basal diameter; large first-order branches positioned low on stem forming an angle of more or less 50° from horizontal; crown is rounded and compact; large number of fruits per bunch and fruits ripen at the same time or nearly so; bearing large fruits with three seeds per fruit; and long seed length. The ideotype may tolerate some amount of shade and should be spaced 2 m × 2 m or wider.

D-09 Changes in climate and air pollution—new directions in forest monitoring, research and modeling

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The use of electronic dendrometer bands to detect responses of tropical trees to drought. Lingenfelder, M. (*University of Freiburg, Germany; marcus@biom.uni-freiburg.de*), Newbery, M. (*University of Bern, Switzerland; david.newbery@ips.unibe.ch*).

Assessing the immediate effects of potentially more frequent and intense climate-change-related droughts on normally a seasonal, everwet tropical forests is challenging. Here we suggest the use of dendrometer bands for continuous high-resolution monitoring of stem girth variation to observe tree species' responses to changes in water availability. We present results of a study in a lowland dipterocarp forest in Sabah, Malaysia. Permanent electronic tree-growth sensors and conventional dendrometer bands were installed on six key tree species along with soil moisture sensors in a long-term research plot. The data so far (monitoring is ongoing) revealed a strong relation of water availability and stem size variation. The trees showed a pronounced daily rhythm of

stem water depletion during the day and refilling at night. The response to water availability was also visible across weeks and months (mean change: 4.2 mm y^{-1}), with large differences between the individual trees (range: –1.5 to 31.9 mm y^{-1}). We propose that permanent girth monitoring will give an insight to species-specific mechanisms of drought tolerance/avoidance and disclose short-term responses of tropical trees to dry events, possibly revealing the (dynamic) intensity of droughts that could lead to irreversible damage to the structural stability of the forests.

Warming-determined spatial and temporal patterns of forest dieback in Inner Asia. Liu, H., Wu, X. (*Peking University, China; lhy@urban.pku.edu.cn wuxiuchen2000@gmail.com*), Anenkhonov, O. (*Institute of General and Experimental Biology, Russian Federation; anen@yandex.ru*).

Temperate and boreal forests border Inner Asia, the world's largest dryland, and form a long and diversified forest-steppe ecotone. Forest dynamics in this circum-gobi ecotone strongly contribute to regional climate feedback, carbon pool, and environmental conditions in the northern hemisphere. Geographical heterogeneity was stressed in studies on vegetation response to climate change at the site scale, although water deficit was documented to be commonly constraining tree growth. Here we report a MAP-associated forest growth pattern with forest-dieback near the xeric tree-line, reduction in forest-growth within the forest-steppe ecotone, and increase in forest-growth in continuously distributed forests. Tree-growth as indicated by ring-width and basal area index (BAI) is significantly associated with Palmer drought severity index, proxy of soil moisture, in this region. We also identified a threshold of drought duration of 15 dry months during the growing season of the prior 3 years for forest dieback, regardless of contribution from winter water storage. The border between water surplus and water deficit for tree-growth has shifted and area of water deficit has been enlarged, which is clearly caused by raised temperature, during the past 50 years. To monitor forest dynamics in this region, a transect across the ecotone is proposed.

The carbon balance of forest ecosystems in China. Piao, S. (*Peking University, China; slpiao@pku.edu.cn*).

Clarifying the size and spatial pattern of China's forest carbon stocks is important for understanding the regional and global carbon cycle, because China is the largest country in Asia and has been experiencing the largest afforestation in the world. Since the late 1970s, the Chinese government has implemented several large forest ecological programs including Three-North Protective Forest Program, Taihang Mountains Greening Project, South China Timber Program, Combating of Sands Desertification Project, and the Yangtze River Protective Forest Project. In this study, we use the Chinese National forest inventory data since the early 1980s and the corresponding NOAA/AVHRR NDVI data to estimate China's forest biomass C storage and its variations. Process-based ecosystem models are also applied to quantify the effect of changes in CO_2 and climate on the forest growth and carbon balance in China. The major objectives are: (1) to elucidate China's forest biomass carbon storage and its spatial patterns; (2) to quantify the size and distribution of China's forest biomass carbon sources and sinks over the next several decades; and (3) to characterize how future changes in precipitation, temperature, and atmospheric CO_2 concentrations will influence forest carbon cycle.

Vulnerability of mountain biogeography and biogeochemistry to changes in climate, CO_2, and tropospheric O_3 in the Yunnan Province, southwest China. Poulter, B. (*Swiss Federal Research Institute WSL, Switzerland; poulter@wsl.ch*), Sitch, S. (*University of Leeds, UK; s.sitch@leeds.ac.uk*), Schaub, M., Zimmermann, N. (*Swiss Federal Research Institute WSL, Switzerland; marcus.schaub@wsl.ch; niklaus.zimmermann@wsl.ch*).

Interactions between tropospheric O_3, climate change, and elevated CO_2 are increasing in their importance in determining ecosystem functioning. Evidence from field and modeling studies suggest that increasing O_3 and warmer climates can have additive effects, whereas the effects of O_3 and CO_2 on photosynthesis may compensate one another. At the regional scale, disentangling the spatial and temporal vulnerability of forest ecosystems to multiple stressors is required to inform management and monitoring options. We modify the physiologically-based LPJ dynamic global vegetation model (DGVM) to include an ozone damage function that directly reduces photosynthesis as a function of stomatal conductance, species, and ozone concentration. The model is used to investigate the vulnerability of spatial-temporal dynamics of mountain biogeography and biogeochemistry in the Yunnan Province, southwest China. These ecosystems represent a globally significant biodiversity hotspot as well as an important landscape that sustains food and fibre resources to local communities. The LPJ DGVM includes physiological feedbacks from stomatal conductance and water use efficiency which is scaled to individual species and vegetation competition. The steep environmental gradients in this mountainous region result in varied patterns of vulnerability and ecosystem change, which can be used to prioritize resources for monitoring and management of forest systems.

The EANET challenge on the catchment-scale analysis for the future integrated monitoring. Sase, H., Luangjame, J. (*Acid Deposition and Oxidation Research Center, Japan; sase@adorc.gr.jp; Jesada@adorc.gr.jp*), Garivait, H. (*Environmental Research and Training Center, Thailand; garivah@deqp.go.th*), Urban, S. (*Malaysian Meteorological Department, Malaysia; sinia@met.gov.my*), Yamashita, N. (*Acid Deposition and Oxidation Research Center, Japan; nyamashita@adorc.gr.jp*), Nakahara, O. (*Hokkaido University, Japan; nakahara@chem.agr.hokudai.ac.jp*), Kietvuttinon, B., Visaratana, T. (*Royal Forest Department, Thailand; bopitk@hotmail.com; tt_b42@yahoo.com*), Kobayashi, R. (*Acid Deposition and Oxidation Research Center, Japan; rkobayashi@adorc.gr.jp*), Takahashi, M. (*Forestry and Forest Products Research Institute, Japan; masamiti@ffpri.affrc.go.jp*), Hakamata, T. (*Japan; tomo61@as.airnet.ne.jp*), Chappell, N. (*Lancaster University, UK; n.chappell@lancaster.ac.uk*), Leong, C. (*Malaysia; leong.chowpeng@gmail.com*), Ohta, S. (*Kyoto University, Japan; otasei@kais.kyoto-u.ac.jp*), Shindo, J., Hayashi, K. (*National Institute for Agro-Environmental Sciences, Japan; shindo@niaes.affrc.go.jp; kentaroh@affrc.go.jp*), Matsuda, K. (*Meisei University, Japan; matsuda@es.meisei-u.ac.jp*).

Integrated monitoring of atmospheric deposition, soil, vegetation, and inland water is required to evaluate effects of atmospheric deposition on ecosystems qualitatively and quantitatively. For this purpose, the Acid Deposition Monitoring Network in East Asia (EANET) has promoted case studies on catchment-scale analysis in several forest types of the East Asian region, including a tropical seasonal forest in Sakaerat, Thailand; a tropical rainforest in Danum Valley, Malaysia; and a temperate coniferous forest in Kajikawa, Japan. The similar catchment-scale monitoring has also been conducted in the catchment of Lake Ijira in Japan, one

of the EANET sites. Several factors, including climate, hydrology, geology, soil, vegetation, and atmospheric deposition may affect stream water chemistry. In the tropical catchments, stream water chemistry at the Sakaerat site changed significantly from the beginning to middle of wet season, reflecting the distinct climatic seasonality, while that at the Danum Valley site was regulated mainly by water discharge. In the temperate catchments, atmospheric deposition may have a larger role; acidification of soil and/or stream water has been seen with high sulfur and nitrogen depositions. Data and experience from these case studies will also be informative for development of biogeochemical model applicable to the East Asian catchments.

Challenges of long-term ecological research in forest ecosystem under climate change and air pollution: biogeochemical perspectives in northern Japan. Shibata, H. (*Hokkaido University, Japan; shiba@fsc.hokudai.ac.jp*).

Climate change and air pollution are among the major disturbances factors for forest ecosystems. Understanding the biogeochemical processes in forest ecosystems with large temporal and spatial scales is critically important to clarify the mechanisms, drivers, and future prediction of ecosystem functions under environmental changes. Decrease of winter precipitation, shortage of snowpack period, and the increase of long-range transport of air pollutants with winter monsoon from Asian continents would be possibly hot issues to alter the biogeochemical processes such as nitrogen cycling, carbon sequestration, water quality formation, and so on. Long-term ecological research (LTER) is a strong research approach to study ecosystem structures and functions in core-research sites. Long-term monitoring and modeling in northern Japan LTER sites have produced valuable research findings for future research directions that include the decrease of the snowpack over the past 50 years, change of soil nitrogen cycling due to the soil freezing under the lesser snow, and the future change of stream nitrate chemistry due to the increase of air CO_2 concentration and atmospheric nitrogen deposition. The networking and comparative research programs utilizing the LTER sites would provide innovative research opportunities and functional research platforms for upcoming research.

Posters

Acetone and hot water extractives, carbohydrate, and lignin content of O_3-exposed *Pinus thunbergii* as new indicators for stress evaluation. Han, S., Kim, D. (*Korea Forest Research Institute, Republic of Korea; simhee02@forest.go.kr; dhkim@forest.go.kr*), Shin, S. (*Chungbuk National University, soojeongesf@hotmail.com*).

We have tried to find new indicators to evaluate stress tolerance in O_3-exposed *Pinus thunbergii.* The first group wasn't exposed to O_3 as a control. The second group was exposed to O_3 for 2 years, and the third group was exposed to O_3 during the first year and released from O_3 stress during the second year. The extractives of acetone and hot water and carbohydrate content decreased in the needle of 2-year-exposed seedlings when compared to the control, and those of 1-year-exposed and released seedlings were similar with the control. In contrast, lignin content increased in the leaves of the 2-year-exposed seedlings, and the 1-year-exposed and released seedlings showed a similar lignin content as the control level. Carbohydrate content in the leaves was affected by cellulose content. Although sterol content was not significantly different, it decreased during O_3 exposure and then reached the control level during the recovery stage. According to the results, it is suggested that the extracts of acetone and hot water and carbohydrate and lignin content as well as sterol content may be considered as very useful indicators to evaluate stress tolerance.

D-10 Mountain forestry in a changing world—challenges for research and education in continental Asia

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Erosion relevant topographical parameters derived from different DEMs: a comparative study from a forested Himalayan watershed. Datta, P., Schack-Kirchner, H. (*Freiburg University, Germany; pawandatta@rediffmail.com; helmer.schack-kirchner@bodenkunde.uni-freiburg.de)/*

Removal of vegetation from steep slopes in conjunction with high-intensity rainfall results in accelerated soil erosion in the fragile Himalayan region. Assessment of degradation hazard using soil erosion modelling tools is crucial for landuse management in this region. Soil erosion studies use a digital elevation model (DEM) to derive the topographical characteristics of the terrain. In most soil erosion studies from mountainous areas, DEMs are incorporated as a given parameter that is not tested extensively, in contrast to soil, land use, and climate related parameters. This study compares erosion relevant parameters—elevation, slope, aspect, and topographical LS-factor—computed for a 13-km^2 watershed located in the Indian Lesser Himalayas. The DEMs used were a digitized DEM generated from 1:50,000 topographical map, SRTM DEM at 90m resolution and ASTER DEM at 15-m resolution. The DEM-derived topographical parameters were compared with 152 field measurements from the catchment. Significant differences across the DEMs were observed for all parameters. ASTER DEM was observed to fail for steep slopes and rough terrain. SRTM and digitized DEM showed similar behavior in their variability from the field measurements, suggesting SRTM as a DEM of choice for soil erosion modelling in the region.

Participatory mountain forestry development in Nepal. Lamsal, R.P. (*Ministry of Forest and Soil Conservation, Nepal; ramplamsal@gmail.com*).

The mountains of Nepal significantly influence the people's well-being directly and indirectly by providing both materials and environmental services. To prevent degradation of mountain ecosystems and sustainably manage the forest resources, two major participatory approaches—community forestry and community-based conservation areas—have been evolved. This study assesses the conceptual, legal, and institutional aspects of the two approaches, their similarities and dissimilarities including existing antagonism between them; analyzes the complexities in implementing community forestry in the northern high mountains and southern Siwalik hills; and proposes possible improvement measures. This study is based on primary information, experiences,

and literature review of various agencies. Despite many similarities, the two approaches differ on legal status, management priority, rights and obligations, institutional system, and benefit sharing. The specific features of strengths and problems of each sub-mountain regions make it impractical to propose a generalized approach. However, the common denominators are to find a balance between conservation and utilization, recognize communities as the primary guardian and bring changes in traditional mindset of mountain forest management. Finally, recommendations are made on policy issues along with the removal of antagonism between the two approaches by promoting constructive ideas for coexistence or integration.

Developing sustainability assessment indicators within an adaptive cycle framework: a case study of rural multiple-use forest in the southwest mountain region of China. Peng, S.J. (*Gent University, Belgium; psjing@gmail.com*), Sun, Z.Z., Ou, X.K. (*Yunnan University, China; sunzh@live.com; xkou@ynu.edu.cn*).

Community-based forest management has become a major feature of the contemporary world's forest governance, yet lack of proper indicators for sustainability assessment restricts it in practice. Especially in forest-dependent communities, lack of consideration of internal adaptation hampers our understanding of sustainability in rural multiple-use forest management. In this study, we attempt to identify sustainability indicators for rural forest management by using an adaptive cycle framework. Based on specific case of Tibetan-oak forest system in southwest mountain region of China, patterns and processes of various rural forest practices are examined. Quantitative and qualitative analysis have been conducted using data from semi-structured household interviews in forest-dependent community groups. Firstly, relationships were established among key household characteristics, forest productions, resource utilization behaviors, and forest management perceptions. Secondly, a conceptual framework was developed to illustrate the household-level adaptive cycle of rural multiple forest practices. At lastly, potential indicators to assess the sustainability were identified. Findings emphasize functional interdependencies and efficiency in forest management. In addition, this approach may lead to development of a process-oriented indicator, which can facilitate the understanding of factors influencing decision-making and goes beyond isolated indicator sets at the forest management unit level.

Temporal patterns of demands for forest land use conversion in South Korea. Seol, A., Chung, J., Song, J. (*Seoul National University, Republic of Korea; araseol@hanmail.net; jschung@snu.ac.kr; readjean@hanmail.net*).

Temporal patterns of demands for forest land use conversion at the national level were analyzed and the future demands were estimated by using time series analysis. According to national statistics, in the past 26 years (1982–2007), the area of forest land use conversion has a fluctuation pattern of around 8,000 ha, whereas the number of occurrences of forest land use conversions had a tendency to increase. In the 1980s, land use conversion for mining, pasture, and military facilities was in high demand associated with the political condition and industrial structure. Since the 1990s, demands for building roads, plants, and houses have increased in relation to the national land development plans and showed sensitive responses to changes in housing and economic policies. Recently, demands for building golf facilities have occupied a great proportion of the area of forest land use conversion, bringing social debates on environmental protection versus economic benefit. Meanwhile, future demands were predicted by Vector Autoregressive Model, having population and increase rate of urbanization as exogenous variables. The area of forest land use conversion showed fluctuation patterns within the range of the maximum 13,880 ha and the minimum 6,430 ha until 2020.

Regional characteristics of forest land use changes in South Korea. Song, J., Seol, A., Chung, J. (*Seoul National University, Republic of Korea; readjean@hanmail.net; ara2007@hanmail.net; jschung@snu.ac.kr*).

The objective of this study was to investigate the temporal patterns of forest land use changes by 16 provincial districts of South Korea. The national statistics from 1982 through 2007 for the provincial forest land use changes were used in interpreting the temporal patterns in relation with the 10-year national land development plans in the past. The provincial characteristics of forest land use patterns from 2001 through 2007 were also analyzed using principal component analysis (PCA). In using PCA, three explanatory variables were chosen, including the number of occurrences of forest land use change per person as the first principal component; hectares of forest land use changes for construction of roads and industrial and residential sites as the second; and hectares of forest land use changes for construction of military installations, telecommunication facilities, and farmlands as the third. The three principal components explained 71% of variations among the provincial forest land use patterns, and the scatter plots of the three principal components appeared to be quite reasonable in classifying the forest land use change patterns of the 16 provincial districts associated with the corresponding regional characteristics.

Posters

A study of revitalization method of forest green tourism in Gangwon Province after KORUS FTA. Ahn, S.I. (*Gangwon Provincial Office, Republic of Korea; seung9258@gwd.go.kr*), Woo, J.C., Choi, I.H. (*Kangwon National University, Republic of Korea; jcwoo@kangwon.ac.kr; inchoi@kangwon.ac.kr*).

Mountain villages in Korea have many problems such as declining population, aging, increasing farm debts, and poor life environments. It will be also much worse than now when UR (Uruguay Round), DDA (Doha Development Agenda), and KORUS (Korea and USA) FTA come into effect. People require more than ever before to benefit from recreation and tourism from forests near their mountain villages. A new green-tourism policy is needed to revitalize the economic condition of mountain villages, and existing forest management direction needs to change to reflect this need. This study investigated the existing green-tourism policy of Gangwon province in place since the beginning of KORUS FTA negotiation, considering mountain village actual conditions of Gangwon Province and a resident attitude survey. Conclusions point to: (1) development of a tourism-resource-oriented focus by promoting forest management with amenity in the mountain village region; (2) inefficiencies caused by dispersed development of mountain village regions in central departments; (3) software development is needed for the diverse and unique mountain villages region; and (4) activism movement through communication between mountain villages and urban areas for the institutionalization of public authority.

Forest vegetation and sites of seminatural production forests in the montane zone of the western Qingling Mountains, Gansu Province, China: the basis for near-natural forestry. Dai, C., Reif, A. (*University of Freiburg, Germany; dai.chunling@waldbau.uni-freiburg.de; albert.reif@waldbau.uni-freiburg.de*).

Seminatural forestry has to be based on knowledge of the ecology of the species, their site demands, and forest communities. In China, these relationships have been only poorly known until today. The ca. 300-ha study area is located in a region with seminatural forests in the western Qingling Mountains, Gansu province, China. Using a systematic sampling design, site and vegetation parameters were recorded on 120 plots, each of 400 m^2 size. Light parameters (direct solar radiations) were measured as geographic and topographic variables, analysed with DACHRad. The water household was modelled using meteorological data, corrected by elevational trends, and irradiation differences due to aspect, slope, and free horizon, and expressed using the humidity index and the water balance concept. Vegetation data were analysed using multivariate methods (ordinations, classifications). Near-natural forest communities were defined based on the species composition. Four forest communities were defined, and their sites characterised by their water household (irradiation, humidity index, water deficit) during the vegetation period (April to October). This allows recommendations for tree species selection of a near-natural silviculture.

Seed viability and amount of major fallen broadleaved tree seeds in the central region of the Korean peninsula. Kim, H.J., Lee D.K. (*Seoul National University, Republic of Korea; hjkim0916@gmail.com; leedk@snu.ac.kr*).

To examine the possibility of natural regeneration of broadleaved mixed forest, we measured 785 samaras per ha that fell in the *Fraxinus nigra var.mandshurica* (Rupr.) Lingelsh trees, and at least 178 drupes per ha that fell in *Juglans mandshurica* Maxim. trees. The total seeds of 13 tree species were 829,995 per ha. Seeds were divided into four groups— sound, under-developed, empty, and decayed or damaged. Viable seeds of *Kalopanax septemlobus* (Thunb.) Koidz. had the lowest value of fallen seeds (3.4%), and those of *Acer pictum* var. *mono* had 6.6% fallen seeds. Viable seeds of *F. rhynchophylla* Hance had the highest value of fallen seeds (53.4%). This study shows that viable seed supply might be a key factor in natural regeneration of broadleaved mixed forest in Korea.

Growth characteristics analysis in age class VIII and IX *Zelkova serrata* artificial forest of Gwangneung Experimental Forest in Gyeonggi Province, Korea. Kim, H.S., Bae S.W., Lee K.J. (*Korea Forest Research Institute, Republic of Korea; firekim98@hanmail.net; bae1144@forest.go.kr; lkj0217@forest.go.kr*).

This study was performed to provide basic growth information for sustainable forest management of *Zelkova serrata* artificial forest in Korea, through analysis of stand structure and growth characteristics. Current stem density of site 1, age class IX and site index (SI) 14, is 409 (trees ha-1). Total stand volume (TSV) is 219.2 m^3/ha, including dominant tree 69.2 m^3/ha (31.6%), co-dominant 144.3 m^3/ha (65.8%), intermediate tree 5.2 m^3/ha (2.4%), and suppressed tree 0.4 m^3/ha (0.2%). Growth increment of dominant tree, analyzed by stem analysis, had mean annual increment (MAI) of DBH 0.45 cm/yr and volume 0.012 m^3/yr. Current stem density of site 2, age class VIII and SI 18, is 414 (trees ha-1). TSV is 192.6 m^3/ha, including dominant tree 139.3 m^3/ha (72.3%), co-dominant tree 41.0 m^3/ha (21.3%), intermediate tree 9.9 m^3/ha (5.2%), and suppressed tree 2. 4 m^3/ha (1.3%). Growth increment of dominant tree, analyzed by stem analysis, had MAI of DBH 0.44 cm/yr and volume 0.013 m^3/yr. Both study sites have higher stem density for their stand age because management not done at a suitable time after planting.

Vegetation transition process for about 40 years in subalpine forest after belt-cut treatment for natural regeneration in Okuchichibu Mountains. Tanaka, G., Sakurai, S. (*Nihon University, Japan; angra_mainyu@bird.ocn.ne.jp; ssakurai@brs.nihon-u.ac.jp*).

Already more than 40 years has passed since a belt-cut treatment was done in 1966 in the subalpine zone of Okuchichibu Mountains. We report the stand growth and surrounding conditions by comparing the actual survey with re-visits at the same stands in 1992, 2006, and 2009. *Betulla ermanii* dominated the canopy layer in 1992, numbers of *B.emarnii* have decreased year by year and basal area showed the same behavior. As individuals of *Tsuga diversifolia* increased 1,709.2/ha to 3,988.1/ha, approximately double, comparing 2006 with 1992. By the data obtained from new seedling surveys in 2009, *T. diversifolia* had the percentage that was 47.1% of all, 11,9235/ha; *Abies mariesii* had 29.6%; and *A.veitchii* had 15.8%. However, the most dominant species in 1992 and 2006, *B.emarnii*, didn't exist in 2009, and we supposed it would decline in the future. In addition, *Cervus nippon* (sika deer) began to increase recently at this area, and their heavy feeding damage to the vegetation will inhibit regeneration. Both the *Abies* species were fed upon to approximately 80% of each species, and *T. diversifolia* was fed upon at approximately 34.4%. We can estimate how many individuals have been killed by feeding damage from *C. nippon*.

D-11 Trends in Asian forest fire: effects on carbon, nutrient cycling and regeneration

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The dynamic of forest ecosystem after fire: changes of biodiversity composition and its structure. Boer, C. (*Mulawarman University, Indonesia; deboer1@telkom.net*).

The low growth of trees in most tropical rain forests is due in part to effects of fire, which can also temporarily set back the normally high level of diversity of animals and plants, resulting in a need for effective forest management. However, most forests in Indonesia have little to no management, in part because of large distances between national and local/provincial governments and also because of barriers and challenges regarding authority, corruption, and law enforcement. Such bureaucratic problems in developing countries like Indonesia require time to develop management strategies conducive to good forest governance.

International help must demand authority and responsibility for forest management and require guarantees that forests will be managed continuously and sustainably. Institutional structures that guide market behavior have been a driving force in the decline of biodiversity, so they must also contribute to any solution. Totally protected areas have an important role to play in biodiversity conservation, although they are a high cost solution in some areas. Clearly, a different strategy is needed to improve forest management systems, to overcome the uncertainty about biodiversity and other non market values, imperfect understanding of natural processes, and environmental impacts of logging and natural disasters, especially fire.

Ten years' vegetation regeneration in *Pinus densiflora* forests following fire. Choung, Y., Lee, K.S. (*Kangneung-Wonju National University, Republic of Korea; yschoung@kangwon.ac.kr; leeks84@kangnung.ac.kr*).

Pinus densiflora forests, which cover the largest forested area in Korea, are the most vulnerable to forest fires. However, the long-term process of natural regeneration has not been studied even though it is basic information for the management of the pine stands. In terms of stand development and species composition, vegetation recovery has been monitored for 10 years following the recorded East Coast fire, which occurred in 2000. Permanent plots were established in places with different burn severities and initial regeneration classes. Irrespective of different burn severities and regeneration classes, the herb and the shrub layers developed in the year of the fire occurrence. The upper layers, however, developed faster at the severe-burn plots than those at light-burn plots. Among plots with different regeneration classes, 'high' plots showed fast recovery, developing the sub-tree layer in the seventh year, while 'low' plots stayed at the shrub stage. We found that species composition is highly related to pre-fire composition, as most plant species have been regenerated from burnt stumps and subterranean organs. Successional trajectory shows that resprouting oak species such as *Quercus mongolica* and *Q. variabilis* are replacing pre-fire pine stands except for the 'low' plots.

Fire-induced disturbances of CO_2 exchanges between peat swamp forest and the atmosphere in Southeast Asia. Hirano T. (*Hokkaido University, Japan; hirano@env.agr.hokudai.ac.jp*).

Southeast Asia contains the largest area of tropical peatlands in coastal and subcoastal lowlands. Tropical peatlands, which coexist with swamp forests, have accumulated vast amounts of carbon as soil organic matter. Recently, however, tropical peatlands have been disturbed on a large scale by deforestation and drainage to produce timber and create farmlands. Such disturbance changes the peatland environment and enhances the decomposition of organic carbon into CO_2. In addition, drought caused by El Niño and Southern Oscillation (ENSO) and its consequent large-scale fires accelerate CO_2 release to the atmosphere from peat soil through decomposition and burning. We have measured CO_2 flux using the eddy covariance technique above three peatland ecosystems differing in disturbance conditions in Central Kalimantan, Indonesia, since 2004: an undrained forest, a drained forest, and re-growing vegetation after burning in 2002. The re-growing site was burnt again in 2009 and the drained forest was seriously damaged by the fire. I will talk about the effects of fires on the CO_2 balance of tropical peat swamp forest by comparison between CO_2 fluxes measured during, before, and after fires.

Effects of frequent surface fires on the forest structure and carbon stock in mixed conifer-broadleaved forests, southern part of Russian Far East. Kobayashi, M. (*Hokkaido University, Japan; baobab@for.agr.hokudai.ac.jp*), Bruanin, S.V., Nemilostiv, Y.P. (*Far Eastern Agricultural University, Russian Federation; fesau@mail.ru; nyp1112@mail.ru*), Kajimoto, T., Matsuura, Y. (*Forestry and Forest Products Research Institute, Japan; tkaji@ffpri.affrc.go.jp; orijoy@ffpri.affrc.go.jp*), Yoshida T., Satoh F., Sasa K., Koike, T. (*Hokkaido University, Japan; yoto@fsc.hokudai.ac.jp; f-satoh@fsc.hokudai.ac.jp; sasa@fsc.hokudai.ac.jp; tkoike@for.agr.hokudai.ac.jp*).

In the southern part of the Russian Far East, while birch-larch mixed forests possess huge carbon stock in vegetation, the forests have suffered from recent increases in surface fire. To evaluate the mechanism of how frequent fires affect the carbon stock there, we compared forest structures as affected by different frequencies of surface fires. In the transition stage from birch-dominant to larch-dominant forests (about 40 years old), the size distribution of DBH including all standing trees showed a bell-shaped type in the forest affected by more fires, while the forest with less fires showed reverse J shape. In both forests, larger trees (more than 6 cm of DBH) were not damaged at all. In contrast, birch and larch regenerate as seedlings in forests with less fire. Meanwhile, small larches were killed entirely in the forests with more fires, but there many small sproutings of birches. From the chronosequential survey of carbon stock in forests, birch forests stored less carbon as compared to larch forests in the older stage of succession. This suggests frequent surface fires may inhibit the change from birch-dominant to larch-dominant forests by preventing larch replacements. As a consequence, less carbon stock was estimated in the region.

Estimation of carbon emission from *Pinus densiflora* stands burned by crown fire in South Korea. Lee, B.D., Won, M.S., Koo, K.S., Yoon, S.H., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; byungdoo@forest.go.kr; mswon@forest.go.kr; kyosang@forest.go.kr; tree007tree@hanmail.net; mblee@forest.go.kr*).

Carbon emissions from forest fires have been considered as an important factor in the carbon balance of ecosystems and global climate change. We estimate the carbon emission from *Pinus densiflora* stands caused by crown fire at Mt. Palgong in Daegu Province, South Korea, by looking at three categories: surface, shrub, and crown layers. The combustion biomass is calculated by subtracting the biomass of burned stands from the biomass of undamaged stands with similar stand structures and site environments. In order to estimate the total biomass in the sample area, two different types of sampling methods are used. First, 2-m × 2-m sample plots are used to estimate the biomass of surface and shrub layer; and second, 10 trees in undamaged areas and 5 trees in burned areas are used to estimate crown layer biomass by cutting them via direct harvesting techniques. The results of the estimation of CO_2 emission shows 18,865 kg of CO_2/ha for the surface layer, 11,752 kg of CO_2/ha for the shrub layer, and 23,454 kg of CO_2/ha for the crown layer. Hence, the total CO_2 emission is 54,071 kg of CO_2 per ha.

Effects of management on the regeneration of plant communities after forest fire, Korea. Lee, K., Lee, S., Park, S., Shin, S., Kim, S., Kim, T., Won, D. (*Gangneung-Wonju National University, Republic of Korea; leeks84@gwnu.ac.kr; Leesh0115@hanmail.net; sdpark@gwnu.ac.kr; cewsook@hanmail.net; sc3226@hanmail.net; yesman007@hanmail.net; dk965060@naver.com*).

The vegetation regeneration process, soil erosion, and runoff discharge after forest fire were investigated at four sites differently managed in east coastal region, Korea: unburned (UBP), abandoned (BNA), pine-planted (BPL), and terrace sodding work site(BEC). Vegetation structure, vegetation indices, and standing biomass were UBP > BNA > BEC > BPL. Among the burned sites, BNA showed the most effective regeneration of woody layer and BEC showed the most effective regeneration of herb layer. Plant species showing high performance at the burned sites were *Lespedeza cyrtobotrya*, *Quercus mongolica*, *Miscanthus sinensis*, *Arundinella hirta*, etc. Ruderals and naturalized plants at BPL and BEC showed higher importance value than at UBP and BNA. Among burned sites, BNA showed the highest similarity of species composition with UBP. Soil erosion and runoff discharge showed strongly negative correlation with vegetation recovery state after forest fire. Amount of soil erosion and runoff discharge were UBP > BNA > BEC > BPL. We concluded that abandonment was the most effective management technique for natural and fast vegetation development and retardation of soil erosion. And terrace sodding work was the more effective management technique for the retardation of secondary disasters than pine planting work in the low regenerated sites.

The forest fire situation in Mongolia. Nachin, B. (*National University of Mongolia, Mongolia; baatarbileg@biology.num.edu.mn*).

Mongolia is a country with small forest resources. About 92 percent of the total original forest area of 17.5 million hectares is currently growing trees, while 8 percent is not. The main causes of forest degradation and deforestation are fire, overgrazing, mining, and illegal logging. Forest fire constitutes a major factor that determines spatial and temporal dynamics of forest ecosystems. About 4 million ha are disturbed to varying degrees, either by fire or logging. On the average, 50 to 60 large forest fires and 80 to 100 large steppe fires occur annually. Traditional forestry practices and low-impact and sustainable use of non-wood forest products in Mongolia are being subjected to dramatic changes, which are stimulated by increasing national and international demands for forest products. In conjunction with non-sustainable land-use practices and exploitation of natural resources, these fires have caused considerable ecological and economic damages and some have had trans-national impacts, such as through smoke pollution, loss of biodiversity, or forest degradation at the landscape level. Recent initiatives in Mongolia and the neighboring countries of Central Asia show encouraging results in addressing the fire problem by involving concepts of ecology- and community-based fire management.

Combination effects of understory dwarf bamboo and gap formation on tree regeneration in a post-fire deciduous broadleaved forest in northern Japan. Sato, K., Kobayashi, M., Hideyuki, S., Masato S., Takayoshi, K. (*Hokkaido University, Japan: sp796kh9@jupiter.ocn.ne.jp; baobab@for.agr.hokudai.ac.jp; saitoo@for.agr.hokudai.ac.jp; shibuya@for.agr.hokudai.ac.jp; tkoike@for.agr.hokudai.ac.jp*).

In northern Japan, man-made surface fires mainly consume dense dwarf bamboo (DB) which shadows the forest floor and inhibits tree regenerations. Post-fire, the forest floor experiences gradations of light because of different recovery speeds of DB. Furthermore, a surface fire kills the canopy trees partly and forms canopy gaps; these combination changes in understory and overstory vegetation can create complex light conditions. We hypothesized tree seedlings with different traits of light requirement would prefer the different habitats created by a surface fire, and consequently a surface fire contributes to the diverse tree composition. We established four types of sites differing in canopy conditions (closed or gap) and DB treatment (cleared or covered) and investigated the light conditions and response of tree-seedling emergence. Removal of above-ground parts of DB and gap formation resulted in the improvement of PPF. Light-demanding species in covered sites were less than in cleared sites, and that in gap sites was less than in the closed sites. Meanwhile, shade-tolerant species in the covered sites were more than in cleared sites, and no consistent trend was found between light-demanding traits and canopy conditions. Gap species showed respective trends. These results may support our hypothesis.

Climate change impacts on fire weather severity of the Great Xing'an Mountains boreal forests, northeastern China. Yang, G., Di, X.Y. (*Northeast Forestry University, China; lx_yg@163.com; dixueying@126.com*).

Fire has long been one of the most important reflecting factors for climate change in boreal forests. This paper concentrated on the Great Xing'an Mountains boreal forests of northeastern China, which contain about the most southern part of the global boreal forest biome. The objective of this study was to estimate the response of forest fire weather associated with global climate change. Simulations with the HadCM3 for the present (1960–1990) and future (2010–2099) derived climate data sets that were used to calculate indices of the Canadian Forest Fire Weather Index System. By comparing derived annual forest fire weather variation in the study region and indices calibrated and validated from the local weather and fire data, an increasing trend of fire weather severity was found for the period 2010–2099 under climate scenarios of SRES A2a and B2. For the scenario A2a, the annual-average FWI was predicted to rise by approximately 5% in the 2020s, 18% in the 2050s, and 46% in the 2080s when compared to the 1980s. For the scenario B2a, the annual-average FWI decreased by 3% in the 2020s, but increased 24% in the 2050s, 26% in the 2080s when compared to the 1980s.

Posters

Changes in forest ecosystems in the early stage after fire in the east coastal region in Korea. Lim, J. (*Korea Forest Research Institute, Republic of Korea; forefire@korea.kr*).

In 2000, 23,794 ha of forests in the east coastal region burned. The major tree species damaged by fire was *Pinus densiflora*. This study presents the result of monitoring the changes of damaged pine forest ecosystem after forest fire. *Quercus mongolica* dominated the northern facing slope and *Q. variabilis* dominated the southern facing slope after regenerating itself by sprouting from the fire-damaged stumps. But the height:growth ratio of these oaks started to show a notable decrease 9 years after fire. They only made sprouts on the stump again and again. On the ridge the seedlings of *P. densiflora* showed a radical invasion 8 years after fire. Dominant species of understory layer changed dynamically from year to year. *Lestedeza bicolour* dominated at the initial stage. Then only 3 years later, it changed to *Carex lanceolata*. For 10 years after fire, these kinds of changes occurred constantly. This phenomenon occurred similarly with insects, birds, etc. The number of *Parus major* decreased in the early stage and then increased 7–8 years after fire. Among aquatic species, dominant species changed 9 years after fire. It seems that every component of a rehabilitated forest ecosystem changes its composition about 10 years after fire.

The application of fine fuel moisture code (FFMC) and prediction of surface fuel moisture under future climate change in eastern Kangwon-Do, Korea. Park, H. (*Dongguk University, Republic of Korea; parkhs08@naver.com*), Lee, S., Kwon C. (*Kangwon National University, Republic of Korea; lsy925@kangwon.ac.kr; kcg3338@kangwon.ac.kr*), Yun H. (*Dongguk University, Republic of Korea; yunhy@dongguk.edu*).

The prediction of a forest fire occurrence under future climate change is very important for prevention of disaster in the future. As forest fire occurrence is related to environmental factors (climate, species of forest, topography, moisture of surface fuel, etc.), forecast of future environmental factors is needed to predict forest fire occurrence. In this study, we compared and analyzed surface moisture contents between assumed moisture contents from FFMC and observed moisture contents in Donghea region, eastern Kangwon-Do. We measured observed moisture contents from 1 day to 3–5 days after rain in forest from forest fire periods in 2007–2008. And we classified these data according to the rate of forest density (very dense, dense, and sparse). As the correlation coefficients between observed and assumed moisture under various forest densities were very high, we would assume moisture contents in deciduous forest and apply FFMC in eastern Kangwon-Do, Korea. Through more comparison on other regions in Korea, we would verify the usage of FFMC and this result would be a great help to draw a forest fire danger map under future conditions.

D-12 Forest restoration and economic valuation for poverty reduction and environmental conservation in Southeast Asia

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An assessment of carbon sequestration and metal phytoremediation potentials of four tropical timber tree species grown on tin tailings. Ang, L.H. (*Forest Research Institute, Malaysia; anglh@frim.gov.my*).

Abandoned tin minesites in Malaysia are contaminated with heavy metals. Metal phytoremediation with suitable tree species is preferred over other remedial methods of contaminated soils for many reasons, including their cost-effectiveness and environmental benefits (including carbon storage). This paper reports the finding of carbon sequestration and phytoremediation potentials of *Acacia mangium*, *Hopea odorata*, *Intsia palembanica*, and *Swietenia macrophylla* grown and established at a 125-ha study site at Bidor in Peninsular Malaysia through the ASEAN-Korea Environmental Cooperation Project. Soils were systematically sampled at the site and six representative trees of each species were selected from a 0.25-ha plot for determination of their dry biomass and heavy metal concentrations, i.e., cadmium (Cd), lead (Pb), arsenic (As) and mercury (Hg). Samples of soils and plants were analysed according to established methods. Results showed higher concentration of heavy metals in the stem than the primary roots (diameter > 2 cm) for all species. *A. mangium* and *H. odorata* accumulated significantly higher total amount of Pb, As and Hg than the other two slower growing species. This study highlights the potential of trees for carbon sequestration and phytoremediation in a degraded tropical ecosystem.

Spatially explicit tool for the assessment and monitoring of biodiversity: lessons from Mt. Makiling Forest Reserve, Philippines. Bantayan, N.C. (*University of the Philippines Los Banos, Philippines; ncbantayan@uplb.edu.ph*).

The paper presents years of on-the-ground experience in developing a GIS-based database for systematically generating data and information on biological and other natural resources of the Mt. Makiling Forest Reserve, one of the best-known biological areas in the Philippines. Since the data and information are spatially explicit, relationships between and among flora and fauna vis-a-vis environmental phenomena like soils, geology, slope, and hydrology are explained and contribute towards developing management prescriptions for the reserve. There are at least 100 years of data and information on Mt. Makiling from the early years of the School of Forestry. Since 1919, Elmer described 1,195 species with 50 species of mammals, 22 of which are endemic. However, habitat loss leads to species loss, pointing to the importance of keeping the ecosystem intact. Amidst a vast sea of rapidly expanding human settlements, agricultural croplands, and urban and industrial zones, the mountain ecosystem's integrity and environmental health is continuously threatened. To ensure a comprehensive assessment, future studies should focus on biodiversity at altitudinal, disturbance gradients, and sub-soil levels. The Makiling geodatabase offers scientists and managers the ability to better manage and protect the mountain's resources and services. The tool is replicable to other areas as well.

Economic valuation for sustainable mangrove ecosystems management in the Philippines. Carandang, A., Camacho, L., Dizon, J., Camacho, S., De Luna, C., Peras, R., Paras, F., Gevaña, D., Rebugio, L. (*University of the Philippines Los Baños, Philippines; tony115858@yahoo.com, camachold@yahoo.com.ph, josefina_dizon@yahoo.com, sonny_camacho@yahoo.com, delunacc@yahoo.com, rjjperas@yahoo.com, fdparas@gmail.com, wuweidix@yahoo.com, lucrebugio@gmail.com*).

Mangroves and other coastal forest ecosystems in the Philippines play an important role in the life of people. These ecosystems provide an endless array of productive and protective benefits. The paper makes use of the total economic value (TEV) as its framework for estimating the values of the different uses of mangroves that includes both market and non-market benefits. Data on the volumes of harvests and their prices, number of households involved, and the costs incurred in catching, harvesting, or gathering these goods from mangroves were obtained and used to estimate the net benefits from the direct uses. Biodiversity and recreation values were estimated using contingent valuation and travel cost methods. The study was conducted in two study sites: Banacon Island in Bohol Province, and Barangay Kamuning in Puerto Princesa City. Initial results showed that the highest direct use value was estimated for Banacon Island (P25.52 million), followed by Palawan (P10.97 million). In terms of indirect mangrove benefits, an initial assessment of these values reveals that many of these functions are considered to be of great importance and value, such as the carbon sequestration value of mangroves, recreational and biodiversity benefits, among others.

Assessment on agroforestry species for rehabilitation of degraded forest land and biodiversity in Huairang-Klongpeed watershed, Trat Province, Thailand. Jamroenprucksa, M., Klangsap, N., Puangchit, L. (*Kasetsart University, Thailand; fformtj@ku.ac.th; rdispk@ku.ac.th; fforlwp@ku.ac.th*).

The natural forests in the Huairang-Klongpeed watershed have been degraded through over-logging for more than two decades, and have been replaced by grassland and plantation monocultures leading to environmental degradation and food insecurity. A study was conducted involving mixed species plantations, bamboo, and observations on the structural characteristics of successional forest in the logged-over area. The results showed successful integration of fast-grown introduced species, such as *Acacia mangium*, with slow growing indigenous species, such as *Dipterocarpus alatus*. Ongoing project activity has continued to record growth responses of both species to a thinning of the *A. mangium* carried out at age four years. Other timber species included in the study were: *Artocarpus rigidus, Hopea odorata, Peltophorum dasyrachis*, and *Xylia kerrii*. In an agro-forest landscape, bamboo, especially *Dendrocalamus latiflorus*, seemed to be promising as a means of connecting different scattered agricultural areas with forested lands. While only three farmers have participated in the experiment so far, the acceptance of the bamboo plantings is apparent, given that many other farmers have indicated their interest in planting bamboo along their farm boundaries.

Valuation methods for the mangroves in Xuan Thuy National Park. Lien Son, H. (*Ministry of Agriculture and Rural Development, Vietnam; hlson2000@gmail.com*).

Mangrove ecosystems have both high economic values and biological productivity. Statistics in 2005 show that there are 155,290 ha of mangrove forests in Vietnam, or about 38% of the area that existed in 1943. There are many causes for mangrove forest loss in the past 60 years, including lack of knowledge about mangrove values, which has led to extensive conversion for agriculture and aquaculture. This research aims to provide information on the total economic values of mangroves to contribute to their sustainable use and management. The 7,100-ha Xuan Thuy National Park, located in the Red River Delta about 150 km Southeast of Ha Noi, has great potential values for marine ecosystems, tourism, natural reserves, and wetlands with a large number of wildlife animals and migratory birds. It is the first RAMSAR site in Vietnam. The objectives of the research were to: classify and determine ecosystem services of Xuan Thuy, determine valuation methods, and recommend suitable valuation methods. Based on that, the research has identified the values of Xuan Thuy, including research, education, shoreline protection, direct extractives, aquaculture, breeding, and biodiversity, by using the valuation methods such as actual costs, replacement costs, market prices, and contingent valuation method.

Tree species diversity, composition, and stand structure of tropical deciduous forests in Myanmar. Oo, Y. (*Forest Research Institute, Myanmar; tnoo71@gmail.com*), Lee, D. (*Seoul National University, Republic of Korea;*), Woo, S., Park, Y. (*Seoul National University, Republic of Korea; leedk@snu.ac.kr; wsy@uos.ac.kr; parkyd70@snu.ac.kr*).

The characterization of tree species and forest stand conditions is an important element of biodiversity conservation planning. The objective of this study was to describe tree species diversity, species composition, and stand structure of tropical deciduous forests distributed in three regions in Myanmar. Forest inventories were conducted in the Oktwin teak-bearing forest, the Letpanpin community forest, and Alaungdaw Kathapa National Park. Eighty-five species (31 families), 70 species(33 families), and 186 species (53 families) were found in the Oktwin, Letpanpin, and Alaungdaw Kathapa locations, respectively. Mean tree density (n/ha) was 488, 535, and 412, while basal areas per hectare was 46.96 m^2, 49.01 m^2, and 60.03 m^2, respectively. At the family level, Verbenaceae, Myrtaceae and Combretaceae occupied the highest importance value. Species composition was notably dissimilar among the sites due to the different disturbance regimes, management objectives, and climatic conditions. This study suggests that deciduous species would continue to dominate in OTTBF and ALKP, while semi-evergreen species would continue succession to evergreen species in LPPCF. This study also explained the impacts of disturbances in conservation of tree species diversity and composition.

Restoration of a degraded gold mining site by recycling tailing waste in the establishment of fast-growing trees producing better carbon biomass: a case study in PT. Aneka Tambang Pongkor, Bogor, Indonesia. Pasaribu, H., Siregar, C.A. (*Ministry of Forestry, Indonesia; hadispsaribu@yahoo.com; siregarca@yahoo.co.id*).

Restoration of degraded sites and abundant tailing wastes are critical problems. Studies were designed to evaluate possibility of recycling high Pb tailings as growth medium for rehabilitating degraded land in gold mining areas through incorporation of high levels of organic fertilizer, and producing fast carbon biomass. Field research showed that organic fertilizer significantly affects growth of 4-month, 1-year, 2-year and 3-year-old *Eucalyptus pellita*. Best plant growth was observed in the tailing, dung, and solum treatment at a ratio of 1:1:1 by volume. This same treatment slightly improved growth of *Gmelina arborea.* Further research used *Michelia montana*, and results indicate that mixture of dung and tailing produces vigor growth at age 15 months. Based on local allometric equation $Y = 0.1728 (DBH)^{2.2234}$, eucalypt grown with spacing of 2m × 2m is estimated to produce approximately 100 ton biomass (183 ton CO_2 eq.) per hectare at age 5 years (diameter and tree height average 12.2 cm and 14.8 m respectively); and this critical value may be used as an indicator for successful land rehabilitation of degraded mining site of about 1 million ha located in a forested state. Policy measurement is a must to protect the forest from further degradation.

Economic valuation for sustainable mangrove ecosystem management in Thailand: a case study of the valuation of the Ban Pred Nai mangroves, Trat Province, Thailand. Puangchit, L., Hoamuangkaew, W., Sunthornhao, P. (*Kasetsart University, Thailand; fforpts@ku.ac.th*).

The Ban Pred Nai mangrove forest is located in Haong Nam Khao subdistrict in the Muang district of Trat province, Thailand. For more than 2 decades, it has been a degraded forest, mainly due to severe stocking depletion. Nowadays, mangroves have a high potential, providing not only tangible, but also intangible values since a rehabilitation program was carried out in 1998. Tangible or direct use values include: wood for casual use, edible plants, and herbs; and grapsoid crabs, mud crabs, fish, honey, and other aquatic resources. The intangible values or environmental services include: the shoreline, carbon sequestration, aquaculture, nursery feed, and biological diversity services. Nowadays, the target group residing in the Ban Pred Nai area has a

population of 591 households and they are heavily dependent on the mangroves for the collection of aquatic resources. In order to sustain the mangroves, a determination of their aggregated value is needed. The information obtained can be very useful as a guideline for formulating an appropriate management plan. Hence, a study of both the direct use value and the aggregated value could be carried out by using the market price valuation method and contingent valuation method, respectively.

Mixed-species approach to reforestations in the Philippines: a challenge to balance between biodiversity and productivity for smallholder conditions. Sales-Come, R. (*Visayas State University, the Philippines; rfs_lsu@yahoo.com*), Hoelscher, D. (*Georg-August Universitaet-Goettingen, Germany; dhoelsc@gwdg.de*).

Natural rainforests in the tropics are mostly highly diverse in tree species and also comprise a substantial functional variability. Continuous loss of these forests, however, leads to creation of large areas of planted forests that primarily rely on few species, thus limiting its functional diversity. A different approach to reforestation, the so called rainforestation, has been developed in the Philippines, emphasizing mixed stands and the preferential use of native species supplemented by fruit trees. Presently, more than 19 provinces hold rainforestation sites and the number is continuously increasing as it is being promoted as the official approach to reforestation in the country. In such stands, three pioneer plots established in Leyte in the mid-1990s were studied to determine the functional diversity of co-existing species. The method used was species-specific leaf traits assessment of adult trees in the field and seedlings grown in the nurseries. A great variation on the leaf traits among species was found, suggesting a high leaf functional diversity that is almost similar to natural forests. Such information may help to adjust the species combination in further developments of the reforestation scheme to goals specifically to balance biodiversity conservation and productivity of these stands.

Participatory agroforestry for poverty alleviation at Gunung Walat Educational Forest, Indonesia. Sundawati, L., Darusman, D. (*Bogor Agricultural University, Indonesia; leti_sunda@yahoo.com; ddarusman@yahoo.com*).

Since the economic crisis in Indonesia in 1997, population pressures on forest areas have been increasing. The Gunung Walat Educational Forest (GWEF) of Bogor Agricultural University, has been facing rapid degradation due to illegal cutting and encroachment by local people. Establishment of agroforestry systems together with local people was thought to be the most promising solution. An action study funded by the ASEAN-Korea Environmental Cooperation Project has been conducted since 2001 at the GWEF. A new partnership approach between local people and the management of GWEF has been established, which allows local people to be involved in the decision-making and to have rights of using forest areas for relatively long periods for crops cultivation and getting 50% yield of trees. Intensive extension activities have been conducted to strengthen local institutions and income-generating activities. Study results show that establishment of agroforestry in the encroached forest area has prevented further encroachment activity; contributed cash income and given a certain level of staple food security to the farmers; and increased the diversity of plant species in GWEF. In conclusion, higher people's role and interest, along with securer land tenure, can support forest rehabilitation and increase in human welfare.

Posters

Assessing the impacts and influences of community-based forest management towards forest restoration and employment generation in the Philippine uplands. Camacho, S.C., Espiritu, N.O., Dolom, P.C., Villanueva, M.M.B., Donoso, L.A. (*University of the Philippines Los Baños, Philippines; sonny_camacho@yahoo.com; noespiritu@yahoo.com; predolom@yahoo.com; lyn_bvillanueva@yahoo.com; fdccfnr@yahoo.com*).

Low performance of various people-oriented forestry projects has prompted the Philippine government to adopt the community-based forest management (CBFM) program as a strategy for addressing upland poverty and deforestation. The CBFM program is based on the premise that if local communities are given access to and control of forest resources and allowed to benefit from them, they will be transformed into responsible stewards and partners in the promotion of sustainable forest management. This study investigated impacts and influences of the CBFM program as a source of employment and income in the Philippine uplands. Findings were derived from household surveys, key informant interviews, and focus group discussions from 20 people's organizations in varying areas of CBFM projects. This study showed that various developmental activities had generated considerable employment opportunities. The variables that influenced the rise and fall in the employment generation capability of the CBFM were closely tied to the following: five-year work plan, resource use permit, presence of income-generating projects, financial assistance from various sources, species planted, and production-sharing arrangement. The CBFM program has also achieved an increase in forest cover as compared to other reforestation projects in the past. Policy recommendations were also drawn from the study.

Gap characteristics and natural regeneration in Mt. Makiling Rainforest, Philippines. Cho, D.S., Kim, E.H., Kim, T.G., Kim, H.J. (*Catholic University, Republic of Korea*; *dscho@catholic.ac.kr; 97curi-curi@hanmail.net; hairyroot@hanmail.net; ddolki82@hanmail.net*).

This study was conducted to determine characteristics of gaps and natural regeneration of trees in Mt. Makiling, the Philippines. Canopy gaps in or around two 1-ha permanent plots and on 3-km line transects were investigated. Most of the gaps studied were formed or affected by typhoon Milenyo in September 2006. The most frequent mode of death of gapmakers was snap-off, and uprooting was relatively less important. The most frequent gapmaker was *Diplodiscus paniculatus* and the next were *Celtis luzonica* and *Dillenia philippinensis*. In contrast, the most frequent gap-filler was *Celtis luzonica*. At the sapling layer, the most important species was *Celtis luzonica*, but there was a high proportion of lianas and palms. Large gaps had higher soil and air temperatures than smaller gaps or non-gaps. Most of the gaps had LAI values between 3 and 5. There was a clear trend of decrease of gap size and increase of LAI for 2 years between 2007 and 2009. New seedlings emerged very abundantly for the same period of time. The rapid changes in the gaps were partially due to the good ability of resprouting of tropical trees after the crown or stem damage by the typhoon.

Ecological characteristics and roles of wild banana (*Musa balbisiana*) in Mt. Makiling, Philippines. Cho, D.S., Kim, T.G., Lee, K.G. (*Catholic University, Republic of Korea*; *dscho@catholic.ac.kr; hairyroot@hanmail.net; surangbest@naver.com*).

This study was conducted to determine the ecological characteristics and roles of wild banana (*Musa balbisiana*) in Mt. Makiling, the Philippines. The study site was severely damaged by typhoon Milenyo, which hit the area in September 2006. All individual of wild bananas > 30 cm height in two 1-ha permanent plots were measured for their height, diameter at 30-cm height, and number of leaves, and the presence of fruits was checked. Twenty-eight experimental plots (seven replications of four treatments: gap with banana, gap without banana, *Arenga pinnata*- dominated site, and intact canopy site) were established. Growth of seedlings of *Parashorea malaanonan* and *Diplodiscus paniculatus* and germination rates of wild banana seeds were compared among different treatment plots. Wild banana showed a severe clumped dispersion pattern: bananas were present only in the gap sites. There were more smaller bananas at the permanent plot II (600 m asl),which has still bigger gaps than plot I (400 m), indicating that banana recruitment is more active under the gap conditions. None of the experimentally planted seeds germinated under the intact canopy, while study of the seed bank in the soil under the intact canopy showed some banana seed germination.

Introduction to the ASEAN-Korea Environmental Cooperation Project (AKECOP). Kang, H., Lee D. (*Seoul National University, Republic of Korea; silvi@chol.com; leedk@snu.ac.kr*).

The ASEAN-Korea Environmental Cooperation Project (AKECOP) was established to contribute to the sustainable forest management in the ASEAN region through collaboration in research and education. The project on the restoration of degraded forest ecosystem in the Southeast Asian tropical region was conducted during its 1st phase (July 2000–June 2005) and 2nd phase (July 2005-June 2008) of implementation. Through AKECOP's highly effective partnership and collaboration between ASEAN and Korea, it has successfully completed the planned activities including the regional and on-site researches with the mission of restoring degraded forests, strengthening the agroforestry system, and conserving biodiversity in Southeast Asia. However, the long-term and complex nature of sustaining forest ecosystems in terrestrial and coastal environments strongly urges the sustained commitment and holistic approach of the project considering the ever-increasing ASEAN concern about environmental issues, rapidly deteriorating forests, and people's well-being in the region. To achieve the set goal, the 3rd phase (July 2008–June 2011) of the project has adopted the following strategies: 1) cross-sectoral, multi-disciplinary, and holistic assessment of national programs on forest management in the past; and (2) enhancement of national capacity in dealing with existing and emerging issues on sustainable forest ecosystem management.

Participation of local communities in restoration activities of degraded upland area in Ranau, Sabah, Malaysia. Lintangah, W.J., Solimun M., Mojiol A.R., Kodoh J. (*Universiti Malaysia Sabah, Malaysia; ewalterj@yahoo.com; majhinus@ums.edu.my; andy@ums.edu.my; julius@ums.edu.my*).

A degraded upland area is located on the west side of Mount Kinabalu, Sabah, Malaysia. In the past, the communities who live in this area used slash-and-burn activities. Some of the forest fires in the past changed the landscape in some areas from primary forest to degraded land. This study was carried out by direct observation and questionnaire with the communities, to obtain their participation and learn their perceptions of tree plantation activities. It was found that *Hevea brasiliensis* (rubber tree) and *Durio* sp. (durian) were the most planted species. Other species on a smaller scale are *Tectonia grandis*, *Acacia mangium, Pinus* spp., *Eucalyptus* spp., and indigenous species of *Neolamarckia cadamba* (Laran) and *Octomeles sumatrana* Miq. (Binuang). The planting of trees is for financial value, landscaping, soil conservation, and future investment. Most plantation sites were located alongside existing roads. Some factors influencing the tree plantations among the communities were species' selection, amount of area for tree plantation, number of trees planted, availability of road network, their willingness to wait for long term investment, and their interest in the tree plantations in the future.

Temporal changes in leaf, flower, fruits, and seed production in a tropical rain forest, the Philippines. Park, P.S. (*Seoul National University, Republic of Korea; pspark@snu.ac.kr*), Barile, J. (*University of the Philippines Los Baños, Philippines; jojobarile@yahoo.com*), Cho, D.S. (*Catholic University, Republic of Korea; dscho@catholic.ac.kr*), Suh, K-H. (*Daegu University, Republic of Korea; ecology@daegu.ac.kr*), Lee, D.K., Han, A. (*Seoul National University, Republic of Korea; leedk@*snu.ac.kr; *phoya@naver.com*).

Temporal changes in the production of leaf, flower, fruits, and seeds have been studied between 2006 and 2009 to understand the long-term temporal changes of a tropical rain forest. Fifty 1-m × 1-m traps were established at two 1-ha permanent study sites (400 m and 700 m asl) in the Mt. Makiling Forest Reserve, the Philippines. Leaf, branch, flower, fruit, and seed production in each seed trap were monitored monthly for 3 years. The leaf production was more than 65% of dry weight of contents in seed traps. Branch, fruit, and flower production were about 19%, 10%, and 2% of dry weight of contents in seed traps, respectively. Moisture contents of leaf, flower, and branch were approximately 50%. Litter production was low during dry season, and high in June, which is wet season. A 700-m plot had almost twice as much as weight of fallen flower, fruit, and seed than a 400-m plot. The dry weights of flower and fruit were high in November and low in February and March. The seasonal trend in the leaf and seed production is related to the weather switch-off between wet and dry season.

Establishment of allometric equations of mangrove forest for carbon biomass estimates in West Java, Indonesia. Siregar, C.A., Dharmawan I.W.S. (*Forest Research and Development Agency/Ministry of Forestry, Indonesia; siregarca@yahoo.co.id; salifa03@yahoo.co.id).*

Indonesia has 9.2 million hectares mangrove forest, the largest extent in the world. Nowadays, destruction of it is occurring on as much as 71% of the total area mainly due to human activities. To foster the ecological function of mangroves in coastal zone conservation, rehabilitation of degraded habitats through mangrove plantation is indispensable. This study aimed at establishing allometric equations of two important species, *Avicennia marina* and *Rhizophora mucronata*, in which tree total biomass (kg) is regressed on diameter at breast height (cm). Thirty-six tree destructive samplings were used for analysis on each species covering small, medium, and large diameter, resulting in $Y = 0.2901\ (DBH)^{2.2605}$, $R^2 = 0.97$, and $Y = 0.1366\ (DBH)^{2.4377}$, $R^2 = 0.97$ for *Avicennia* and *Rhizophora* respectively. Statistical analysis indicates that there is no significant difference between the two

allometric equations, and suggests that all parameters observed could be pooled into one data set, to produce a more generic equation Y = 0.2064 (DBH) 2.34, R^2 = 0.98. Assuming tree diameter average is 25 cm at age of 10 years, with density 600 trees per hectare, this will stock not less than 231 ton carbon biomass (552 ton CO_2 eq.) per hectare.

Application of microsatellite markers in measuring seed dispersal distances of *Ficus* spp. in forest restoration areas. Wangpakapattanawong, P., Thongkumkoon, P., Chomdej, S. (*Chiang Mai University, Thailand; prasit.w@chiangmai.ac.th; mameaw_patchy@hotmail.com; siriwadee@yahoo.com*).

Ficus spp. are considered to be "keystone species" in tropical forest ecosystems as they are available for wildlife all year round. Several fig species are used in forest restoration by the Forest Restoration Research Unit (FORRU, http://www.forru.org), Chiang Mai University, using framework species method, because they can attract seed-dispersing wildlife. The framework species are also native species that grow fast, have dense and spreading crown to suppress weeds, and are fire resilient. Seed dispersers can bring in new plant individuals and/or plant species into the restored areas. Seven species of figs—*Ficus auriculata*, *F. fistulosa*, *F. hispida*, *F. hirta* var. *hirta*, *F. hirta* var. *roxburgii*, *F. semicordata*, and *F. triloba*—were collected from natural and restored forests in Chiang Mai, northern Thailand. Four micro-satellite primers (FM3-64, MFC-1, Frub 391, and FinsP8) could be used to analyze the relationship between the maternal trees and seedlings of *F. hirta* var. *hirta*. DNA fingerprint of the maternal trees and the seedlings from 7-year-old forest restoration plots could be compared. However, a higher number of populations is required for analyses of seed-dispersal distances.

D-13 Biology and ecological functions of forested peatlands

Organizer: Tetsuya Shimamura, *Ehime University, Japan, simamura@agr.ehime-u.ac.jp.*

The political process of marginalization: social causes of deforestation in Indonesia. Abe, R. (*Rikkyo University, Japan; ryuabe333@yahoo.co.jp*).

Indonesia has been named the third largest carbon-dioxide-emitting country by the World Bank report released for COP13/CMP3 in 2007 in Bali, including estimation of rapid degradation of forest that caused a quick loss of carbon sink. Despite the fact the government initiated rehabilitation of deteriorated forest in the mid 1980s, the forest depletion ratio has never declined. Today the international community provides assistance to the Indonesian government both financially and technically to implement a variety of reforestation programs, but most of these efforts nevertheless fail to yield results. This presentation attempts to expose the social causes that nullified, or even made worse, these efforts in rural Indonesia. First, one of the largest reforestation projects in South Sumatra, where land conflicts between a legitimated reforestation industry and the local community has resulted in a huge scale of forest fires is examined. Next, a brief look shall be taken at the deep tropic peatland in Central Kalimantan known as the worst carbon discharging area, where inappropriate landownership is exercised. Lastly, it is argued that political alienation often hampers one's aspiration for planting, illustrating a case of an area where migrants had long cleared forest in the watersheds in North Sumatra.

Some characteristics of peat swamp forest in Riau's Biosphere, Sumatra, Indonesia. Gunawan, H. (*Center for Tropical Peat Swamp Restoration and Conservation, Indonesia; haris1901@gmail.com*), Kobayashi, S (Kyoto University, Japan.

Riau's Biosphere is an important ecosystem that will be used to conserve peat swamp ecosystem and biodiversity in Sumatra. To provide important data for protection of peat swamp forest remnants of the reserve, we collected data on diversity, composition, structure, and regeneration in several types of forests. According to the results, the Riau's Biosphere is divided into three forest conditions: (1) pristine peat swamp forest, (2) logged over forest, and (3) peat swamp forests disturbed by wind and fire. The highest species richness is showed in the pristine forest, and the lowest is showed in the burnt forest. The most dominant families are Ebenaceae (burnt forest); Myrtaceae and Sapotaceae (logged over forest); Anarcardiaceae and Myrtaceae (wind disturbed forest); and Sapotaceae (pristine forest), represented by trees ranging in dbh between 3–30 cm and 60 cm (rarely exceeding this). The regeneration status of the forests is good (logged over forest); fair (disturbed forest by wind factor); and new regeneration (burnt forest). The forest structure possibly changes in time, especially in the burnt and disturbed forest, and will be dominated by individuals of species that showed good regeneration, such as *Campnosperma brevipetiolata*, *Shorea teysmaniana*, *Palaquium sumatranum*, and *Tectrotomia tetandra*.

Carbon loss associated with land-use change in tropical peat forests: methods and quantification. Hergoualc'h, K. (*Center for International Forestry Research, Indonesia; k.hergoualch@cgiar.org*), Verchot, L.V. (*Center for International Forestry Research, Indonesia; l.verchot@cgiar.org*).

Tropical peat forests store large amounts of carbon and their increasing and alarming degradation and conversion to other land uses may contribute greatly to climate change. Although the quantification of C loss from the biomass associated with land-use change may not present major difficulties, losses from the peat are much more complex to quantify. Linking the subsidence rate or drainage depth of the peat to its rate of heterotrophic soil respiration is one of the proposed methods. Here, we applied the 'gain-loss' approach of the IPCC for assessing this loss and looked at how the change in vegetation cover altered the main C inputs (litterfall and root mortality) and outputs (heterotrophic respiration, CH_4 flux, fires, soluble and physical removal) before and after conversion. From a literature review, we estimated that peat C loss associated with the conversion of forests to oil palm plantations was 30 Mg CO_2 equivalent ha^{-1} y^{-1}. Corresponding C loss from the aboveground living biomass was assessed using the stock change approach and estimated at 26 Mg CO_2 equivalent ha^{-1} y^{-1}. Peat C loss contributed at more than 50% to total C loss, demonstrating the urgent need in terms of global warming to protect tropical peat forests.

Ecological functions of peat swamp forest and peat-land resource management for mitigation of global warming in Southeast Asia. Kobayashi, S. (*Kyoto University, Japan; skobayashi@asafas.kyoto-u.ac.jp*), Shimamura, T. (*Ehime University, Japan; simamura@agr.ehime-u.ac.jp*).

The Ramsar treaty on wetland conservation was concluded as an international agreement in 1971. Wetland forests in the tropics have, however, been experiencing drastic land-use changes that, together with tropical forest degradation, have also been a focal point of global environmental issues. Southeast Asia in particular has a very wide area of wetlands in which mangrove, peat swamp, and freshwater forests are distributed in 22.2 million hectares. Such wetlands areas are increasingly being converted to agricultural farms or shrimp farming ponds, then subsequently abandoned due to productivity decline. Peat swamp, stored with abundant organic matter, becomes a source of greenhouse gases such as carbon dioxide and methane generated by decomposition of organic matter, since such lands have not been properly utilized. It is, therefore, urgently necessary to conduct research on peat-land resource management options and local society empowerment for global-warming prevention in Southeast Asian wetlands. The study site is located at Riau Province and Central Kalimantan Province, Indonesia, and Brunei. After land use changes, surface temperature increased, the moisture of peat became dry and mild acidic. Then the peat changed from fabric peat to mesic peat and to sapric peat. After changing, peat completely decomposed.

Managing peat swamp forests, ecosystem functions, and local communities: translating the ecosystem approach into action. Nik, A.R., Hamzah, K.A. (*Research Institute Malaysia, Malaysia; rahimnik@frim.gov.my*).

Tropical peat swamp forests, an important wetland type, deliver a wide range of ecosystem functions, such as water supply, water purification, climate regulation, biodiversity conservation, and recreational opportunities. Peatlands and peat swamp forests accounts for approximately 70% of Malaysian total wetland area. The main management issue is the often-conflicting interests of the economy and the environment; and increasing demands for conversion of peatlands to other uses. A 5-year project funded by UNDP/GEF was implemented since 2002–2007 to address the conservation and wise use of the remaining peat swamp forests in Malaysia. The Project had identified the major threats and assessed the peat swamp forest biodiversity richness and its hydrological and ecological integrity. In the production forest zone where forests are intact, the selective harvesting method is prescribed using a specially adapted machinery called "log fisher". Addressing the diverse stakeholders presents a challenge to the planning and managing process, and hence, the project adopted an ecosystem approach, engaging local communities and other key stakeholders in developing an integrated management plan (IMP) through a consultative process. Highlighted in this paper are some lessons learnt, particularly the consultative process, and impacts of the management planning process and wise use of wetland resources.

Challenges and potential benefits of rehabilitating degraded tropical peat swamp forest. Page, S.E., Hoscilo, A., Laura Graham (*University of Leicester, UK; sep5@le.ac.uk; ah165@le.ac.uk; llbg1@le.ac.uk*), Shimamura, T. (*University of Leicester, UK and Ehime University, Japan; st198@le.ac.uk*), Waldram, M. (*University of Leicester; msw13@le.ac.uk*).

Extensive areas of peatland in Southeast Asia have been degraded through deforestation, drainage, and fire, leading to both a loss of ecosystem services and on- and off-site environmental and socio-economic impacts of local to global significance. These degraded landscapes present enormous challenges for ecosystem rehabilitation. This paper reviews and illustrates, using information from Central Kalimantan and Sumatra, Indonesia, the current state of knowledge pertaining to the vegetation dynamics of degraded peatlands and the opportunities for rehabilitating peatland hydrological and carbon sequestration functions. Following low-intensity ecosystem disturbance, vegetation succession back to secondary forest is possible, but repeated and high intensity degradation, for example as a result of deep drainage and frequent fire, results in a loss of ecosystem resilience and a shift towards species-poor, non-forest communities. Re-wetting the peat and re-establishing forest cover are important prerequisites to ensure protection of remnant ecosystem values, including biodiversity support and carbon storage. The effectiveness of these measures is discussed and likely longer-term benefits evaluated. The paper concludes by stressing that successful planning for rehabilitation of degraded tropical peatlands needs to be grounded in scientific theory and knowledge, but also has to be relevant to local environmental and socio-economic circumstances.

The relationships between plant diversity and carbon sequestration in tropical peat swamp forest. Shimamura, T. (*University of Leicester, UK; st198@le.ac.uk*), Shinta, E. (*Ehime University, Japan; eshinta2000@yahoo.com*), Page, S. (*University of Leicester, UK; sep5@leicester.ac.uk)*, Limin, S. (*University of Palangka Raya, Indonesia; cimtrop_suwido@yahoo.com*).

Tropical peatlands have a dome-like structure. Many studies have observed a concentric pattern of five to seven forest types that differ in composition and structure over the gradient of peat depth. We investigated relationships between plant diversity and carbon sequestration in a tropical peat swamp forest by establishing six plots from shallow, marginal peat to thick peat at the centre of the peat dome in the upper River Sebangau catchment, Central Kalimantan. Plot data were used to determine the distribution of plant species and understand the contribution made by each species to carbon sequestration in the different forest stands, as measured by basal area and litter production. Species that dominate in three or four plots, (i.e., *Palaquium leiocarpum*, *P. cochlearifolium*, etc.) contributed most to the total basal area across the peat dome, while species dominant in fewer plots, (i.e., *Rapanea borneensis*, etc.) showed the lowest contribution. The results indicate that some plant species are of greater importance than others in maintaining carbon sequestration in tropical peat swamp forests. In the presentation we will show how these plant groups contribute to peat accumulation by showing data for net primary production and leaf/litter chemical properties.

Ecological and silvicultural aspect of *Gonystylus bancanus* (Ramin) in Indonesia: areview. Tata, H.L. (*Forest and Nature Conservation Research and Development Centre, Indonesia; hl.tata@gmail.com*), Istomo, I. (*Bogor Agricultural University, Indonesia; ecology@ipb.ac.id*), Komar, T.E. (*Forest and Nature Conservation Research and Development Centre, Indonesia; tekomar@indosat.net.id*).

Peat swamp forest is a unique ecosystem, which is established from organic matters. Peat swamp forests in Indonesia covered about 17 million ha in 1987. Even though this ecosystem is very fragile, it was estimated up to 3 million ha peat swamp forest was converted to agriculture between 1987 to 2000. The silvicultural system that is applied in this natural peat swamp forest is selective cutting. The system allows cutting only commercial trees with certain diameter limit, and leaves a number of core trees for the next cutting cycle. *Gonystyllus bancanus* (Ramin), which can only grow in peat swamp forests, is a species listed in the

CITES appendix II. However, a specific silvicultural system for Ramin has not existed yet, and the strong production of Ramin from peat swamp forests has been devastating. Considering that Ramin's characteristic habitat is in waterlogged peat swamp forests, a system of harvesting and wood transportation that is environmentally friendly, *humanity* friendly, and efficient is necessary to establish. Ecological study and review on regulation of silvicultural aspects of Ramin currently practiced in Indonesia will be discussed.

Posters

Effect of logging operation on carbon storage and water quality of peat swamp forest in Sarawak. Gandaseca, S., Haruna, O., Muhamad, N. (*Universiti Putra Malaysia, Malaysia; secags@yahoo.com; osman60@hotmail.com; nik@forr.upm.edu.my*).

Tropical peat swamp forests have high tendency for soil degradation. Objectives of this study were to determine whether logging operations affect soil carbon storage and water quality of tropical peat swamp forest. Soil sampling was conducted before and after logging operations at 0–15-cm depth on six 0.1-ha plots; physico-chemical characteristics of water quality were investigated randomly at representative stations, before and after harvesting at Batang Igan forest, Sibu, Sarawak. Soil samples were analyzed for acidity, organic matter content, total carbon, total nitrogen, total phosphorus, cation exchange capacity (CEC), available potassium and C/N ration, before and after logging. Results showed the availability of unstable carbon and stable carbon were controlled by soil acidity on undisturbed peat swamp forest; even after logging, humification was strongly maintained. The C/P ratio positively correlated with humic acid and stable carbon on both before and after logging conditions, but more prominently on logged peat swamp forest. Regarding water quality, there were no significantly different values for pH, total dissolved solids, conductivity, dissolved oxygen, or total suspended solids before logging operations, although temperature, turbidity, and salinity showed significant differences. After logging, only turbidity showed significant difference. We conclude that Sibu peat swamp water system is considered unpolluted.

Ecology of small mammals in the Sabangau peat swamp forests, Central Kalimantan, Indonesia. Poesie, E.S., Hamamoto, K. (*Ehime University, Japan; e_poesie@hotmail.com*), Shimamura, T. (*Ehime University, Japan*), Limin, S. (*Palangka Raya University, Indonesia*), Ninomiya, I. (*Ehime University, Japan*), Harada, K. (*Ehime University, Japan*).

Peat swamp forests represent a distinctive type of forest growing on unproductive environments (e.g., waterlogged and poor nutrients) which contains an important genetic reservoir of biodiversity in Southeast Asia. As faunal habitat, peat swamp forests are home to large populations of wildlife animals due to loss their original habitat. In spite of its importance, habitat use and animal communities that are associated with peat swamp forests remain unexplored. To examine how the characteristics of peat swamp forests affect small mammals, we investigated their breeding and feeding habits. Seven species of rodent were recorded in the Sabangau peat swamp forest in the wet (March) and dry (October) season 2007. *Maxomys whiteheadi* was the most common species trapped in all forest types. Overall trap success was low, but individual captures varied among forest types. *M. whiteheadi and Sundasciurus lowi* showed signs of breeding, and pregnant females of both species were trapped until the end of the wet season. Analysis of stomach contents revealed that all trapped species relied heavily on seeds and the degree of overlap in diets was high. The results are discussed in relation to the environmental conditions in the forest.

D-14 A comparative analysis of forest sustainability transitions in developed and developing countries

Organizers: Yeo-Chang Youn, *Seoul National University, Republic of Korea, youn@snu.ac.kr*; Wil de Jong, *Kyoto University, Japan, wdejong@cias.kyoto-u.ac.jp;* Wen Tiejun *Renmin University of China, China.*

Forest transition in Korea: trends, characteristics, and lessons learned. Bae, J. (*Korea Forest Research Institute, Republic of Korea; forestory@forest.go.kr*).

Time series data on forest resources and population from 1927 to 2007 were constructed and analyzed to identify trends and characteristics of forest transition in Korea. Korean forest transitions could be classified into three phases in terms of the average annual growing stock of forest: forest degradation (1927–1952), forest stagnation (1953–1972), and forest growth (1973–2007). Over the past 80 years, forest area decreased 0.05% each year. The rate of decrease was very low, especially considering rapid economic growth and increased population of Korea, with over 60% forest cover. Growing stock per hectare significantly increased, from 5.6 m^3 in 1952 to 97.8 m^3 in 2007, or 17.5 times during 1952 to 2007. Despise of increasing population and rapid economic growth, in particular, growing stock per capita has increased from 1.7 m^3 in 1952 to 12.9 m^3 in 2005. In this regard, Korea represents a case of modern forest growth. Among 56 countries with population of more than 10 million and 10% or more of forest cover over the period 1990 to 2005, Korea is classified as a country that has high forest cover but low deforestation rate.

The tragedy of socialistic forestry in theory and in the Philippines, contrasted with Finland. Palo, M. (*Independent Scientist, Finland; matti.palo@metla.fi*).

A global initiative REDD+ was created in 2008 to reduce emissions from deforestation. The social opportunity cost of sustainable forestry has been artificially high under socialistic forestry (state forests >50%) to allow excess deforestation. Low administrative stumpage prices also allow excess accessibility for logging. In Garret Hardin's seminal 1968 *Tragedy of the Commons*, he described how "open access" to natural resources would generate serious environmental deterioration. My paper analyses the impacts of socialistic forestry on corruption, open access, and deforestation in the tropics. Nearly all the natural forests in the tropics are owned by the states, and high corruption prevails in the tropical countries. The state as a major forest owner has a

relevant motive—corruption—to underprice standing timber. This creates a financing source for corruption and supports deforestation by increasing artificially the social opportunity cost of sustainable forestry. Under corruptive conditions *de facto* open access conditions are created to expand forest degradation and deforestation. Such socialistic forestry implies government and market failures with consequent deforestation, causing negative externalities of increasing greenhouse gases, erosio, and decreasing biodiversity. The Philippines as a case is supporting this tragedy and Finland provides contrasting evidence.

Forest sustainability transition in the Philippines: possibility or illusion? Pulhin, J. (*University of the Philippines Los Baños, Philippines; jpulhin@yahoo.com*).

The Philippines provides an interesting case to examine the underlying causes and challenges associated with forest transition towards sustainability in developing countries. Recent forestry statistics from the government indicate that forest cover has increased over the past decade, although members of the civil society and other sectors denied that forest transition has started to take place. This paper examines the possibility of transition towards sustainable forestry in the Philippines in the context of changing perspectives on the role of forests in development. First, a historical analysis is provided on the changing role of forests in development at the international and national levels and how it influenced forest policies and programs in the country. Second, the actual status and trend of forest cover in the country is assessed to clarify if a forest transition is actually taking place. The drivers of deforestation and the factors influencing forestry transition are then analyzed. Issues and challenges associated with forest transitions are also discussed. The paper concludes by emphasizing the importance of institutionalizing a regular high-quality national forest resource assessment and the role of responsive policies and capable institutions for forest transition to be a reality.

Factors affecting success in transition to sustainable forestry–the case of Korea. Youn, Y., Park M. (*Seoul National University, Republic of Korea; youn@snu.ac.kr; mpark@snu.ac.kr*).

After liberalization from Japanese colonization, Korea has been divided into two separate political regimes, Peoples Democratic Republic of Korea (PDRK or North Korea) and Republic of Korea (ROK or South Korea). North and South Korea have been pursuing different paths of policies based on different political ideologies, namely communism and capitalism, respectively. Forest policy is not an exception. North Korea emphasizes resource development strategies, while South Korea stresses rehabilitation policies. As the result of strong regulation enforcement and implementation of reforestation programmes, the forestlands of South Korea have been successfully rehabilitated. On the other hand, a quarter of the forestland of North Korea has been deforested and the remaining forests have been degraded. This research compares direct and indirect factors affecting the success or failure of forest policy that has lead to rehabilitation or deforestation on the Korean Peninsula. Changes in the quantity and quality of forests have been induced by forestry activities as well as by social, economic, and cultural variables at the national and international levels. This case study of Korea demonstrates the importance of incorporating a broad policy mix for success in transition to sustainable forestry.

General Posters: Asia's Forests for the Future

Rooting of selected tree species at Pasoh Forest Reserve, Malaysia. Bruckman, V.J. (*Austrian Academy of Sciences, Republic of Austria; viktor.bruckman@oeaw.ac.at*), Glatzel, G. (*University of Natural Resources and Applied Life Sciences, Republic of Austria; gerhard.glatzel@oeaw.ac.at*).

Root systems of *Shoera leprosula, Dyera costulata*, and *Oncosperma horridum* were studied in a typical Southeast Asian tropical lowland rain forest at Pasoh Forest Reserve (Peninsular Malaysia). Forest management-induced effects were considered for *S. leprosula* virgin and regenerating stands. Roots were sampled in north, east, south and west transects at 1/3 and 2/3 of mean crown projection to a depth of 40 cm. The novelty in this study was to consider only roots of a single sample individual based on its optical and physical root characteristics. All three species showed highest fine-root mass in the uppermost horizon (0–10 cm), with 63 $g.m^{-2}$ (52% of tot. for *Shorea*, 30 $g.m^{-2}$ (67%) for *Dyera* and 116 $g.m^{-2}$ (48%) for *Oncosperma.* Fine-root mass in the top 10 cm was significantly higher in the virgin stand, whereas no significant difference was observed for coarse-root mass. Significantly more fine roots were found in southern transects of *Dyera*, likely a response to prevailing northerly winds. Coarse-root mass generally showed a greater variance but the maxima for all species were found in the second horizon (10–20 cm), with 46 $g.m^{-2}$ (46% of tot.) for *Shorea*, 52 $g.m^{-2}$ (32%) for *Dyera*, and 199 $g.m^{-2}$ (45%) for *Oncosperma*.

Soil mineralogy and its ecological consequences at Pasoh Forest Reserve, Malaysia. Bruckman, V.J. (*Austrian Academy of Sciences, Austria; viktor.bruckman@oeaw.ac.at*), Ottner, F., Wriessnig, K. (*University of Natural Resources and Applied Life Sciences, Austria; franz.ottner@boku.ac.at; karin.wriessnig@boku.ac.at*).

Relatively little is known about the soils in Pasoh Forest Reserve beyond the intensely studied permanent plots. Therefore, the aim of this study was to (i) conduct a bulk mineral analysis (BMA), (ii) identify the clay mineral composition (CMA), and (iii) reveal quantitative information about grain size distribution (GSD) in a larger area. Clay minerals are adequate compounds to determine weathering status of soils and they play a vital role in nutrient cycling in tropical forest ecosystems. Seven soil samples were taken using a hand auger up to 40-cm depth, and homogenized. X-ray diffractometry was used to perform BMA and CMA. GSD was determined by a sedimentation method. According to the U.S. Department of Agriculture soil texture triangle, samples were classified as clay, silt clay, silt clay loam, and sandy clay loam. BMA showed typical patterns of heavy weathered soils, with quartz dominating followed by layers of silicates and Fe-minerals (goethite and hematite). Weathering status could be explained by the proximity to riverbeds. Kaolinite was in all samples with > 95% the dominating clay mineral. We suggest that sedimentation from rivers constantly renews forest soils and hence influence the nutrient cycle beyond effects caused by translocation of organic matter.

Optimum fertilization to reduce nutrient loss and improve growth performance of containerized seedlings. Cho, M.S., Park, B.B., Lee, S.W. (*Korea Forest Research Institute, Republic of Korea; gungdong@hanmail.net, bbpark@forest.go.kr, lsw361@forest.go.kr*).

Fertilization is very important in nursery culture to increase seedling quality. In fertilization practices, an optimum amount of fertilization is required to reduce nutrient loss and prevent soil and water contamination around the nursery. We tested three fertilization strategies: (1) fixed rate (Con), which has been used conventionally; (2) exponential rate (Exp), whose fertilization increases from tiny to over-supply, "nutrient loading"; and (3) three-stage rate (Thr), which follows seedling growth patterns. We used 1-year-old *Liriodendron tulipifera* seedlings growing in 20 holes per tray (400 mL/hole) and fertilized N-P-K (19-19-19) solutions for 10 weeks. We measured physiological characteristics such as photosynthesis rate, chlorophyll fluorescence, and chlorophyll contents; and growth performance such as height, root collar diameter, and dry weight. Nutrient supply of Exp is about 60% of Con and Thr, but height, root collar diameter, and dry weight were not significantly different among treatments. Like growth performance, physiological characteristics were higher at Con than at other treatments, but not statistically different among treatments. Exp method showed high nutrient efficiency as well as the least nutrient loss. Results suggests the exponential method can prevent soil and water contamination around the nursery with similar growth performance of *L. tulipifera*, which reduces producers' investments.

Structure of valley forest vegetation communities based on National Forest Inventory data in Korea. Chung, D.J., Song, Y. H. (*National Forestry Cooperative Federation, Republic of Korea; cdj3663@nfcf.or.kr; 042839@nfcf.or.kr*), Hwang, H.T. (*Korea Forest Service, Republic of Korea; h581@foa.go.kr*), Kim, S.H., Kim, J.S. (*Korea Forest Research Institute, Republic of Korea; shkim@forest.go.kr; js4029k@forest.go.kr*), Nor, D.K. (*National Forestry Cooperative Federation, Republic of Korea; ndk1108@nfcf.or.kr*).

To collect basic vegetation information for the ecological preservation and efficient management of valley forests in Korea, 436 species were selected; their vegetation types were classified using the phytosociological method, and their biological characteristics were identified. As a result, the habitat was classified as *Cornus controversa* community group, which was then subdivided to *Zelkova serrata* community and *Juglans mandshurica* community. *Z. serrata* community was classified in the *Rhododendron mucronulatum* group and *Celtis jessoensis* group, while the *Celtis jessoensis* group was classified in *Picrasma quassioides* subgroup and *Sapium japonicum* subgroup. *Juglans mandshurica* communtiy was classified in the *Ulmus laciniata* group and *Alnus japonica* group, while the *Ulmus laciniata* group was classified in the *Acer mandshuricum* subgroup and *Ulmus laciniata* typical subgroup. Thus, the valley forest vegetation of Korea was classified into 1 community group, 2 communities, 4 groups, and 2 subgroups, and found to have 6 vegetation units in total. The correlation between main species of trees and environmental factors (altitude, slope, topography, and aspect) has been analyzed using canonical correspondence analysis (CCA). The *Z. serrata* community was distributed in an area of some high slope, while the *J. mandshurica* community was distributed in an area of high altitude.

Vegetation type and ecological characteristics in Korea based on the 5th National Forest Inventory. Chung, D.J., Song, Y.H. (*National Forestry Cooperative Federation, Republic of Korea; cdj3663@nfcf.or.kr; 042839@nfcf.or.kr*), Hwang, H.T. (*Korea Forest Service, Republic of Korea; h581@foa.go.kr*), Kim, S.H., Ryu, J.H. (*Korea Forest Research Institute, Republic of Korea; shkim@forest.go.kr; jhryu99@forest.go.kr*), Nor, D.K. (*National Forestry Cooperative Federation, Republic of Korea; ndk1108@nfcf.or.kr*).

To collect basic vegetation information for the ecological preservation and efficient management of national forests based on the 5th National Forest Inventory data in Korea, 200 sample plots were selected; vegetation types were classified using the phytosociological method and biological characteristics were identified. The results of surveying the flora were recorded as 528 taxa; 37 ordo, 106 families, 298 genera, 528 species. Filicineae of Pteropsida were 23 taxa; 2 ordo, 8 families, 15genera, 23 species. Coniferophytae of Gymnospermae were 12 taxa; 1 ordo, 4 families, 8genera, 12 species. Monocotyledoneae of Angiospermae were 72 taxa; 7 ordo, 11 families, 43 genera, 72 species. Dicotyledoneae of Ansiospermae were 421 taxa; 27 ordo, 83 families, 232 genera, 421 species. The habitat was classified as *Pinus densiflora* community group, which was then subdivided to *Lindera glauca* community and *Quercus mongolica* community. *Q. mongolica* community was classified in the *Q. dentata* group and *Corunus controversa* group, while the *Q. dentata* group was classified in *Chamaecyparis obtusa* subgroup, *Athyrium yokoscense* subgroup, and *Corylus heterophylla* subgroup. Thus, the forest vegetation of Korea was classified into 1 community group, 2 communities, 2 groups, and 3 subgroups, and found to have 5 vegetation units in total.

Development of ecological amplitude of topological factors with forest types in Taiwan. Feng, F. (*National Chung Hsing University, China-Taipei; ffeng@nchu.edu.tw*).

Forest-Grid was developed for spatial analysis, distribution graphing (normalized Gaussian distribution), and mapping of ecological amplitude. Objectives of this study were use Forest-Grid for spatial analysis of habitat factors to estimate the ecological amplitude of forest types. Theme maps were based on vector format with 22,501,993 cells of 40- × 40-m grid on Taiwan Island. Topological factors—elevation, slope, and aspect—were derived from digital terrain model (DTM). Spatial interpolation was used to get the character distribution of forest habitats. Forest-type maps with 54 types were interpreted from aerial-photos and ground surveys in Taiwan's 3rd Forest Inventory. Results showed most elevation ecological amplitude of natural forest types could fit well with Gaussian distribution, except grassland. *Abies* forest type is the highest (mean: 3,132 m) in Taiwan, followed by *Tsuga* forest (2,697 m), *Picea* (2,562 m), pine (2,489 m), and Cypress forest (2,226 m), hardwood-coniferous forest type (1,941 m), and bamboo-coniferous forest type (1,209 m). All the natural forest types are related to slope habitat factors above 30 degrees. Some forest types such as natural pine forest, bamboo-coniferous mixed forest, grassland, Yushanian bamboo thicket, etc. are located in their own aspect; most forest types occurred on any aspect.

A model experimental system for the male cone development of a conifer, *Cryptomeria japonica*. Fukui, M. (*Forestry and Forest Products Research Institute, Japan; mitsue@ffpri.affrc.go.jp*).

The effects of environmental factors on plant morphogenesis can be examined precisely by using an easily repeatable experimental system. In one of the Japanese conifers, *Cryptomeria japonica*, flowering of saplings grown from cuttings can be initiated by treatment with GA_3. In this study, a simple experimental system for the male cone morphogenesis of *C. japonica* was

developed in a closed environment. Two-year-old saplings of *C. japonica* were sprayed with 50 ppm of GA_3 in the middle of July and kept at 30/25 °C (day/night) with a 14-hour photoperiod for 7 weeks. Thereafter, the conditions were as follows: 25/20 °C (day/night) with a 12-hour photoperiod for 5 weeks, 20/15 °C (day/night) with an 11-hour photoperiod for 4 weeks, 15/10 °C (day/night) with a 10-hour photoperiod for 1 week, and then 10 °C with a 10-hour photoperiod for 11 weeks. At the 28th week (the end of January), saplings were transferred to the field. In March, mature pollens were released and the germination rate of pollens was tested. The process of male cone development to pollen maturation will be presented.

Variation in soil properties of forest stands in Mt. Makiling Forest Reserve, Philippines. Galang, M. A., Alvarez, K.B., Catameo, F.K.T., Elchico, Q.L., Silayan, D.M.C., Dequilla, A.J.T. (*University of the Philippines Los Baños, Philippines, marcogalang@gmail.com; kimberly_alvarez09@yahoo.com; kcatameo@yahoo.com; qjade_08@yahoo.com; paracetamol_21@yahoo.com; ajdequilla@yahoo.com*).

Soil sampling and characterization in Philippine forests has been largely based on agricultural depth of 0–20 cm. This procedure neglects the nature of forest tree species, which normally have roots beyond the 1-m depth. Following this premise, soil samples were taken at greater depths (20–50 cm and 50–100 cm) in a secondary growth forest, and mahogany and Dipterocarp plantations in the Mt. Makiling Forest Reserve, Philippines. The general objective is to determine the range in forest soil properties in these stands that have been classified, in general, under one soil order (Alfisol). Preliminary results showed that of the three forests stand, the Dipterocarp plantation of about 80 years old and a basal area of 981 m^3 ha^{-1} has the highest forest floor material (O horizon, depth, and weight). Soil physical and chemical properties were observed higher for the Dipterocarp forest compared to the rest of the stands. This study proves the significance of soil characterization at deeper depths in areas under the influence of forest vegetation. Further, it demonstrates the varying influence of forest types on the eventual soil properties of the site, which is important in the management of forest stands and in future land use suitability assessment.

Study of the impact of ice disaster on rare and endangered plant communities. Guo, W., Li, J., Shen, Y., Kang, D., Kang, W., Su, M., Zhou, W., Song, T., Hao, P., Zhao, Z. (*Beijing Forestry University, Republic of China; guowenxia000@yahoo.cn; lijq@bjfu.edu.cn; shenyb@bjfu.edu.cn; 497708565@qq.com; 343811677@qq.com; 364192342@qq.com; 597640468@qq.com; 165146606@qq.com; 272626838@qq.com; cunsai@163.com*).

In January 2008, Hunan, Jiangxi, Guizhou provinces and so on suffered from a serious ice disaster that has been rarely seen in history. Many rare and endangered plant communities were severely damaged. In this study, 5 protected first-grade rare and endangered plant communities and 5 protected second-grade rare and endangered plant communities were selected from three national nature reserves that suffered severe damage in Hunan province. The methods of contrastive analysis and correlation analysis were used to compare the regeneration status of different communities and to find the main factors influencing their regeneration. The results show that the regeneration status of *Amentotaxus argotaenia* (Hance) Pilger was better than the others; in all the communities, the number of 1–2 year-old renewal seedlings was highest, but there were fewer 3-year-old renewal seedlings; however, 5-year-old renewal seedlings were basically non-existent. Most renewal seedlings of every community distributed agminate in forest gaps (formed after the ice disaster) close to seed trees. These suggest that natural recovery of these rare and endangered plant communities is difficult, so a certain degree of human intervention is required; and the dominant factor affecting the regeneration is light.

Comparison of soil seed banks under different canopy closure levels in secondary natural forest and plantations in the Mt. Makiling Forest Reserve, Philippines. Han, A.R., Park, P. S., Sohng, J. E (*Seoul National University, Republic of Korea; phoya@naver.com; pspark@snu.ac.kr; einehana@paran.com*), Barile, J. (*University of the Philippines Los Baños, Philippines; jojobarile@yahoo.com*).

Density and species composition of soil seed banks were investigated in different canopy closure levels (gap and closed canopy) between a secondary natural forest and nearby plantation in the Mt. Makiling Forest Reserve, the Philippines. Soil seed bank samples were collected at 3 soil depths (0–15 cm at 5-cm intervals) with 10 replications during the dry season in gap and closed canopy condition in secondary natural forest and plantation. Collected seeds from soil seed bank samples were subjected to a germination test at an open nursery, and emerging seedlings were counted every 2 days for 8 months. Mean number of seeds in the 0–15 cm soil layer in the secondary natural forest were 140/m^2 in gap and 109/m^2 in closed canopy condition. Secondary forest had more germinating seeds than plantation, being 103/m^2 and 90/m^2 in 0–15 cm soil layer in gap and closed canopy condition, respectively. Number of germinating seeds was greater in gap than closed canopy condition. Twelve species were found at each secondary forest and plantation, 7 species in common and 5 species different.

Estimating site index equations for *Pinus densiflora* based on National Forest Inventory data in Gangwon Province, Korea. Han, S.H. (*National Forestry Cooperatives Federation, Republic of Korea; huni36@nfcf.or.kr*), Jung, I.B., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; leohunter@naver.com; shkim@forest.go.kr*), Nor, D.K., Song M.S., Kim, J.G., Kim, D.H. (*National Forestry Cooperatives Federation, Republic of Korea; ndk1108@nfcf.or.kr; smoons@nfcf.or.kr; jonggirl2@daum.net; dong77n@nfcf.or.kr*).

Site index is the essential tool for forest management to estimate the productivity of forest land. Generally, site index equation is developed and used by relationship between stand age and dominant tree heights. However, there is a limit to use the site index equation in the application of variable ages, environmental influence, and estimation of site index for unstocked land. Therefore, we attempted to develop new site index equations based on various environmental factors including site, soil, and topographical variables. Therefore, analysis of theses reciprocal actions carries an important meaning for forest productivity. This study was conducted to develop site index equations based on the relationship between site index and environmental factors for *Pinus densiflora* in Gangwon Province. Site indices basis on 30 years were estimated by the cumulative NFI data. For development equations by multiple regression models, researching verified data required a supplementary budget. The site index equations developed in this study were also verified by three evaluation statistics such as model's estimation bias, precision of model, and mean square error type of measure. Internal correlate indicators were excluded from step-wise regression and each indicator was distributed by GIS technique.

Comparison of photosynthetic characteristics between dominant stem and recessive stems of *Quercus variabilis* sprouts in a coppice forest. Ji, D.H., Lim, J.H., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; goon76@forest.go.kr; forefire@forest.go.kr; mblee@forest.go.kr*), Kim, P.G. (*Kyungpook National University, Republic of Korea; pgkim@knu.ac.kr*).

To investigate the influence of the vigor difference of coppice shoots on photosynthetic production, 2-year-old coppice stems of *Quercus variabilitis* were classified into dominant stems and recessive stems, and their dry matter production and physiological properties were investigated. The dominant stems showed many more leaves and branches than the recessive stems, suggesting that the dominant stems have more assimilatory organs. In addition, each leaf of the dominant stems was wider and their chlorophyll content and photosynthesis rate at light saturation point were higher, indicating that the material productivity of each leaf is high. Moreover, the dominant stems showed higher specific leaf dry mass (g/m^2), higher maximum amount of water storage, and more resistance ability to water loss, which means that they are more tolerant to water stress.

Ground beetle community structure along a chronosequence of primary vegetation succession on Mt.Fuji. Jimbo, K., Kubota, K., Zaal, K. (*The University of Tokyo, Japan; jimbo@nenv.k.u-tokyo.ac.jp; kohei@fr.a.u-tokyo.ac.jp; zaal@k.u-tokyo.ac.jp*).

This study analyzes the patterns of ground beetle species diversity along vegetation succession gradient in a volcanic desert on Mt. Fuji with the aim to understand the links between vegetation and ground beetle successions. The habitats on Mt. Fuji, where the last big eruption happened 300 years ago, represent a chronosequence from pioneer plant colonization to climax forest. Our study sites represented three different successional stages: colonization stage on volcanic desert, seral forest, and a climax forest. In addition, we sampled ground beetles in 20 patches of *Polygonum cuspidatum* Sieb. et Zucc of different sizes to analyze the early successions in more detail. We used pitfall traps to sample ground beetles, and analyzed ground beetle communities using TWINSPAN. Early-successional vegetation patches, seral forest, and climax forest differed clearly in dominant ground beetle subfamilies. Within vegetation patches representing different sub-stages of early succession, ground beetles formed three distinct groups. Ground beetle species richness correlated more strongly with tree species richness than with overall plant species richness. We conclude that species composition of ground beetles along the chronosequence of primary succession responded primarily to vegetation patch size and tree species richness.

Diameter growth analyses of Korea's main forest tree species based on National Forest Inventory data. Joo, C.H. (*National Forestry Cooperatives Federation, Republic of Korea; randb2002@nfcf.or.kr*), Kim, S.H., Shim, W.B. (*Korea Forest Research Institute, Republic of Korea; shkim@forest.go.kr; airphoto@forest.go.kr*), Rho, D.H., Song, M.S. (*National Forestry Cooperatives Federation, Republic of Korea; ndk1108@nfcf.or.kr; songms0311@nfcf.or.kr*).

Stem core data obtained through the National Forest Inventory were used to study diameter growth increments of major forest tree species in Korea. We used data on tree ages, tree height, growth increment, and bark thickness to evaluate diameter growth rates for different age classes for each species studied, and to evaluate the relationships between growth rates and site conditions (elevation, aspect, slope and topography) and environmental factors. Correlation analyses were also carried out to evaluate relationships among diameter growth rates and slope position and environmental factors. *Pinus densiflora*, *Robinia pseudoacacia*, and *Quercus acutissima* were found to have larger diameter grown rates than *Q. mongolica*, *Q. serrata*, and particularly *P. koraiensis* (Korean pine), which has the slowest growth. Correlations between diameter growth increments and environmental factors, elevation, aspect, and topography revealed few significant relationships, although the relationship between slope and diameter growth was found to be highly significant (at the 1% level).

Relationship between soil properties and site index for Sawooth Oak (*Quercus acutissima* Carruth.) in Korea. Jung, S.Y. (*Gyeongsang National University, Republic of Korea; suyoung.jung@gmail.com*), Park, N.C., Lee, K.S., Shin, H.C. (*Korea Forest Research Institute, Republic of Korea; pnch@forest.go.kr; beldel660@forest.go.kr; shinhc99@forest.go.kr*), Lee, S.H. (*Chonbuk National University, Republic of Korea; leesh@chonbuk.ac.kr*).

We estimated site productivity for unstocked land based on the relationship between site index (SI) and soil properties of sawooth oak (*Quercus acutissima* Carruth.) stands. For this study, we selected 78 sites in 22 stands of central temperate forest zone in Korea, and sampled soils for physical and chemical soil analysis. To estimate the best model of site index derived from 13 soil properties, data on the soil properties were used to predict site index comparatively using both multiple linear and principal component regression (PCR) methods. In PCR, we applied principal component analysis (PCA) based on the correlation matrix to the independent variables; then we selected the most significant two PCs and took PCR on all the recalculated original independent variables having reliable coefficients sign and magnitude in the final SI model by considering multicollinearity. The significant variables were total nitrogen, Exch. K^+, Exch. Na^+, organic matter, and pH in descending order of their contribution to the estimated SI model. These results may be useful to provide not only reliable criteria for establishment of *Q. acutissima* stands especially in unstocked land, but also a guidance for aforestation in this new plantations.

Comparison of dead wood at three stands in Jeju Experimental Forests. Kim, C.M., Park, C.R., Kim, D.H., Chung, Y.G. (*Korea Forest Research Institute, Republic of Korea; helmin@forest.go.kr; park@forest.go.kr; dhkim1973@gmail.com; YGCHUNG99@forest.go.kr*).

This study was conducted to comprehend composition of dead woods (fallen trees, stumps, and snags) at three stands in Jeju Experimental Forests (JEFs) from 2008 to 2009. We developed survey protocols and recorded the quantity and volume of dead woods, and we estimated the quality ranking of four grades based on decay status of dead woods in 20- × 20-m plots in three stands (cedar forests, deciduous forests, and evergreen forests). Also we recorded woodpecker pecking signs at each dead wood. Total volume of dead woods was significant high in deciduous forests, and low in evergreen forests. Stump dominated the cedar forests, and snags and fallen trees dominated deciduous forests. In deciduous forests, highly decayed trees were *Styrax japonica*, *Pinus densiflora*, *Lindera erythrocarpa*, *Maackia faurie*, and *Daphniphyllum macropodum*; low-decay trees were *Carpinus laxiflora*, *Cornus walteri*, and *Neolitsea aciculata*. Also, woodpecker pecking signs were high at *M. faurie*, *L. erythrocarpa*, *P. densiflora*, *S. japonica*, and *Mallotus japonicus*. Three stands showed different composition of dead wood, and deciduous

stands had more snags known as potential nests of woodpeckers. This result can provide management guidelines for dead woods to manage the JEFs sustainably.

Nutrient dynamics in decomposing leaf litter at the Geumsan LTER site, Korea. Kim, C.S., Jeong, J.Y. (*Jinju National University, Republic of Korea; ckim@jinju.ac.kr*; *jy668@nate.com*), Lee, I.K. Lim, J.H. (*Korea Forest Research Institute, Republic of Korea; iklee@forest.go.kr; limjh@forest.go.kr*).

This study was conducted to examine litter decomposition rate and nutrient dynamics in decomposing leaf litter of *Quercus serrata*, *Carpinus laxiflora*, and *C. cordata*, which are three dominant tree species at the Geumsan LTER site, Korea. Remaining mass after 919 day's incubation was significantly lower in *C. cordata* (31.8%) than in *C. laxiflora* (36.0%) and *Q. serrata* (49.8%). Nitrogen and phosphorus concentrations in decomposing leaf litter were significantly lower in *Q. serrata* than in *C. laxiflora* and *C. cordata* during the period of study. Potassium concentration in decomposing leaf litter was not different among three species. The potassium concentration rapidly declined, with about 80% release for 919 days. Calcium concentration in decomposing leaf litter was significantly higher in *C. cordata* than in *C. laxiflora* and *Q. serrata.* Magnesium concentration in decomposing leaf litter was lower in *Q. serrata* than in *C. laxiflora* and *C. cordata*. The results indicate that the dynamics of litter decomposition and nutrient dynamics in decomposing leaf litter were different among three tree species. Generally, leaf litter of *Q. serrata* showed a slow mass loss and low nutrient concentration compared with other two deciduous hardwood tree species.

Estimation of growth model for *Quercus acutissima* considering environmental and forest stand factors. Kim, D.H., Kim, E.G., Kim, H.H., Park J.H. (*Gyeongsang National University, Republic of Korea*; *kdh221@gnu.kr; egkim@gnu.kr; khh@gnu.kr; forestry@gnu.ac.kr*), Kim, D.H. (*Korea Forest Research Institute, Republic of Korea;dhkim1973@gmail.com*).

The purpose of this study was to examine the environmental factors and forest stand factors influencing the growth of *Quercus acutissima*, which is widespread in the Republic of Korea. We used site index as a dependent variable and applied environmental and forest stand factors as independent variables for regression analysis using field data and the location of permanent plots from the 5th National Forest Inventory (2006–2008). A total of eight independent variables were selected with stepwise method using SPSS. Monthly average, lowest and highest temperature, average rainfall, cumulative rainfall, and annual mean temperature were considered as environmental factors. Soil type, soil texture, and slope aspect were included as forest stand factors. After conducting linear regression analysis, we showed that environmental and forest stand factors influencing site index are dry dark red forest soil (DR_1), northern slope, mean September rainfall, and May highest temperature, which had positive effects. On the contrary, dry red forest soil ($R{\cdot}Y\text{-}R_1$), slightly dry brown forest soil (B_2), slightly eroded soil (Er_1), and mean June rainfall showed negative effects on site index of *Q. acutissima*.

Physical stock accounting of forest resources using national forest inventory data in Korea. Kim, D.H. (*National Forestry Cooperatives Federation, Republic of Korea; dong77n@nfcf.or.kr*), Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; shkim@forest.go.kr*), Nor, D.K., Han, S.H. (*National Forestry Cooperatives Federation, Republic of Korea; ndk1108@nfcf.or.kr; huni36@nfcf.or.kr*), Hwang, H.T. (*Korea Forest Service, Republic of Korea; h581@foa.go.kr*).

The National Forest Inventory deals with the measurement of trees and stands—the estimation of their volume, growth prediction, biomass, carbon stocks, and the description tree characteristics, as well as the land upon which they are growing. The objective of this study is to develop accounts of forest resources based on the system of integrated environmental economic accounts (SEEA) by National Forest Inventory data in Korea. Forest land area decreased from 6.44 to 6.38 million ha between 1997 and 2007, continuing a slight downward trend in area beginning in the late 1990s. However, forest resources of Korea have continued improving in general condition and quality, as measured by increased average size and volume of trees. Growing-stock volume of Korea increased from 17 to 123.79 cubic meters per ha between 1976 and 2007. According to the forested land asset accounts generated with NFI data, logging area is larger than reforestation area, and total forested land has decreased. The changes due to economic activity refer to production activities such as harvest, harvest damage, and afforestation that affect the stock of forests.

Estimation of diameter and basal area growth pattern using tree ring data from the National Forest Inventory in Korea. Kim, D.H. (*National Forestry Cooperatives Federation, Republic of Korea; dong77n@nfcf.or.kr*), Lee, S.H. (*Chonbuk National University, Republic of Korea; leesh@Chonbuk.ac.kr*), Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; shkim@foa.go.kr*), Nor, D.K., Chung, D.J. (*National Forestry Cooperatives Federation, Republic of Korea; ndk1108@nfcf.or.kr; cdj3663@nfcf.or.kr*).

The National Forestry Cooperatives Federation conducts the National Forest Inventory every 5 years to obtain accurate baseline data for national forest policy. The new inventory system measures a 20% sample of Korea's forests every year. When taking forest inventory, the following are important factors to measure and note: species, diameter at breast height (DBH), height, site quality, age, and defects. Tree-level data consist of observations of individual trees, where trees with DBH more than 6 cm are measured from plots. From data collected one can calculate the number of trees per ha, the basal area, the volume of trees in an area, and the value of the timber. The objective of this research was to provide basic information on *Larix letolepis* for the prediction system, which consists of the best model of diameter and basal area. Data were collected from cores of 459 sample trees for *L. letolepis* using tree ring data from the National Forest Inventory in Korea. Of the projection functions tested, a polymorphic equation using the overlapping data showed higher precision of fit than did an anamorphic equation. The equation, therefore, could be available as basic information for estimation of growth and management of *L. letolepis* stands.

Establishment of *Rhus javanica* in riparian *Robinia pseudoacacia* forests. Kurokochi, H. (*University of Tokyo, Japan; aconitum-k@fr.a.u-tokyo.ac.jp*).

It is well-known that many plants reproduce both sexually and asexually. *Rhus javanica* is also one of clonal trees and could expand its distribution through adventitious bud formation on roots and stumps. To clarify the establishment process of clonal trees is helpful for understanding tree reproduction. In this study, *R. javanica* populations that were established under *Robinia pseudoacacia*-dominated riparian forests were investigated to demonstrate the establishment process by counting all annual rings

at 2 cm above the ground and tracing roots. As a result, three patches (a, b, c) of *R. javanica* were verified and the stand densities were 20.3 trees/m^{-2}, 12.2 trees/m^{-2}, and 9.4 trees/m^{-2}, respectively. Root tracing made it clear that each population was constructed by one genet. Although there were positive correlations between tree age and tree height, tree height and diameter of 2 cm above the ground, and tree age and diameter of 2 cm above the ground, the growth in the first year was not possibly correlated with tree age or tree standing position. These results suggest that *R. javanica* that has germinated by chance expands its distribution by root suckers, but the ramets seem to be nutritionally independent of each other.

Relationships between distributional pattern of liana species and their ecological traits in a subtropical evergreen broadleaved forest in southwest Japan. Kusumoto, B., Enoki, T. (*Kyushu University, Japan; kusumoto.buntarou@gmail.com; enoki@forest.kyushu-u.ac.jp*), Kubota, Y. (*University of the Ryukyus, Japan; kubota.yasuhiro@gmail.com*).

Lianas have considerable roles in the dynamics and function of forest ecosystems. Understanding ecology of lianas is meaningful to perform biodiversity conservation and sustainable forest management. We examined relationships between distributional patterns of liana species and their ecological traits in the subtropical forests in Okinawa Island, Japan. We compared abundance and topographic distribution patterns of liana species between primary and secondary forest. Two study plots were 8 ha and 16 ha in area for primary and secondary forest, respectively. The plots were divided into 25-m × 25-m cells. Topographic index was calculated from digital elevation map with 10-m intervals in each cell. Lianas (larger than 2 cm in diameter) were recorded in the two plots. Sampling of living leaves were conducted in and around the plots. Leaf traits (leaf area, specific leaf area (SLA), and nitrogen concentration) and climbing habits were treated as ecological traits. We found 1,528 liana stems from 22 species belonging to 4 climbing habits. Leaf traits partly explained the distributional pattern of each species. Low SLA species tended to have broad topographic distribution ranges and abundance in primary forest. However, the trends were different among climbing habits.

The photosynthesis and growth response of narra (*Pterocarpus indicus*) to different light intensities. Lee, K.A., Woo, S.Y., Lee, S.H., Kwon, M.Y. (*University of Seoul, Republic of Korea; galammenta@ymail.com; wsy@uos.ac.kr*; *earlyma1004@yahoo.co.kr; ms874@naver.com*).

This study was conducted to investigate photosynthetic ability of Narra (*Pterocarpus indicus*) to different light conditions. The experiment was performed on 2-month-old and 2-year-old seedlings. The treatments have different light intensities (100%, 65%, and 30% of full sunlight). It showed different photosynthesis capacity, height, and diameter on narra seedlings. In August, 2-month-old seedlings showed higher photosynthesis than that of 2-year-old seedlings. The values of photosynthesis in 100%, 65%, and 30% of full sunlight for 2-month-old seedlings were 8.34, 5.48, and 5.62 μmol m^{-2} s^{-1}, respectively; 2-year-old seedlings showed 5.50, 4.68, and 4.89 μmol m^{-2} s^{-1}, respectively. In contrast, in September, in 100%, 65%, and 30% of full sunlight, 2-year-old seedlings have higher photosynthesis than 2-month-old seedlings; the 2-year-old seedlings have 7.10, 3.06, and 6.19 μmol m^{-2} s^{-1}, and 2-month-old seedlings have 3.72, 1.74, and 2.75 μmol m^{-2} s^{-1}, respectively.

Stand structure and growth classified by vegetation type of Japanese red pine forest (*Pinus densiflora* Sieb.et Zucc) in Korea. Lee, K.S., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; beldel660@forest.go.kr; pnch@forest.go.kr*), Jung, S.Y. (*Gyeongsang National University, Republic of Korea;suyoung.jung@gmail.com*), Shin, H.C. (*Korea Forest Research Institute, Republic of Korea; shinhc99@forest.go.kr*).

The area of Japanese red pine (*Pinus densiflora* Sieb.et Zucc) forest in Korea is gradually decreasing, while that of deciduous, mostly oak, forest is increasing mostly occupied by oak forest is in increasing trends. The object of this study aims to find a better way to induce natural regeneration of pine forests by analyzing stand structure and succession process. The pine forest was classified into five groups—cork oak community, serrate oak community, Manshurian fullmoon maple community, Sasa borealis community, and typical community—and there were significant differences of stand characteristics by region. Considering dominance of different layers of the pine forest site, in the upper story pines are dominative species, but in the middle story deciduous tree species dominate, and in the understory pine seedlings are hardly found. Although pines seem to have high ecological influences on these stands, it is expected that dominant species in current pine forest area will be replaced by oak species after pines decline through autogenic succession. Growth patterns of pine forest are significantly characterized by each stand type, so a practical approach for management of pine forest should be applied and followed according to their specific stand structure and growth characteristics.

Effects of seedling density on physiological characteristics and growth performances of containerized seedling of *Liriodendron tulipifera*. Lee, S.W., Cho, M.S., Park, B.B. (*Korea Forest Research Institute, Republic of Korea; lsw361@forest.go.kr; gungdong@hanmail.net; bbpark@forest.go.kr*).

It is important to produce good seedling quality to get high field performance. This study was conducted to investigate the effects of seedling density (150, 190, and 260 seedlings/m^2) on photosynthetic responses, chlorophyll fluorescence, chlorophyll contents, and growth performances of containerized seedling of *Liriodendron tulipifera*. *L. tulipifera* showed the highest photosynthetic capacity, 6.77 μmolCO_2·m^{-2}·s^{-1}, at 150 seedlings/m^2, while the lowest, 4.62μmolCO_2·m^{-2}·s^{-1}, at 260 seedlings/m^2. Photochemical efficiency and the maximum value (F_v/F_m) of apparent quantum yield for the photochemical reaction decreased as the seedling density increased. These results were consistent with the patterns of photosynthetic capacity. Total chlorophyll content was the highest at 150 seedlings/m^2, while the lowest was at 260 seedlings/m^2. As seedling density increased, root collar diameter, height, and total biomass decreased. Root collar diameter, height, and total biomass were significantly higher at 150 seedlings/m^2 than at other seedling densities. Total biomass at 150 seedlings/m^2 was about twice higher than at other seedling densities. In this study, growth performances followed the same trends of physiological characteristics of *L. tulipifera*. Based on physiological characteristics and growth performances, seedlings produced at 150 seedlings/m^2 would have high growth performances in the field.

Short-term air quality changes in Ulaanbartar and Sanzai, Mongolia. Lee, S.W., Lee, C.H. (*Korea Forest Research Institute, Republic of Korea; soilloverlee@forest.go.kr; hwa21@forest.go.kr*), Tsogtbaatar, J., Javzan, Ch. (*GeoEcology Institute, Mongolian Academy of Sciences; geoeco@magicnet.mn; choijil_javzan@yahoo.com*).

To investigate changes in wet precipitation and ambient gaseous pollution in Mongolia, air quality was monitored at urban (UB) and mountainous (Sanzai) sites from 2001 to 2008. During the period, annual mean concentration of SO_2 in UB and Sanzai averaged 23 ppb and 5 ppb, respectively. Concentrations of NO_2 were 32 ppb and 3 ppb in UB and Sanzai, respectively. Acidity of wet precipitation in UB (pH 6.7) was higher than in Sanzai (pH 6.2), because the acid neutralization capacity of alkali earth ions (Ca^{2+}, Mg^{2+} etc.) in the precipitations would be greater in UB. Major ions of wet precipitation were SO_4^{-2} among anions and Ca^{2+} among cations. Total dissolved solids of precipitation in dry season 2009, at UB was two times of Sanzai. However the annual mean pH of wet precipitation both in the two sites has gradually decreased since the early monitoring years. Although the ambient concentrations of SO_2 and NO_2, primary oxidants cause very high wet precipitation acid in UB, acid wet deposition does not occur under the very dry and windy climate of Mongolia.

Germination characteristics and some aspects of phenology of four important rattan species in Sabah, Malaysia. Mohamad, A. (*University Malaysia Sabah, Malaysia; aminmohd@ums.edu.my*), Ree, C. (*Sabah Forestry Department, Malaysia*).

Rattan is an important minor forest produce after timber. About 107 species are found in Sabah, Malaysia. A study to look into some phonological aspects of *Calamus subinermis, C. manan, C. caesiu,s* and *C. ornatus* was observed a period of about 2 years at KoLapis, Sandakan Forest Reserve, Sandakan, Sabah. Seeds from flowering and fruiting were collected for germination capacity tests. Germination capacity of the species studied were also observed. Most of the species took about 8 months from flowering to fruiting. For germination most took about 3 to 6 weeks to germinate, except for *C. subinermis*, which took longer time to germinate (more than 7 months).

Comparison of above- and below-ground growth between naturally regenerated and planted stands of *Pinus densiflora* for. *erecta*. Na, S.J. (*Korea Forest Research Institute, Republic of Korea; joon81u@ynu.ac.kr*), Lee, D.H. (*Yeungnam University, Republic of Korea; dhlee@ynu.ac.kr*), Woo, K.S., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; woo9431@forest.go.kr; jskim20@foa.go.kr*).

This study was undertaken to compare above- and below-ground growth characteristics—such as height; diameter at root collar (DRC); and dry weights of stems, branches, needles, and roots—between naturally regenerated and planted stands of *Pinus densiflora* for. *erecta* Uyeki in Dae-gi and Bo-gwang areas, Gangwon province, Republic of Korea. Average height of the naturally regenerated stands was significantly greater than that of planted stands, 146.2 and 83.9 cm in Dae-gi area, and 199.0 and 93.1 cm in Bo-gwang area, respectively. Average DRC growth differed between the naturally regenerated and the planted stands only in Bo-gwang area, 4.66 cm and 2.61 cm, respectively. The composition ratio of the dry weights for each part of the measured trees was the highest in the stem in the naturally regenerated stand; however, in the planted stand, the needle was the highest. The ratios of the below- to above-ground biomass in the Dae-gi and Bo-gwang areas in the naturally regenerated stand were 0.17 and 0.18; and in the planted stand, 0.25 and 0.30, respectively. The results of this study can be used for studies on environmental adaptability of trees through long-term monitoring in different growth stages.

Early evaluation of a *Shorea macrophylla* progeny test in Central Kalimantan. Naiem, M., Widiyatno (*Universitas Gadjah Mada, Indonesia; moh_naiem@yahoo.com Indonesia; widiyatno.yk@gmail.com*).

Shorea macrophylla, known as tengkawang, belongs to the *Dipterocarpaceae* family. It becomes a large tree in favorable sites. This species is avoided for harvesting, because it produces an economically important nut to substitute for cacao butter production. To maintain genetic diversity in the face of forest degradation, a progeny test of Tengkawang was established and was done in Sari Bumi Kusuma Forestry Company, Central Kalimantan. The area located in Sei Seruyan, ranged from 00° 36′ to 01° 10′ S and 111° 39′ to 1112° 25′ SE; annual rainfall and raining days varied from 2.909 mm to 3.424 mm, and from 95 to 112 days. The design used was RCBD, 94 families, 5 tree plots, 8 blocks, spacing 6 × 3 meters. Measurement of 3-year-old trees showed a significant different in both height and diameter. Individual heritability values in both height and diameter were low (0.030 and 0.046); however, the family heritability both for height and diameter were medium (0.15 and 0.23). A large amount of genetic diversity is still being maintained and it can be used for breeding strategy of the species.

The study of *Cudrania tricuspidata* community dynamics in Korea. Oh, C.J., Kwon, Y.S. (*Jeon-nam National University, Republic of Korea; ohcj3441@korea.kr; bandon@hanmail.net*), You, H.C., Son, S.G. (*Korea Forest Research Institute, Republic of Korea; hckor7810@korea.kr; sonsak@korea.kr*), Park, W.S. (*Jeon-nam Forest Environment Research Institute, Republic of Korea; pws0815@korea.kr*).

This study examined 16 *Cudrania tricuspidata* stands to analyze ecological characteristics based on vegetation structure among natural grown stands of Korea. A total of 134 species were found in all study sites; we also found above 5% importance values for *C. tricuspidata, Pinus densiflora, Robinia pseudo-acacia*, and *Styrax japonica*. Various diversity indices in the *C. tricuspidata* stands were measured using the Shannon diversity index (H'), which ranged from 0.65 to 1.36; H'max ranged from 1.08 to 1.70; eveness(J') ranged from 0.57 to 0.84; and dominance(D) ranged from 0.16 to 0.43. Indices of stand similarity in Imsil-Gochang (66.2%), Imsil-Gunsan (64.8%), and Jinju- Hadong (60.0%) were higher than the indices of other sites. The stand similarity analysis showed that 8 stands including Gwangyang-Gimje and Goheung-Hongseong stands were very heterogeneous. There was significantly positive correlation among *Lindera erythrocarpa, Cornus walteri, Quercus serrata* and *Platycarya strobilacea* var. *strobilacea* for. *strobilacea*; also among *Callicarpa japonica, Actinidia arguta* var. *arguta, Sapium japonicum, Cephalotaxus koreana*, and *Lindera obtusiloba* var. *obtusiloba* same result. By cluster analysis, community types were classified as communities with *C. tricuspidata*-deciduous; *C. tricuspidata; C. tricuspidata-Robinia pseudo- acacia-Q. acutissima;* and *P. densiflora-C. tricuspidata.*

Vegetation structures of tea plant (*Camellia sinensis* (L.) O. Kuntze) populations in Korea. Oh, C.J., You, H.C. (*Jeon-nam Forest Environment Research Institute, Republic of Korea; ohcj3441@korea.kr; hckor7810@korea.kr*), Kim, Y.H. (*Jeongeupsi Agricultural Technology Center, Republic of Korea; kyh1536@korea.kr*), Lee, S. (*Chonbuk National University, Republic of Korea; devillup@naver.com*), Wi, A. (*Jeon-nam Forest Environment Research Institute, Republic of Korea; ajwiko@korea.kr*).

This study examined 22 kind of tea plant populations to analyze ecological characteristics based on vegetation structure in Korea. Species with above 4% of importance value in the study sites were *Pinus densiflora, Camellia sinensis, Quercus serrata, Acer palmatum, Torreya nucifera, P. rigida, and Styrax japonica*. Indices of genetic diversity in tea plant populations that were measured using the Shannon diversity index (H') ranged from 0.70 to 1.28; H_{max}, ranged from 1.15 to 1.59; evenness (J') ranged from 0.51 to 0.88; and dominance (λ) ranged from 0.12 to 0.49. The population similarity was broadly low, 20%, which could imply that the composition of species among the populations were very complex and heterogeneous. A total of 126 plant species were found in the study sites and there were positive relationships among 43 species that had more than 5% importance value. By cluster analysis, community types were classified into six communities: *Q. serrata*-conifer; deciduous; *Q. serrata-A. palmatum-Chamaecyparis obtusa; Quercus-A. palmate; P. densiflora;* and *T. nucifera.*

The effects of topography, rock volume, and tree density on root biomass. Park, B.B., Kim, Y.K., Sung, J.H., Shin, J.H. (*Korea Forest Research Institute, Republic of Korea; bbpark@forest.go.kr; youngkul@forest.go.kr; jhs033@forest.go.kr; kecology@forest.go.kr*).

We examined the effects of topography, rock volume, and tree density on root biomass at two different forest ecosystems in Korea. We used pit quantitative method and measured root biomass with 4 diameter classes: 0–2, 2–5, 5–10, and >10 mm. The relationships between root biomass and rock volume, tree influence index, and selected soil properties were analyzed. Root biomass was generally lower in valley-floor than in ridge-top. In vertical root distribution, 2–10-mm roots were higher in ridge-top than in valley-floor only at 0–10-cm depth. As rock volume increased, root biomass decreased in 0–2-mm ($P = 0.02$) and 0–10-mm ($P < 0.01$) roots. Tree density around the pits influenced root biomass: fine root biomass less than 2 mm in diameter increased as tree influence index increased. Some soil properties influenced root biomass, which was negatively correlated with sand amount ($P = 0.08$) and pH ($P = 0.07$). Surprisingly, soil exchangeable Ca^{2+} and Mg^{2+} concentrations were significantly reverse-related with 0–2-mm roots. This study suggests the effects of topography, rock volume, tree density, and soil properties on root biomass should be considered in root biomass studies.

Effect of canopy closure on the population dynamics of perennial *Disporum smilacinum*. Park, Y. M., Park, P.S., Seo, J.S., Sohng, J.E. (*Seoul National University, Republic of Korea; pym5250@hanmail.net; pspark@snu.ac.kr; junsuseo@snu.ac.kr; einehana@paran.com*).

Forest disturbance or forest management controls the degree of canopy closure, which affects the reproduction strategy of understory plant population resulting in the population dynamics of the species. *Disporum smilacinum* is a typical monocarpic pseudo-annual plant of Liliaceae, distributed throughout the East Asia region. Morphological characteristics and reproductive strategy of *D. smilacinum* under four levels of canopy closure (0%, 25%, 50%, and 100%) were investigated to determine the effect of canopy closure on the population dynamics. Shoot densities, number of leaves, and number of flowering shoots of *D. smilacinum* were recorded in each canopy closure level. Light penetration ratios through the canopy were also measured using a PAR quantum sensor. While mean leaf number per shoot and number of flowering shoots per plant were different among canopy closure levels ($P < 0.05$), the shoot densities were similar. The mean leaf number per shoot was 5 in 0% and 8 in 100% canopy closure level. The number of flowering shoots was 8 and 191 in 0% and 100% canopy closure level, respectively. These results show that more leaf numbers related to better chance for photosynthesis and productivity, supported more flowers, and enhanced sexual reproduction of *D. smilacinum* population.

The distribution and reproductive ecology of *Ficus* species in riparian forests of Northern Thailand. Pothasin, P. (*Chiang Mai University, Thailand; nok_p_p@hotmail.com*), Compton, S.G. (*University of Leeds, UK; S.G.A.Compton@leeds.ac.uk*), Wangpakapattanawong, P. (*Chiang mai University, Thailand; prasit.w@chaingmai.ac.th*).

The diversity of riparian *Ficus* species in northern Thailand is quite high; 4 species were found generally—*Ficus racemosa* L., *F. auriculata* Lour., *F. squamosa* Roxb., and *F. ischnopoda* Miq. These were found only along streams in mixed deciduous forest (100–500 m) to dry evergreen forest (above 500 m). This study was carried out along four streams in Chiang Mai province, Thailand, during March to November 2009. We aimed to assess riparian fig diversity and to report on field investigation into reproductive biology and the influence of ecological factors on flowering, seed and pollinator production of riparian fig species. All figs along a 10-m line were identified and had location recorded by GPS. Diversity was analyzed by Shanon-Weiner Index. GIS overlay technique was used to detect suitable fig sites. Riparian figs were commonly found distributed closely along the river banks or on the rock in streams. In male figs, a mean of 647 flowers produced a mean of 263 pollinating wasps, mostly female wasps (~70.8%), indicating a relatively high fitness for the pollinator and the fig. Female inflorescences generally appear to initiate more flowers than male inflorescences, and produce more seeds than male inflorescences that produce female pollinator wasps.

Competition effect of *Robinia pseudoacacia* and *Populus deltoids* on the coastal backbone forest strip at the mouth of the Yangtze River, China. Rui, W., Li, S., Zhang, J. (*Jiangsu Academy of Forestry, China; nolarui@yahoo.com.cn; lishuqin88@qq.com; 8zjl8@163.com*).

The establishment of coastal protective forest is an important part of China's six key forestry programs. It is urgent for the construction of a high quality protective forest in the circumstance of changing global climate, especial for brittle muddy coastal ecosystems. To provide experiences for the construction of mixed forest, we conducted an investigation on a 12-year-old *Robinia pseudoacacia* and *Populus* mixed forest based on three typical sample plots. Results showed that the rate of suppressed trees of *R. pseudoacacia* was as high as 64.1%. in the sample plot with *Populus* with a relative importance value of 2.1 The intensity of

competition of *R. pseudoacacia* in the sample plot with *Populus* with a relative importance value of 2.1 on average was 188% higher than that of with only 0.9. Moreover, interspecific competition accounted for 81.9% in the sample plot with *Populus* whose relative importance value was 2.1; however, it was only 35.5% in that of 0.9. In addition, the growth and competition situation was rather different, although the *Populus* relative importance value was similar. The results suggest that not only the mixed rate, but also the mixed patterns should be studied for healthy *R. pseudoacacia* and *Populus* mixed forests.

Growth and spatial distribution characteristics of planted forests of *Robinia pseudoacacia* on the coastal backbone forest strip at the mouth of the Yangtze River, China. Rui, W., Li, S., Zhang, J. (*Jiangsu Academy of Forestry, China; nolarui@yahoo.com.cn; lishuqin88@qq.com; 8zjl8@163.com*).

The construction of shelter belts along the seaboard is an important part of forestry development strategies, not only for its meaning to the ecology safety, but also for the safety of people's lives and property. Based on an investigation of a 12-year-old man-made forest of *Robinia pseudoacacia* with four densities, the characteristics of growth, spatial distribution, and intraspecific competition were studied. Results showed the death rate and diameter at breast height (dbh) of *R. pseudoacacia* was 73.5%, 61.9%, 30.0%, 21.9%'; and 9.4 cm, 10.9 cm, 11.8 cm, 13.3 cm in the density of 1 m × 1 m, 1 m × 2 m, 2 m × 3 m, 3 m × 3 m, respectively. The highest biomass per tree was in the density of 3 m × 3 m, while the highest biomass per hectare was in the density of 1 m × 1 m. Differences also existed in the spatial distribution characteristics of dbh; variation of dbh was enhanced with increased density. Results also showed that intraspecific competition was 4.6 times higher in the density of 1 m × 1 m than that of 3 m × 3 m. It can be concluded that too high a density was not suitable for the construction of man-made forest of *R. pseudoacacia* in the coastal backbone forest strip.

Effect of cadmium and copper on selected physiological parameters of *Eucalyptus microtheca.* Shariat, A., Assareh, M.H., Ghamari-Zare, A. (*Forests and Rangelands Research Institute of Iran, Iran; shariat@rifr-ac.ir; asareh@rifr-ac.ir; ghamari-zare@rifr-ac.ir*).

Human activities have continuously increased the level of heavy metal ions circulating in the environment. The importance of extending silviculture in Iran leads us to study fast-growing and evergreen eucalypts for reduction of pollution and adsorption of heavy metals. Seeds of *Eucaluptus microtheca* were grown in silt and irrigated by nutrient solution. Forty-two-day-old seedlings were exposed to 10 cadmium and copper treatments during 10 months. Metal content in plant organs and physiological and morphological characters such as soluble sugar, prolin, pigments, leaf water ratio, root to stem index, abaxial and adaxial number, and tolerance index were determined. The concentrations of copper and cadmium in root tissue were higher than in leaf and stem tissue, and stem concentration was lower than the concentration of leaf. The content of prolin was raised by increasing metal concentrations, but the content of pigments decreased. These results provided quantified metals in *Eucalyptus* species, explored relationships between concentrations of metals in nutrient solution and plant organs, and evaluated morphological and physiological symptoms of exessing metals.

Growth and foliar responses of rainforest tree seedlings to differing shade treatments in Sinharaja, Sri Lanka. Singhakumara, B.M.P., Weerasinghe, L. (*University of Sri Jayewardenepura, Sri Lanka; balangodasingha@gmail.com; lankamw@yahoo.com*), Ashton, M. (*Yale University, USA; mark.ashton@yale.edu*).

We studied the seedling growth, mortality, and leaf characteristics of ten rain forest tree species in simulated shade treatments (full sun, partial sun, partial shade, and deep shade; 1,200; 800; 350; 50 μmol m^{-2} s^{-1}, respectively) at Sinharaja World Heritage site, Sri Lanka. Species in the families of Anacardiaceae (*Campnosperma zeylanicum, Semecarpus walkeri*); Annonaceae (*Xylopia championii*); Dipterocarpaceae (*Hopea discolor*); Euphorbiaceae (*Aporusa cardiosperma, Ptychopyxis thwaitesii, Putranjiva zeylanica*); Melastomataceae (*Lijndenia capitellata*); Olacaceae (*Strombosia nana*); and Sapindaceae (*Dimocarpus longan*) were grown for 2 years and at the end, growth, mortality, and leaf characteristics were measured. Growth in height, leaf number, root collar diameter, and total dry mass, and stomatal density varied significantly across the shade treatments for all species with the exception of *P. zeylanica* for root collar diameter and total dry mass. The best growth for all species was either in partial shade or partial sun, while the highest mortality was in full sun with the exception of *D. longan*, which was greatest in growth in full sun. We conclude that shade is an important environmental variable that affects tree seedling distribution within the rainforest environment.

Seasonal variation of fine-root biomass in a mixed pine-oak stand in central Korea. Yi, M.J., Heo, U.Y., Jeong, M.J. (*Kangwon National University, Republic of Korea; mjyi@kangwon.ac.kr; makia7@nate.com; sky4887@hanmail.net*), Hwang, J.H. (*Korea Forest Reasearch, Republic of Korea; jhwang@forest.go.kr*), Son, Y. (*Korea University, Republic of Korea; yson@korea.ac.kr*), Kim, J.H., Han, S.S. (*Kangwon National University, Republic of Korea; kimjh@kangwon.ac.kr; sshan@kangwon.ac.kr*).

The invasion of Korean pine (*Pinus koraiensis*) seedlings into oak forest from surrounding mature Korean pine plantations are often observed in central Korea. We determined fine-root biomass during the early growing season of 2009 in a bi-level stand. Fine roots were sampled by soil core method. Soil cores were divided into two layers by depth: 0–10 cm (upper) and 10–30 cm (lower) mineral soil layers. Root biomass varied between two tree species of different sampling time. The peaks were found in live fine-root biomass in late May for both species. The peak of root biomass might be related to a peak in fine-root production before canopy closure. Biomass of live fine roots for two species decreased with increasing growing season, while dead-fine-root biomass increased during sampling time. In both pine and oak the ratio of necromass to total fine-root biomass increased during the early growing season, while the ratio of live to dead roots decreased with the time. Thus, the later the growing season, the greater the proportion of dead fine roots. The majority of pine seedlings roots were in the upper mineral soil layer, whereas most oak tree roots were in lower soil layer.

Forest structure in relation to altitude and part of slope in a valley forest at Baekbong, Wando-arboretum. Yoo, S.B., Wi, A.J., Park, W.S. (*Jeonnam Forest Environment Research Institute, Republic of Korea; yoosb1@korea.kr*).

Forest structure in relation to altitude and slope was studied in a valley forest in the Wando Arboretum. Forty-eight quadrats were set up in the valley forest at different slope positions along an altitudinal gradient of 100 m to 600 m. Density, mean DBH, and

basal area of the canopy trees were 3,067–9,080 trees/ha, 8.8–12.3 cm, 21.43–104.33 m^3/ha, respectively. Mean DBH and basal area of canopy stratum and basal area of tree stratum were the greatest at the middle elevation belt of the valley. As elevation increased, the importance of *Styrax japonica*, *Lindera erythrocarpa*, *Acer pseudosieboldianum*, and *Sapium japonicum* increased; while those of *Quercus acuta*, *Camellia japonica*, and *Eurya japonica* decreased. However, The importance of *Q. acuta*, *C. japonica*, and *Styrax japonica* increased going from lower to upper part of slope, while the opposite trend was found for *Carpinus laxiflora*, *Albizzia julibrissin*, and *Eurya japonica*. Number of species and species diversity decreased with increasing elevation and going from lower part to upper part of the slope. The range of similarity indices between elevation belts and between part of the slope were 54.3–68.9% and 85.6–88.5%, respectively.

A study of acidity and ion balance of wet precipitation in Mt. Kyebang area, Hongcheon. Korea. Youn, H.J., Lee, S.W. (*Korea Forest Research Institute, Republic of Korea; greenbona@gmail.com; soilloverlee@forest.go.kr*).

To look into the degree of the long distance movement of the air pollution within Mt. Kyebang, Hongcheon, one of the clean regions, we analyzed major ions and components of collected wet precipitation, by using ion chromatography after measuring pH and electrical conductivity. The quality assurance of chemical composition data was checked by considering the ion balance and electrical conductivity. Also, the pH of precipitation showed in the pH 5.0–5.5 range, less than the pH 5.6, which is the standard for the acid precipitation. On the whole, the more precipitation received, the less the ion concentration became. It could be showed that the fluctuation of the precipitation pH was influenced by fluctuation and neutralization of the according materials. In the meantime, as composition ratios of wet deposition, SO_4^{2-}, and nss-SO_4^{2-} of anions, NH_4^+, and nss-Ca^{2+} of cations accounted for high percentages. Especially, when the concentration of SO_4^{2-}, the artificial pollutant, and Ca^{2+}, the soil substance, showed high, Mt. Kyebang, Hongcheon, which has few fixed air-pollutant sources, was most likely influenced by pollutants moved in from long distances.

Seedling growth of three tree species in multi-cavity container trays in Japan. Yukihito, O., Takeshi, Y. (*Forestry and Forest Products Research Institute, Japan; yukihito@affrc.go.jp; kenchan@ffpri.affrc.go.jp*).

Because bare root seedlings are most common material for afforestation in Japan, techniques for producing seedlings in multi-cavity container trays have not been developed enough until recently. In 2008, the first domestic production of 150-cc and 300-cc multi-cavity container trays appeared. To check these new products, the seeds of three tree species (two major conifers, hinoki and sugi, and one broad leaf, Keyaki) sowed in November 2008. The multi-cavity container trays were placed in the green house at the Forestry and Forest Products Research Institute in Tsukuba Japan. The height of seedlings were measured every week after germination. During winter, the inside temperature of the green house was kept at more than 10 degrees centigrade. The germinated seedling of three species grew constantly from January to March. However, when spring come, the seedlings stopped growing from April to June. They started to grow again in July. The control of winter temperature is important for the constant growth of the seedlings. The height of the seedlings in the 300-cc container was less than that of the seedlings in the 150-cc container.

Theme E: Forest Products and Production Processes for a Greener Future

E-01 Green forest products marketing and business management

Organizer: Richard Vlosky *Louisiana State University, USA, vlosky@lsu.edu.*
Moderator: Richard Vlosky (USA).

Livelihood strategies of small-scale furniture producers in Jepara (Central Java) in facing tight market competition. Achdiawan R., Purnomo H. (*Center for International Forestry Research, Indonesia; rachdiawan@cgiar.org; hpurnomo@cgiar.org*).

Furniture contributes significant value to total Indonesia forest products exports. Jepara, Central Java, is the most important furniture producer district. It was recorded in 2005 at least 15,271 business units of workshops, showrooms, and warehouses of furniture industries employed 176,470 workers in Jepara. This paper describes the importance of the furniture-making activity to household income and its comparison to other livelihood activities. Why do most people in the district continue to produce furniture in the tight competition and decreasing international market demand due to the world economic crisis in the recent years? How should furniture producers compete with the increasing timber price? What is the most appropriate strategy to produce furniture that is less threatening to timber resources? The study was conducted by applying a household survey on the furniture producers and other households in Jepara district by using systematic sampling. Data were analyzed by using several statistical analyses. Most producers continue to produce furniture because it is not only a source of income but also a cultural identity. Their weakness is mostly in the strength of business management, which includes marketing skills and financial management. Therefore, these skills have to be improved comprehensively, especially for small-scale producers.

Conjoint effect of price, environmental labeling, and disclosure of forest of origin on consumer preferences for wood products in the USA and UK: potential market shares. Aguilar, F., Cai, Z. (*University of Missouri, USA; aguilarf@missouri.edu*; *zcc55@mail.mizzou.edu*).

A conjoint analysis was designed to elicit consumer preferences and estimate market shares for certified wood products in the USA and the UK. We used a full-profile choice-based model to study the effects of price, environmental labeling, and disclosure (or not) of forest of origin on product preferences. Responses from USA and UK consumers were collected using a night table as our product sample. Econometric analysis suggests that a $1 (£1 in the UK) increase over the base price of $/£100 would cause a decrease in preferences of 7 percent. Certification had a positive effect on consumer preferences over non-certified products. No differences between labels issued by a government or environmental non-government organization were detected. A strong negative perception of wood products coming from tropical forests was identified. Preferences for tropical products were 35 lower compared to product alternatives coming from temperate areas or not disclosing origin information. This finding has significant implications as new trade regulations might require identification of product origin. We conclude with various scenarios that show how the potential share of certified tropical wood products could be as high as 40 percent and as low as 3 percent depending on alternative products found in these markets.

FSC in China and Vietnam: benefits, constraints, and drivers of management commitment. Cao, X., Seol, M., Eastin, I.L. (*University of Washington, USA; caoxz@u.washington.edu; mistral@u.washington.edu; eastin@u.washington.edu*).

China and Vietnam are processing nearly half the world's forest products, but less than 1% of the world's certified forests are located in these countries. Increasing local industries' environmental awareness and commitment to forest certification has important implications. Based on managerial interviews and a survey with more than 800 FSC-COC operations in China and Vietnam, March-September 2009, this study aims to: (1) understand how Forest Stewardship Council (FSC) is being perceived by local industries in terms of its benefits and constraints; and (2) identify factors behind companies' commitment to FSC. Initial findings suggest that FSC may deliver four types of benefits: market, environment-social, channel relationship, and government-related. However, FSC raw material supply, market awareness, and certification costs were found to be major constraints encountered by Asian manufacturers. Based on logistic regression analysis, market benefits appear to have the biggest (positive) impact on a company's commitment, while industry experience may work against a company's environmental commitment. Also, stable markets may encourage the industry's environmental movement, particularly among better-financed companies. Looking into the future, growing demand for legal and sustainable timber may fuel FSC's continued growth in the region, but impacts of FLEGT VPA and amended Lacey Act remain to be watched.

Is all carbon created equal? A study of the comparative value of different types of planted-forest-related greenhouse gas emissions offsets. Dargusch, P. (*University of Queensland, Australia; p.dargusch@uq.edu.au*).

Planted forests used to produce greenhouse gas emissions offsets can be planted in various styles. On one extreme, forests can be planted as industrial-scale monocultures that, whilst providing large volumes of low cost offsets, may provide limited ecological and social benefits. On the other extreme, forests can also be planted as community-based small-scale land rehabilitation plantings of multiple species that, whilst providing smaller volumes of higher cost offsets, may provide greater ecological and social benefits. Yet in all regulated carbon markets, public policy currently prescribes that the selling price for offsets is standardised and the same price is paid for offsets regardless of how they are produced. This is arguably a flawed pricing system, as it does not provide incentive for the market to foster the development of styles of forest plantings that optimise public benefits. This study examines these issues by conducting a cost-benefit analysis of a range of different styles of forest plantings in Australia and reporting on a survey of firms listed on the Australian Stock Exchange of their willingness to pay for offsets of differing levels of public benefit. Numerous suggestions for improvements to international climate change mitigation policy are then proposed.

Marketing green forest products as a business strategy. Ham, C. (*Stellenbosch University, South Africa; cori@sun.ac.za*), Karmann, M., Kriscenski, A. (*Forest Stewardship Council, Germany; m.karmann@fsc.org; a.kriscenski@fsc.org*).

Most of South Africa's plantations are certified under the Forest Stewardship Council (FSC) green label standard. A survey amongst growers, processors, and retailers of timber products in South Africa showed that FSC certification is regarded as a way of improving the quality of plantation management, but that direct financial benefits for certified products are very limited. Research surveys in the United States, Europe, and developing countries showed similar results: while larger companies are more interested in promoting their own brands and use FSC as a way of promoting corporate social responsibility, smaller growers and retailers are interested in direct financial benefits from selling green labelled products. Absence of such incentives could lead to disillusionment with green labelling, resulting in growers and processors withdrawing from certification. Examples from different countries show that while active promotion of FSC-certified products is still limited, there is a growing consumer acceptance of green labelled products. Consumer education targeted at individual and corporate consumers helps in building markets, especially when focusing on social benefits of buying from responsibly managed forests. The paper compiles findings about changes in certification perceptions over the past decade and helps to understand new trends.

Perceptions and willingness of Swedish architects towards use of wood frames in multi-storey buildings. Hemström, K., Mahapatra, K., Gustavsson, L. (*Mid Sweden University, Sweden; kerstin.hemstrom@miun.se; krushna.mahaptra@miun.se; leif.gustavsson@miun.se*).

The use of wood from sustainable forestry instead of non-wood products in multi-storey building can reduce primary energy use and carbon dioxide emissions. Furthermore, wood-framed buildings may have other advantages such as a shorter construction time. However, the use of wood frames might also be associated with problems such as sound proofing, combustibility, and stability. These issues along with the construction industry's tendency to use proven methods and materials may influence the actors' decision to adopt wood frames. In this study we evaluate architects' perceptions of, and willingness to use, wood frames in multi-storey buildings. The results are based on a web-based questionnaire study of several hundred architects in the Swedish multi-storey construction industry. It indicates the extent to which Swedish architects are willing to adopt wood frames, their attitude towards wood as a frame material in relation to important aspects of the building project, and what elements may influence the diffusion of wooden framing in multi-storey building. Our study gives a better understanding of the opportunities for wood-framed multi-storey buildings in the construction industry in Sweden.

Foreign direct investment in Brazil: a case study of the forest sector. Hoeflich, V. (*Universidade Federal do Paraná, Brasil;vitor.ufpr@gmail.com*), Tuoto, M.A.M. (*STCP Consultoria, Brasil; mtuoto@stcp.com.br*).

The main objective of this study was to understand the dynamic involved in the flow of foreign direct investments (FDIs) into the Brazilian forest sector. The specific objectives were to characterize and analyze the inflows of FDI in the Brazilian forest sector; to identify and analyze the FDI determinants in the Brazilian forest sector; and to evaluate the impacts of FDIs on the production and exports of the Brazilian forest industry. The methodology adopted in this study was based on the case study method, taking into consideration a comprehensive bibliography review and interviews with executives from subsidiaries of transnational corporations (TNCs) operating in Brazil. The results of this study pointed that the FDI stocks in the Brazilian forest sector are less significant compared to the flow of FDI towards the forest sector worldwide. The FDIs applied to the Brazilian forest sector during the past decade were concentrated in the pulp and paper industry, which was marked by an intensive process of mergers and acquisitions. The results of this study suggest that FDI-inducing factors in the Brazilian forest sector are the high forest productivity/low raw material cost, large market size and potential, macroeconomic stability, the MERCOSUR integration, and political stability.

Strategies for promoting use of wood in urban construction. Nyrud, A.Q., Bysheim K. (*Norwegian Institute of Wood Technology (NTI), Norway; anders.q.nyrud@treteknisk.no; kristian.bysheim@treteknisk.no*).

In Norway the market for wood construction in urban areas is expanding due to new construction technologies and increased demand for sustainable urban infrastructure. Industrial construction technology and use of wood in urban areas have been identified by the Norwegian government as opportunities for development of the domestic wood industry and improving the sustainability of urban areas. The study explores the mechanisms that influence key specifiers, such as architects and contractors, and their choice of building materials. Various criteria impacting on key specifiers' choice of wood as building material was investigated, including attitudes towards physical and mechanical properties of wood, perceived risk of using wood as a building material, and the environmental properties of wood. In addition, the specifiers' use of information sources, and the knowledge status among the key specifiers was investigated. The study identifies key specifiers; and the results give insights into the specification process, provide information for firms that would like to market wood as a construction material, and give suggestions for how to position wood as a construction material for use in urban areas.

Barriers to forest products certification through timber market s in Japan. Shiba, M., Sakamoto, T., Miura, K. (*Kyoto University, Japan; mshiba@kais.kyoto-u.ac.jp; Jasc60@gmail.com; m.kisato@gmail.com*), Pakhriazad, H.Z. (*University Putra Malaysia, Malaysia; azad@kais.kyoto-u.ac.jp*), Schaller, M. (*Technische Universitaet Muenchen, Germany; schaller@tum.de*).

The demand for forest certification in association with its products in the form of a product label-chain of custody—being the term applied to the process of tracking timber from a specific certified forest to final consumer through various production phases of supply chain—is growing rapidly in Japan in response to the demand for log imports in the Asia and Pacific regions. There are currently three different forest certification schemes in operation in Japan. Two of these are international (FSC, PEFC) and the remainder, SGEC (Sustainable Green Ecosystem Council), is a national, voluntary initiative with the intention of promoting sustainable forestry practices in Japan. In 2009 around 4.31% (1.072 million ha) of Japan's forest area is certified by FSC (0.283 million ha, 28 forest lands) and SGEC (0.789 million ha, 84 forestlands) respectively, while 1,444 timber and paper and pulp companies have been awarded the CoC certification (FSC: 977, SGEC: 334, PEFC: 133). The primary purpose of this research is to discuss the potential effects of forest certification in association with CoC on management and market strategies of plantation forestry through different certification schemes that parallel or competently emerge on the same products markets in Japan.

The greening of the U.S. hardwood lumber industry. Smith, B. (*Virginia Tech, USA; rsmith4@vt.edu*), Espinoza, O. (*Virginia Tech, Bolivia; oespin04@vt.edu*), Buehlmann, U. (*Virginia Tech, USA; ubuelm@vt.edu*).

The "green" movement has hit the U.S. building industry with an array of different certification schemes that measure home buildings' environmental footprint. These different schemes offer opportunities for the forest products industry to capitalize on a new niche market that could expand opportunities for wood. However, very little is known on the perceptions of the wood products industry on this movement or how they have responded to these new markets. This study evaluates the U.S. hardwood lumber industry's perception of the "green" movement and how it may impact their business practices in the future. A mail survey of more than 1,000 hardwood lumber sawmills was conducted in summer 2009 to measure their thoughts on green building practices, standards, and how it may benefit or hurt the industry. Open-ended and rating questions were used to determine their perceptions of different aspects of the green movement. Finally, respondents had the chance to identify where opportunities may exist, or where they have captured market share by going "green."

Designers' views of green structural materials: comparing the United States and Australia. Tibbets, A., Macias, N. (*Oregon State University, USA; tibbetsa@gmail.com; natalie.macias@oregonstate.edu*), Bull, L. (*Australian National University, USA; lyndall.bull@anu.edu.au*), Knowles, C. (*Oregon State University, USA; chris.knowles@oregonstate.edu*).

The purpose of this research is to compare and contrast the views of building design professionals in Australia and the United States regarding environmentally responsible materials in structural building systems. Expert opinions will serve as the basis for this project. Data will be collected via group interviews of building design professionals responsible for different aspects of structural design and material selection. Group interviews will be composed of material specifiers who represent major construction markets, projects of different scales, and professionals responsible for different aspects of the specification process from the United States and Australia. Data in the U.S. was collected during 2009. Data in Australia will be collected during 2010. The focus will be on major structural materials—concrete, steel, and wood. A semi-structured questionnaire focusing on structural systems of green buildings will be used. Respondents will be asked to identify the key criteria driving the selection of structural materials, including the importance of the potential environmental impact of a material. Respondents will be asked about the role of meeting a green building standard in material selection. Themes specific to wood products will be discussed including the role of forest certification systems.

UNECE-FAO forest sector marketing and business development in southeast Europe. Vlosky, R. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu*), Pepke, E. (*FAO/UNECE, Switzerland; ed.pepke@unece.org*), Glavonjic, B. (*University of Belgrade, Serbia; brankogl@rcub.bg.ac.rs*).

The United National Economic Commission for Europe (UNECE) Timber Committee and the FAO European Forestry Commission (EFC) work together to promote sustainable forest management in Europe, the Commonwealth of Independent States (CIS), and North America. The UNECE Timber Committee and the FAO EFC consist of the office-holders, that is, chairperson and vice-chairs as well as the chair of the Joint FAO/UNECE Working Party on Forest Economics and Statistics. The group meets annually to give strategic consideration and guidance on particular issues of the work program, often in advance preparation of the session of the Timber Committee (annual) and the EFC (biannual). In 1994, the UNECE/FAO, together with partners, began a program of workshops to build capacity in forest products marketing and wood-based energy development in Central and Eastern Europe, southeast Europe, the Caucasus, and Central Asia. More than 500 participants and presenters from more than 25 countries have attended these workshops. The Team of Specialists on Forest Products Markets and Marketing, one of seven teams of specialists assembled by the UNECE/FAO, has been instrumental in leading this capacity-building effort. In this presentation we will discuss objectives, structures, content, and outcomes of this ongoing capacity building program.

Corporate social responsibility in the Chinese forest industry: understanding the culture and stakeholder perceptions. Wang, L. (*University of Helsinki, Finland; lei.wang@helsinki.fi*), Juslin, H. (*University of Helsinki, Finland; heikki.juslin@helsinki.fi*).

We find that the western CSR concepts do not adapt well to the Chinese market, because they have rarely defined the primary reason for CSR well, and the etic approach to CSR concepts does not take the Chinese reality and culture into consideration. This study resolves these problems and contributes a new definition of CSR, called here: the Harmony Approach to CSR, which is developed from Confucian interpersonal harmony and Taoist harmony between man and nature. Simply, the Chinese harmony approach to CSR means "respecting nature and loving people." Empirically, based on a multiple stakeholders approach and a quantitative research method, this study has found that: (1) The Chinese forest industry prioritizes primary stakeholders (shareholders, consumers, governments, and employees) in their CSR activities, and primary stakeholders have more positive views on CSR than secondary stakeholders (general publics). (2) Stakeholders have more positive views on economic and social responsibility than on environment responsibility. Especially, general publics have the most negative perceptions regarding social and environment responsibilities, and employees have the most negative view on the caring of employee welfare by the Chinese forest industry.

Posters

Systematic strategy for forest product export: incorporated profit model with application of forest certification. Chun, J. (*Seoul National University, Republic of Korea; andrew78@snu.ac.kr*), Seol, M. (*University of Washington, USA; mistral@u.washington.edu*).

This research was conducted in order to suggest a substantial profit improvement strategy for Korean forest villages via exports of certified forest products. Based on a strategic CoC (chain of custody) with application of forest certification, a win-win strategy that multiple stakeholders can create profits at the same time is suggested in the Incorporated Profit Improvement Model consisting of forest communities and multiple NGOs. Those stakeholders are, in detail: a Korean agro-forestry community (supplier); a manufacturer (processor); NGO 1, who connects suppliers and buyers such as Korea Forest Service and Korea Trade Investment

Promotion Agenc; NGO 2, who provides technical support for forest management such as national forestry cooperatives and relevant environmental NGOs; and finally NGO, 3 who is a certification body for forest certification such as Rainforest Alliance. Consequently, every stakeholder in the model was analyzed as having a high potential, and therefore, if the strategic CoC with application of forest certification is actually established, the Korean forest community can create profits from the export of future certified forest product to the global forest certified product market.

Identifying the relevance of "family forest" and "family business" wood product origin for final consumers. Hamner, R., Knowle, C., Hansen, E. (*Oregon State University, USA; rebecca.a.hamner@oregonstate.edu; chris.Knowles@oregonstate.edu; eric.hansen2@oregonstate.edu).*

Traditionally in the United States, family-owned businesses have played an important role in the economy. In today's economy, family businesses are still major contributors to the economy, with estimates that they generate 40 to 60% of the gross national product, and that 90% of U.S. businesses are family-owned. Families are also important regarding forestland ownership in the U.S., with approximately 60% of forestland owned by private individuals. Families own approximately 275 million acres of forestland in the U.S., with the number of families owning forestland steadily increasing in recent years. Despite the importance of family ownership, a literature search revealed no studies focusing on the relevance of family ownership to consumers. A recent stream of research in the marketing literature is the use of product origin for the promotion of value to the consumer. In the general marketing and management literature, this research stream has largely focused on the region or country of origin of the product. This study uses product origin theory to investigate the relevance of family ownership in the U.S. forest products industry to consumers. Data will be collected at home shows in the state of Oregon using paper-based questionnaires.

An analysis of timber sales using hedonic methodology. Hamner, R.A. (*Oregon State University, USA; rebecca.hamner@oregonstate.edu*), Shook, S.R. (*University of Idaho, USA; shook@uidaho.edu*).

The State of Idaho is constitutionally mandated to manage state-owned lands to ". . .secure the maximum long term financial return to the institution. . . ." This mandate covers all types of state-owned lands, including timberland. Financial return on timberland can be driven by a host of factors; including acreage, species composition, number of bidders, distance to mills, etc. The primary objective of this research is to determine those features of state-owned timberland that are most highly correlated with bid price. Applying the hedonic pricing method, we estimate pricing models using 20 years of timberland sale data from the Idaho Department of Lands. A secondary objective is determining those factors that increase the number of bidders on state-owned timberland. With the use of the hedonic pricing model, results provide evidence that the diversity of species present on the timber sale, species that are made up of low value wood, hauling distance to mills, and the number of acres composing a timber sale negatively influence the number of bidders. Twelve of 17 independent variables were found to be statistically significant when timber sale market value was the dependent variable of interest and average slope was the only significant variable negatively influencing market value.

Evolution of decking advertising: 1996–2006. Hamner, R.A., Tokarczyk, J., Hansen, E. (*Oregon State University, USA; rebecca.a.hamner@oregonstate.edu; john.a.tokarczyk@state.or.us; eric.hansen2@oregonstate.edu*).

The 10 years between1996–2006 brought considerable change to the decking industry, including introduction of many new products. Principal among these was wood plastic composite decking. As these products gained increasing market share there is interest in how traditional wood decking companies have responded to competitive threats by way of communication, particularly through advertising. Beyond ascertaining basic effects of a new product entry there is interest in evaluating the sophistication and orientation of both new product ads relative to traditional product ads in the context of a business-oriented periodical. Given that the forest products industry is dominated by business-to-business exchange, there is an expectation that most industry-driven communications and marketing will be directed to other channel members. However, casual observation suggests that the combination of increased competition and recognition of the value of maintaining a greater market orientation has resulted in decking ads that tend to be more consumer-oriented and sophisticated. Overall, this research seeks to identify changes over time in decking advertising since the introduction of composite decking both in physical terms (number and nature of ads) as well as content (sophistication and orientation). This poster outlines the results regarding observed trends in decking advertising.

Corporate social responsibility and its implementation: a study of companies in the global forest sector. Han, X., Hansen, E. (*Oregon State University, USA; xiaoou.han@oregonstate.edu; eric.hansen2@oregonstate.edu*).

Corporate social responsibility (CSR) can be defined as companies acting in accordance with societal demands. In recent years, CSR has gradually become a leading issue in business. Heightened corporate attention to CSR has not been entirely voluntary. Many companies awoke to it only after being surprised by public response to issues they had not previously thought were part of their responsibilities. Firms should follow, even anticipate, these changes and adapt their activities according to the expectations of society. Also, CSR has various meanings in different contexts. When identifying and anticipating CSR-related issues, context should be taken into account. CSR can differ among industries. Thus, a closer look of CSR in a specific industry is necessary. Also, CSR can vary among countries and regions. It should be viewed from a regional perspective as well. In addition, it is suggested that CSR is positively related to company size. Companies that have higher sales levels tend to have a higher CSR performance. This is also true with respect to company profits.

Carbon footprint of imported and domestic wood products in South Korea. Kang, K., Cha, J., Youn, Y.C. (*Seoul National University, Republic of Korea; kyungseoky@snu.ac.kr; jhcha74@snu.ac.kr; youn@snu.ac.kr*).

Korea is a major importer of wood products. Around 90% of roundwood and wood products consumed in Korea are imported from dozens of countries including Canada, New Zealand, Malaysia, and Chile. Embodied energy and greenhouse gas emissions of wood products can be allocated according to various phases such as forestry practices, manufacturing, and transportation engaged in each product. A large amount of life-cycle GHG emissions of wood products came from transportation, especially long-distance marine transportation. In this study, we analyzed carbon footprints of four major wood products: roundwood,

plywood, sawnwood, and particleboard. The carbon footprint of wood products changed according to the change in the main exporting countries and their amount. The carbon footprints of wood products from Latin America were generally bigger than those from Asian countries and Russia. Carbon footprint of domestic roundwood was smaller than that of imported roundwood. GHG emissions in manufacturing of wood products can be varied by countries according to energy source and manufacturing techniques applied; however, the difference was rather small comparing the differences resulting from trading distance. The application of carbon footprint in wood products can be a useful tool to estimate and reduce GHG emissions.

Mountain livelihoods: myths and realities in the backdrop of climate change. Kinhal, G., Choudhary, D., Bhattarai, N., Karki M. (*International Center for Integrated Mountain Development; Nepal, gkinhal@icimod.org; dchoudhary@icimod.org; nbhattarai@icimod.org; mkarki@icimod.org*).

Mountains, especially in the HKH region, have a very narrow band of land-based economic activities to influence the livelihoods of local people. However, these regions have their own specificities linked to niche products that are low volume and high value in so far as the society depends on them. These products are associated with several myths in terms of their uses and local dependence varying from place to place. Medicinal and aromatic plants are one such set of natural resources that exhibit unique niche values and mountain specificities with immense scope for species specific interventions to reap their benefits in the interest of the mountain people. The International Center for Integrated Mountain Development (ICIMOD) has developed and tested certain specific interventions and helped mountain people to encash the mountain specificities and attain economic development alongside resource sustainability. This paper describes such interventions, institutional and policy related, that seem to have very high replication potential.

The role of the CASBEE green building initiative in the Japanese housing industry. Matsuoka, K., Owari T. (*University of Tokyo, Japan; matsuoka@uf.a.u-tokyo.ac.jp; owari@uf.a.u-tokyo.ac.jp*).

The influence of green building initiatives is increasing globally in wood products markets. In Japan, the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was introduced as a green building initiative. The CASBEE program encourages the use of wood originated from sustainable managed forests ("sustainable wood") by giving a relatively high score. This study examined the influence of the CASBEE initiative on wood use in the Japanese housing industry. We conducted a nationwide survey with a structured questionnaire from November to December 2009 with 173 companies employing accredited professionals of the CASBEE for homes (detached house). Results showed that 110 companies (64%) used "sustainable wood" for their structural applications. Most of them were users of domestic softwood, which was included in "sustainable wood" by the CASBEE. Only 19 companies (11%) used certified wood (FSC, PEFC, or SGEC). When contractors and architects purchased wood products, the CASBEE program was less important than the other product/supplier attributes such as price, moisture content, and strength. Companies tended to use the CASBEE as a reference tool for home design rather than as a communication tool.

Customer-perceived value in the Japanese structural lumber market. Owari, T. (*University of Tokyo, Japan; owari@uf.a.u-tokyo.ac.jp*).

An increasing number of forest products marketing researchers are considering value as an essential constituent of marketing strategy development and implementation. Delivering superior value to customers is a key to creating and sustaining long-term business relationships. This study examined the value that Japanese customers of structural lumber perceived in their business relationships. A nationwide survey with a structured questionnaire was conducted from January to March 2008 with 94 companies (structural laminated lumber and pre-cut mills). In the questionnaire, respondents were asked the important product/supplier attributes when choosing the supplier of raw material (lumber). Nine value dimensions with 30 measurement items were generated based on literature review and pre-tests: price, product quality, long-term supply, short-term delivery, personal interaction, contact, information, innovation, and stakeholder relationship. The perceived level of importance was measured using a 7-point scale, where 1 = not at all important and 7 = very important. Results indicated that high product quality was the most important, followed by stable supply and low price. Other important attributes included reliable delivery, stable price level, knowledgeable and helpful sales person, full customer support, and information on the raw material situation.

An econometric analysis of imported softwood log markets in South Korea, by using seemingly unrelated regression equations (SURE). Park, Y.B. (*Korea Forest Research Institute, Republic of Korea; ybpark@forest.go.kr*), Youn, Y.C. (*Seoul University, Republic of Korea; youn@snu.ac.kr*).

The objective of this study is to analyze market structures of softwood logs being imported to South Korea from log-producing countries. Import demand of softwood logs imported to South Korea from America, New Zealand, and Chile is fixed as a function of log prices, the lagged dependent variable, and output. On the basis of the adaptive expectations model, linear regression models that the explanatory variables included and the lagged dependent variable were estimated by seemingly unrelated regression equations (SURE). The short-run and long-run own price elasticity of America's softwood log import demands are –1.738 and –4.250 respectively. Short-run and long-run cross-elasticity of New Zealand's softwood log import demands with respect to American's softwood log import price are inelastic at 0.505 and 0.883, respectively. Short-run and long-run cross-elasticity of Chile's softwood log import demands with respect to American's softwood log import prices were highly elastic at 2.442 and 4.462, respectively. Long-run elasticity was almost twice as high as short-run elasticity.

Sensory analysis and product semantics in wood products marketing research. Roos, A. (*Swedish University of Agricultural Sciences, Sweden; Anders.roos@sprod.slu.se*), Lindberg, S. (*INNVENTIA, Sweden; siv.lindberg@innventia.com*).

Diversification and increasingly more demanding end customers call for more advanced methods for preference mapping and market communication. The wood industry needs a better understanding about the considerations in the material selection process among its customers. Producers of exposed wood products must also understand the associations and aesthetic values that each product generates. This paper focuses on how perceptions and associations influence material selection and the competitiveness of

wood compared with the alternatives. The theoretical and methodological basis for the studies are sensory analysis and product semantics. Sensory studies in Norway and Sweden—'generic' and studies on specific wood products—are described, and key results on how wood is perceived are presented. We also bring out some central concepts and associations that often emerge when people describe their views on wood and substitute materials. Furthermore, the presentation compares reactions on tactile and visual impressions. Finally, our exposé indicates how wood could be placed regarding sensory and semantic assessments compared to other materials and stimuli. The usefulness for the wood industry of product semantics and sensory analysis is finally discussed.

The perception among specifyers and ordinary customers on wood as a material in construction. Roos, A., Woxblom, L. (*Swedish University of Agricultural Sciences, Sweden; anders.roos@sprod.slu.se; lotta.woxblom@sprod.slu.se*), Nyrud, A. (*Norsk Treteknisk Institutt, Norway; anders.q.nyrud@treteknisk.no*).

Architects, engineers, and interior designers influence in different ways the material selection in the building process. However, their perceptions and rating of wood compared to other materials may differ, among different professions, and in comparisons with ordinary people. In this presentation we present and discuss these differences in taste and perspectives on wood and how they could influence the diffusion and marketing of wood building solutions. The study synthesizes experiences from quantitative and qualitative studies in Norway and Sweden, and uses product semantics and theories on attitude and perceptions to explain these differences between and among professionals and ordinary laymen. Our findings describe how different professions and normal people look at the performance of wood in construction, how wood features are described and characterized, and also how wood relates to the professional roles of architects and engineers. Views on environmental performance are also considered. Although wood is a popular building material, expertise in wood construction is not considered as vital for the professional career of an architect or structural engineer. However, there are opportunities to make wood more interesting for professionals involved in wood building. The presentation concludes by suggesting ways to communicate wood to different target groups.

Exploring new sources for legal an sustainable wood supply for handcraft processing: the WWF project in Ghana. Seidu, M. (*WWF-West Africa Forest Programme Office, Ghana; mseidu@wwfghana.org*).

The wood carving industry in Ghana originated from an age-old traditional practice that has been transformed into a major commercial enterprise. However, the over-exploitation of the preferred indigenous species has negatively affected the supply of raw materials. The causal pathway is spiral in nature. The over-dependence on a few indigenous species leads to scarcity and local extinction. The loss of these preferred indigenous species in turn poses threat to the livelihoods of the wood carvers. Promotion of alternative wood sources through awareness creation, formation of farm forestry, and capacity building in quality assurance and greater market access has the potential of sustaining the livelihoods of those who dependent on the carving industry, alleviate poverty, and save biodiversity. A shift from the use of the fast-diminishing preferred species such as *Holarrhena floribunda, Cordia spp.*, and *Diospyros Spp* to suitable fast-growing species such as *Azadirachta indica* and *Cedrela odorata* could sustain the increasing raw material demands of the wood carving industry, thus sustaining livelihoods. The growth and management of such fast plantation species is also a better option for solving the legality and sustainability problems associated with wood sourcing for carving in Ghana.

Political economy of forest certification: WWF experience in Ghana. Seidu, M. (*WWF-West Africa Forest Programme Office, Ghana; mseidu@wwfghana.org*).

Forest certification is undoubtedly the most effective tool for achieving sustainable forest management. The achievement of forest certification ensures compliance with laws and regulation, economic viability, social acceptability, and environmental sustainability of the forest enterprise. This is attested to when the government of Ghana adopted forest certification in the mid 1990s as a tool for sustainable forest management. But why is achieving forest management certification been such a difficult process in Ghana? Experience from field project implementation indicates a complexity of factors ranging from security of tenure, market incentives, and conflicting initiatives, among others. The government and industry players as main actors for moving forward on achieving certification in Ghana are less motivated to achieve certification. Industry has been exhibiting a "conformity tendency"—each company is looking up to the other to get certified. Once a company can still market products, real investment to achieve forest management certificate is postponed. Being a voluntary mechanism, certification is viewed by governments as industry problem. However, the inability of the timber industry to market products as a result of non-achievement of certification has a knockdown effect that goes beyond the finances of the companies.

A qualitative benchmark study of Oregon's forest products industry's emphasis on marketing. Tibbets, A. (*Oregon State University, USA; tibbetsa@gmail.com*).

The purpose of this study is to describe how marketing is implemented in the U.S. Forest Industry. From this information, it will be determined how marketing in the forest sector may be used in the future. This research will be relevant to marketers and business owners alike. Fifteen companies in Oregon will be selected and interviewed using a case study method. These interviews will be composed of specific questions and topical categories in an attempt to understand how each company reaches and caters to its customers. The information will then be compiled to understand the current nature of marketing in the industry. Each company will be compared to one another based on three main umbrella categories: company layout, customer orientation, and competitor orientation. The objective of this study is to analyze how firms in Oregon's forest products industry have responded to the increasing pressure to become market-oriented in each of these areas. A final report will be given to each participating company so they can see how they compare to one another based upon their market orientation.

Wood processing and furniture manufacturing in the western Balkan region. Vlosky, R. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu*), Glavonjic, B. (*University of Belgrade, Serbia; brankogl@rcub.bg.ac.rs*), Borlea, G. (*Directia Silvica Timisoara, Romania; fborlea@mail.dnttm.ro*), Petrovic, S., Sretenovic, P. (*University of Belgrade, Serbia; slavicap2@eunet.yu; predrag@eunet.yu*).

Primary wood processing and secondary furniture production are strategic sectors in most western Balkan countries with regard to contribution to gross domestic product, exports, and employment. After abandoning a socialist business system in the post-Yugoslavia era, all countries in the region have developed transitional reforms to become free-market economies. Some of these changes include changes in ownership structure, recapitalization, and modernization; adapting to meet import standards of developed countries; and developing strategic linkages with supply chain counterparts in developed countries. This paper contains the results of research conducted on the current situation in primary wood processing and furniture industries in seven western Balkan countries. A common characteristic of these sectors across all countries is the century-long tradition of forestry and forest utilization. The development of these sectors will require sustainable management of the region's rich forest resources, political and economic systems that are transparent and market-driven, and investments in production technology and employee training. This presentation presents the most comprehensive review to date of the forest and forest products sector in the western Balkan region of Eastern Europe. For practitioners, policymakers, and other stakeholders it is important to understand current structures and issues in this region.

E-02 Value chain optimization in the forestry industry context

Organizer: Jean Favreau, *FPInnovations, Canada, jean.favreau@fpinnovations.ca;* Lennart Rådström, *Skogforsk, Sweden, lennart.radstrom@skogforsk.se.*

Genetic improvement of *Eucalyptus grandis* and economic impact at the forest industrial chain in Uruguay. Andreoni, M.I., Bussoni, A. (*Universidad de la República, Uruguay; irupepe@hotmail.com; abussoni@fagro.edu.uy*).

In Uruguay, genetic improvement programs, both on the seed level and the propagation level, for the production of wood designed for the cellulose industry, are developed with the purpose of increasing wood productivity, basic density, yield, and fibre quality, among other goals. The use of these materials has different impacts on the raw material producers in the chain. The study measures the growth of added value resulting from the genetic gain in the different stages and examines how the actors benefit from this process, including industry. For this purpose, a methodology was developed by means of which qualified informants were interviewed and different technological levels in four cultivation stages were defined. Finally, the economic impact on the use of different materials for vertically integrated and non-integrated producers was evaluated. In the forest nursery stage, technology has evolved in parallel with the material used but with some differences regarding containers and use of the structure. In the plantation stage, the most obvious difference is the preparation of the site and the density of plantation. On good sites, the differential yield compensates the higher costs of plantation caused by the use of clones.

FPInnovations and Canadian university network in value chain optimization. Favreau J (*FPInnovations; Canada; jean.favreau@fpinnovations.ca*), D'Amours S. (*Forac; Canada; sophie.damours@forac.ulaval.ca*).

Reduced demand for commodity products such as newsprint and structural framing lumber, as well as increased competition from producers in Europe, Russia, China, and South America, are driving Canadian companies to re-examine existing business models. To support their aims, value chain optimization serves to better define strategies and manage operations, for and between companies, as part of the forest bioeconomy networks. FPInnovations is currently working on different initiatives to improve the Canadian competitiveness and implement value chain concepts in the industry. Existing university programs at For@c, CIRRELT, and UBC are also focusing on different aspects of value chain optimization. Matching resources to desired products, emerging markets, transportation optimization, and improving manufacturing processes are key components of the value chain strategy in Canada. The objective of this presentation is to provide an overview of how FPInnovations and Canadian universities work together to support the Canadian forest industry in practicing value chain optimization. A Value Chain Optimization Research Network to support FPInnovations flagship Transformative Technologies program, "Integrated Value Maximization," was established in 2009. FPInnovations is also structured to support and complement the University Research Network.

From good to great: forest to industry interaction in Sweden from a value chain optimization perspective. Rådström, L. (*Skogforsk, Sweden; lennart.radstrom@skogforsk.se*).

The profitability within the forest industry has to be improved, and companies that are caught in the "commodity trap" have to find their way out. This situation calls for new strategies and actions for rapid change. A strong focus on the development of different value chains and more value-added products has to play an important role in that process. This presentation describes how the production of high-value forest products should begin already when planning for forest operations, and how it continues with scheduled logging operations, customized bucking, and logistics. In the Scandinavian countries, the cut-to-length method offers extremely good opportunities for that concept. We will also demonstrate how standards for information and communication systems and decision support systems facilitate the tailor-making of a flexible wood supply with keeping all associated costs under control. In Sweden this development has started and it has already strongly increased the efficiency in the supply chain: shorter lead times from harvesting to production at mill, better wood utilization, lower stock levels, fresher wood, reduced capital costs, lower processing costs. and improved product quality.

Internet-based, technology-driven supply chain optimization in the forest sector. Vlosky, R. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu*), Beresh, K. (*TheLumberMarket.com, Inc., USA; kberesh@mindspring.com*).

Increased efficiency, cost reduction, and information accuracy in channel systems are the primary goals of supply chain management. Specific objectives are to reduce inventories and channel costs. The goal is not to shift inventory, holding costs to other channel members, but rather to reduce system costs whereby all channel members gain. A second goal is to increase responsiveness to customers in the marketplace. In an increasingly competitive world, responsiveness is not a luxury; it is a prerequisite for survival. A third overall goal is to acquire flexibility in production (supplier), delivery (supplier or carrier), and replenishment (customer) capabilities. These goals, which are intimately intertwined, can lead to a number of structural changes

in the way business is conducted at each node in a supply chain. Relative to other industrial sectors, the forest products industry has been slow to adopt technologies that facilitate supply chain management from the forest to the end consumer, creating value for all participants. This presentation will discuss applications of information technologies and practices that can contribute to supply chain optimization in the forest sector.

The symbiosis mechanism of green supply chain in forestry-paper integration system. Zhang, Z. (*Nanjing Forestry University, China; zzg@njfu.com.cn*).

The structure and mechanism of cooperation between paper industry and forestry are researched, in order to provide a theoretical support for the practical implementation of Chinese forestry-paper integration (FPI). First of all, the development trends of FPI organizational pattern and operating mechanism are researched. Then, the symbiosis modes and characteristics of FPI green supply chain (GSC) are analyzed. On these grounds, GSC operation models of FPI are researched on macro and micro levels. As a result, an operating mechanism model of FPI three-chain symbiosis is established, which includes resources chain, ecology chain, and value chain of GSC. Afterwards, the model is further unfolded to construct a model of GSC substance cycles. It is concluded that supply chain system is the trend of FPI organization, and green symbiosis is an effective operating mechanism of FPI. For realizing green symbiosis, resources chain, ecology chain, and value chain not only circulate severally, but also are interwoven together, and promote with each other, to form a green symbiosis mechanism. Each of the three chains plays an important role: resources chain as a foundation, ecology chain as a support, and value chain as a motive power or a bond in GSC.

Posters

Renewing wood product value chains and timber procurement solutions. Heräjärvi, H., Verkasalo, E., Sirén, M. (*Finnish Forest Research Institute, Finland; henrik.herajarvi@metla.fi; erkki.verkasalo@metla.fi; matti.siren@metla.fi*).

Changes in the make-up of commercial forest resources, priorities for wood and timber quality, forest ownership, and customer structure, as well as changes in global and local climate, pose challenges to timber harvesting methods, transportation logistics, information systems, and entire chains of wood utilisation. In today's environmentally conscious business environment, the sustainability, renewability, and safety of wood as a raw material; its capability to store carbon; and other positive environmental performance elements combine to give a strong competitive advantage to the wood products sector. The Finnish Forest Research Institute has launched a 5-year-long (2009–2013) interdisciplinary research programme, "Renewing wood product value chains and timber procurement solutions (PUU)" in the fields of wood science and technology, forest engineering, and business economics. The programme serves timber producers, procurement organisations, and wood product industries by improving their strategic development and operative planning. The programme consists of three different themes: (1) raw material potentials of wood and timber trade functions, (2) timber procurement and competitiveness of harvesting companies, and (3) wood products and customer solutions. These themes are further divided into research topics and detailed research projects. Annually, approximately 30–50 researchers from METLA and its partner organisations will work in the projects.

A GIS analysis in forest operation planning in central Italy. Marchi, E., Montorselli, B.N. (*University of Florence, Italy; enrico.marchi@unifi.it; montorselli@unifi.it*), Spinelli, R. (*National Research Council, Italy; spinelli@ivalsa.cnr.it*).

Forest operation planning (FOP) in forest districts with heterogeneous characteristics could be easily supported by GIS. Many factors affect the working systems selection and the choice and efficiency of extraction methods, such as: morphology (ground uneven and slope); forest type (seedling forest and age, coppice); infrastructure availability (forest road network, tracks, landing); sylvicultural treatments (quantity and size of harvested wood); and extraction directions (uphill, downhill). In order to summarize and assess the effects of all these factors both on the extraction system choice and the efficacy and effectiveness, in terms of cost and environmental impact of forest operation, a GIS analysis is very helpful. In this paper a GIS model for forest operation planning developed in central Italy is described. The study was carried out by DEISTAF e CNR-IVALSA in the forest district of "Rincine," a public forest managed by the consortium of mountain communes, Montagna Fiorentina (Tuscany). An assessment and analysis of the costs in relation with wood assortments that have to be extracted is also carried out.

Market readiness of biomass gasification for power generation in three communities of northwestern Ontario: an integrated systems analysis. Upadhyay, T.P., Shahi, C., Pulkki, R., Leitch, M., Xu, C. (*Lakehead University, Canada; tpupadhy@lakeheadu.ca; cshahi@lakeheadu.ca; rpulkki@lakeheadu.ca; mleitch@lakeheadu.ca; cxu@lakeheadu.ca*).

Biomass gasification and use of synthetic gas for electricity production has proved to be an attractive option among bioenergy production processes. Nonetheless, there are two main challenges to increasing biomass utilization in electricity production: (i) supply chain costs of biomass procurement, and (ii) efficient technology to convert biomass into useful forms of energy. This study analyzes the market readiness of biomass gasification power generating plants of different capacities at the community level in northwestern Ontario (NWO) following systems analysis with an integrated dynamic mixed integer model. Ignace, Nipigon, and Kenora, three selected communities in NWO, are supplied by ten, seven and eight forest management units (FMUs), respectively. The biomass feedstock harvest is optimally procured from different portions of each FMU, selected by the distance matrix using geographic information system (GIS). Total cost (capital, logistics, and operating) per MWh power production at 50MW scale varies from CAD 50.99 to CAD 52.39. Total cost per unit of electricity production decreases significantly as plant capacity increases due to economy of scale in the production system. However, increasing the power plant capacity to 60MW, 70MW and 80MW respectively in Kenora, Nipigon, and Ignace locations is not feasible due to constraints on available biomass feedstock.

A new spatial harvesting simulator to assess the effect of strip road spacing on the total load induced to the forest terrain. Uusitalo, J., Haavisto, M. (*Finnish Forest Research Institute, Finland; jori.uusitalo@metla.fi; maarit.haavisto@metla.fi*), Kataja, J., Niemistö, L. (*Tampere University of Technology, Finland; jaakko.kataja@tut.fi; lassi.niemisto@tut.fi*).

Traditionally, harvesting operations on peatlands have been accomplished during the period of ground frost. More intensive utilization of peatland forest requires increasing logging activity during unfrozen conditions, when the soil load-bearing capacity

forms a severe obstacle for the prevailing harvesting machinery. The paper presents a new spatial harvesting simulator that aims at finding a balance between the magnitude of logging activities and the damage induced to the forest terrain. The simulator has two main data components. A tree list-file contains full specification of all trees to be placed in stand and a stand-file describes shape of stand and locations of strip roads in a raster format. The simulator cuts the trees and places all wood cut in the piles by the strip road. Thereafter the simulator generates all possible routes to collect a load and transport it to a road side storage. An optimized set of routes is then selected so that all piles become collected, while resulting the lowest possible terrain damage. The paper demonstrates how the simulator may be used in analyzing the effect of harvesting method and strip road spacing on the productivity and damage occurred to the strip roads.

The significance of importing the value chain in forest management. Yoshino, S., Sato, T.S. (*Tokyo University of Agriculture, Japan; ventulus14@yahoo.co.jp; satota@nodai.ac.jp*), Minowa, M. (*Japan Forestry Association, Japan; minowa@sanrinkai.or.jp*).

In forest management theories, added value is discussed in terms of nature value and labor value as accumulated forest capital. This suggests that there is little forest management that provides added value from both nature value and labor value. The labor value that can be added at the forest management level is uncertain because of the peculiarity of being produced long-term and locality-specific, which does not always become added value. The consumer public evaluates added value for the first, so it is necessary to think of making labor value part of forest management added value. The value chain that M.E. Porter suggested is the method of elucidating the competition predominance of enterprise and is regarded as the management form. So I think by importing the value chain in forest management, both nature value and labor value would provide added value in forest management. Since there were no studies to discuss forest management with value chain, this study discusses the significance of importing the value chain in forest management from various views. Therefore forest management would make the various environmental values as internal parts of the economy for importing the value chain in forest management.

E-03 Utilization of forest biomass as raw materials for green biofuels and chemicals

Organizers: Ingyu Choi; Joon Weon Choi, *Seoul National University, Republic of Korea, cingyu@snu.ac.kr, cjw@snu.ac.kr;* Soomin Lee, *Korea Forest Research Institute, Republic of Korea, lesoomin@forest.go.kr.*

Economic feasibility of woody biomass harvesting for biofuel production in hardwood forests of the Missouri Ozarks. Aguilar, F., Saunders, A., Dwyer, J., Stelzer, H. (*University of Missouri, USA; aguilarf@missouri.edu*; *amsh58@missouri.edu*; *jdwyer@missouri.edu; stelzerh@missouri.edu*).

An economic feasibility study of harvesting of woody biomass and solid hardwood products from Ozark stands was completed in 2009. Two silvicultural treatments (single tree selection and shelterwoods) were applied to reduce basal area at different levels (3.5, 4.0, and 5.5 sq. meter). The economic analysis provided the feasibility of treatments by estimating harvest operational efficiency, productivity, costs, and necessary prices needed to offset fixed and variable costs. Time in motion data were collected on all system components (harvester, skidder, loader, chipper) to understand how the extra efforts to gather woody biomass (small diameter and slash material) which affect the cost structure of the harvest. The estimated harvest costs for combination of both wood products were $21.80/ton for sawlogs and $24.22/ton for biomass for energy. The cost of harvesting sawlogs only was $27.91/ton. Sensitivity analysis scenarios illustrated the dynamics of how changes to variable and fixed input costs, stumpage prices, travel distances and the public subsidies affect the operating costs of the system. The presentation concludes with data on residual damage to standing trees caused during harvest operations and preliminary data on natural regeneration.

Oil dream with Jatropha (*Jatropha curcas* L.): challenges and prospects. Divakara, B.N. (*ICRISAT, India; bn.divakara@cgiar.org*), Behl H. M. (*Jatropha Network, India; hm.bhel@gmail.com*).

Liquid bio-energy production from vegetable oils is fundamental for development and sustenance of civilization. Bio-diesel production from vegetable oils during 2004–2005 was estimated to be 2.36 million tonnes globally. Of this, EU countries (1.93 million tonnes) with expectation of 30% annual increase and the USA (0.14 million tonnes) together accounted for 88%, and the rest of the world (0.29 million tonnes) for the remaining 12%. In this regard *J. curcas*, native of tropical America and now found abundantly in many tropical and sub-tropical regions throughout Africa and Asia because of its wide adoptability and utility, is under big hype of meeting global demands. However, *Jatropha* failed to meet the seed yield requirements, which in turn forced a rethinking of the crop by investors, policy makers, and project developers. Keeping this in view, an attempt has been made to study the problems which led to failure—lack of knowledge, no proven variety/cultivar, no proven cultivation practices, confusion on myths and realities of *Jatropha*, no encouraging success story, no successful bankable models, etc.—and future prospects by scientific intervention to address agronomic and genetic improvements, multilocation trails revealing the realities against myths to overcome these problems by thorough literature search.

Effects of moisture content on the yield and components distribution of bio-oil produced in the fast pyrolysis of wood. Gou, J., Chang, J., Ren, X., Si, H., Han, Y., Huang, Y. (*Beijing Forestry University, China; jinsheng.gou@gmail.com; cjianmin@bjfu.edu.cn; renxueyong@126.com; sihui@bjfu.edu.cn; hyx.m.s@163.com; annabelleyu@163.com*).

The effects of feedstock moisture on the yield and components of bio-oil from poplar and larch wood samples by fast pyrolysis were investigated in a spout fluidized bed reactor. Experiments were performed with recycled product gas as the fluidizing agent. Feedstock moisture content of 0%, 3%, 6%, 10%, 15%, 20%, 30%, and 50% was used, and other parameters were kept constant (particle size: 0.8–1.2 mm, pyrolysis temperature: 550 °C, heating rate: 10^4 °C/s, vapor residence time: 2–3 s), which were obtained in a previous study that consisted of the highest bio-oil yields. Bio-oil was collected by a two-level condensing

installation, which consisted of a direct spray and bath device. Condensed liquid product was repeatedly used as condenser media through a general pipe heat exchange agent. GS-MS analysis was conducted to determine its composition. Three dominating components, organic acids, phenols, and saccharides, were analyzed in bio-oil qualitatively and quantitatively. Prophase results showed that moisture content significantly influenced yields and components distribution of bio-oil. When moisture content varied from 0% to 10%, the bio-oil yields (tarry phase and aqueous phase) increased lightly with the increasing of moisture content and fell after gradually when the moisture content reached 30%.

Opportunities and barriers for wood pellet production and utilization in Korea. Han, G.S. (*Chungbuk National University, Republic of Korea; ilovewood@naver.com*), Jin, S.P. (*Korea Forest Service, Republic of Korea; fores21@forest.go.kr*).

Wood pellets have become an important fuel in Korea. The actual beginning of using pellets was started in 2008. Makers of pellet boiler started marketing and filling the consumption of pellets by importing them from abroad. Total amount of imports was 7,100 tons, and 68% of the imported pellets, 4,800 tons, were from China. Two plants started producing pellets at the end of 2008, and another two started in spring 2009. Seven more plants are being built now, and recently, the Korean government decided to build 10 more plants in 2010. The Korea Forest Service expected the pellet demand of 2009 to be 30,000 tons, and made a plan to supply 20,000 tons of imported pellets and 10,000 tons of domestic pellets. The Korea Forest Service announced their plan to expand pellet production and use aggressively. In the short term, the government wants to create a pellet demand in the agricultural and the residential areas. And, in the long term, it wants to create an enormous market in the power plant area. The Korean government has been trying to secure forest resources from overseas for a stable supply, and obtained excellent results in Indonesia and Cambodia.

New mechanism and efficiency of bundler for forest harvesting residuals. Nitami, T. (*University of Tokyo, Japan; nitami@fr.a.u-tokyo.ac.jp*), IIzawa, T. (*Uotani-Tekkou Inc, JAPAN; iizawa@ut-t.co.jp*), Suk, S., Sakurai, R., Imou K. (*University of Tokyo, Japan; hl5fca@fr.a.u-tokyo.ac.jp; sakurai@fr.a.u-tokyo.ac.jp; aimou@mail.ecc.u-tokyo.ac.jp*).

A new mechanism was developed for bundling forest residuals after harvesting operation. The operation unit is mounted on a small forwarder to move along small road for operation. The machine was designed to produce bundles from forest residuals which are put aside along roads. A small forwarder, as the base vehicle for the unit, is useful to operate on small roads moving in order to decrease operation cost for residual harvesting. The mechanism of bundling is different from conventional units and its size is small. Compression rate of the bundle is four. Its rotating and liner movement of unit devices affords rapid and efficient processing. The hydraulic system to propel the unit was designed to optimize driving power and the compress-bundle process. The compression process was modeled and monitored for the design and control. The model and monitored compression data were discussed and analyzed. Compression and bundle results were discussed together with their residual composites from stems, branches, twigs, tops, and so on. Also, operation time was analyzed considering variety of conditions such as quality of forest harvest residuals for the quality of bundles and as operational efficiency for the productivity of the machine.

Biochemicals for protection of goods and health. Saranpää, P. (*Finnish Forest Research Institute, Finland; pekka.saranpaa@metla.f*).

The objective of Future Biorefinery, the second research program of Forestcluster Ltd., is to develop new methods enabling fractionation of wood into cellulose, hemicelluloses, lignin, and extractives in their native-like form; and further, to upgrade these fractions into chemicals and materials. The structure of the program is designed to facilitate integration of the new value chains to current pulp mills as well as to emerging biorefineries producing transport biofuels as a by-product. The theme "Biochemicals for protection of goods and health" focuses on biological and biomedical properties of wood and bark components. The aim is to create a firm knowledge base for development of bioactive products; products which could be used for, e.g., protection of biologically sensitive products, such as wood and paper products, or food and cosmetic products in packaging. Biomedically active components could find use in dietary supplements, health-promoting (functional) foods, or pharmaceuticals. The theme is focused on extractives, such as various polyphenols, terpenes, and lipids from heartwood, bark, knots, roots, and stumps, as well as tannins from bark. Hemicelluloses and specialty sugars will also be studied regarding their biological and biomedical properties. Some of the recent results of the program will be presented.

Recovery utilization of logging residue logs accompanying small scale forestry in a rural community-based woody biomass utilization project. Suzuki, Y. (*Kochi University, Japan; ysuzuki@kochi-u.ac.jp*), Nakajima, K. (*NPO Rescue party for forests in Kochi, Japan; ken_naka@kcb-net.ne.jp*), Gotou, J. (*Kochi University, Japan; ryosuke@kochi-u.ac.jp*).

There are a considerable number of government-subsidized projects on woody biomass utilization in Japan against CO_2 emission reduction. Several rural communities, where the forestry sector comprises a main part of the local industry, have started recovering the business of logging residue logs. We investigated one such project at Niyodogawa-town, a typical rural community in Japanese sub-mountain area. In the project small scale shippers contributed a major part of total shipped amount of residue logs, although larger scale shippers were thought to be major shippers. Two series of questionnaires and cost analysis revealed that small scale shippers conducted residue log recovering work as a part-time jobs, not a main work for their incomes; they used redundant time for the recovering operation. One important factor in their success is fairly developed forest road networks that were prepared for conventional logging and forest management objectives. The town purchases residue logs by JPN3000/green-ton for basic price accompanying with additional subsidy-based payment of JPN1000–3000/green-ton, which is paid as rural currency. This additional payment acted as an incentive for small scale forest owners to resume forestry activities, which they had abandoned in recent years because of low income from conventional logging operations.

Woody biomass in the United States with a focus on wood energy. Vlosky, R., Perera, P., Perera, R., Baffoe, A., Wu, Q. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu; pperer2@lsu.edu; rperer3@lsu.edu; abaffo2@lsu.edu; qwu@agcenter.lsu.edu*).

Interest in renewable energy resources has grown significantly among energy producers, developers, legislators, and policy makers over the past decade as the cost of fossil fuel continues to increase with a finite supply. Hydro-electric, geothermal, wind, solar

and biomass energy are the most common forms of renewable energy sources that are being used to replace dependency on fossil fuels. Woody biomass utilization is versatile such as for co-generation, gasification, co-mixed with coal fly ash, or in pellet manufacturing. Availability, use, and trends for using woody biomass in the United States for transportation fuel and energy are all areas that are of great interest. For example, The Energy Independence and Security Act of 2007, which amended the Renewable Fuel Standard of 2005, will likely increase demand for transportation fuels derived from forest biomass. Forest2Market (2008), projects U.S. demand for wood fiber from emerging biomass markets is expected to rise from 2 million tons in 2008 to at least 13.5 million tons in 2013. However, research shows that while there is clearly accelerating interest in wood-based energy, growth for this new industry may be constrained by sustainable harvest levels, availability from other sources, wood fiber prices and transportation costs.

Posters

Removal of offensive odors and harmful gases using insole containing charcoal. Ahn, B.J., Lee, O.K., Cho, S.T., Lee, S.M. (*Korea Forest Research Institute, Republic of Korea; bjahn@forest.go.kr; oklee@forest.go.kr; chost@forest.go.kr; lesoomin@forest.go.kr*).

An insole containing charcoal was examined as an environmentally friendly deodorant against foot odor. The insole was molded from a mixture of EVA and charcoal powder (3 and 5%). In the test of physical properties of the insole, its hardness, tensile strength, tear strength, elongation, specific gravity, and compression shrinkage satisfactorily met the standard, although tensile strength and compression shrinkage of insoles containing 5% charcoal were lower than those of insoles containing 3% charcoal. In the result of deodorant test conducted by air ventilation method, it was found that the insoles removed 67% of the odor in both cases of 3 and 5% charcoal-containing insoles. Also, it was determined by GC/MS-TD method that 46.8 and 72.3% of TVOC were removed by the insoles containing 3 and 5% charcoal, respectively. Especially, acetophenone and 2-phenyl-1,2-propanediol, which are odors from the insole itself, were removed at the levels of 72.3 and 61.0%, respectively. It was also determined that the insole removed 44.2–52.5% of butylaldehyde, a major source of foot odor, by small chamber (20 L) method.

***Acacia mangium* tannin as formaldehyde catcher in co-polymerize with low molecular weight phenol-formaldehyde for plywood adhesive.** Beng Hoong, Y., Md. Tahir P., Chuah Abdullah, L. (*Universiti Putra Malaysia, Malaysia; frence_yeoh@yahoo.com; parida_introb@yahoo.com; chuah@eng.upm.edu.my)*, Yueh Feng, L. (*Malaysian Timber Industry Board, Malaysia; loh@mtib.gov.my*).

The current increase in oil prices has intensified efforts to seek conversion of renewable resources into biopolymers. Phenol, a petroleum-based chemical, is one of the most sought-after chemicals that can be synthesized from the bark of trees. Tannin from bark extracts is rich in phenolic compounds, thus may be able to absorb this free formaldehyde and at the same time provide strength to the joint. Tannin-low molecular weight phenol formaldehyde resins (Tannin-LmPF) were prepared by using the bark extracts of *Acacia mangium* (40% solid content) to substitute a part of the phenol. Tannin-LmPF adhesives prepared have a fast curing time (4 min) which in manufacture substantially reduces the cost of production by lowering the pressing time; and the shear strength of the plywood can meet the requirement at least more than 1.0 MPa exceeding of the European standards EN 314-1 and EN 314-2: 1993. The plywood panel bonded with tannin exhibited a lower formaldehyde emission according to BS EN 210: 1992 compared to the control LmPF at temperature 130 °C and 4 min pressing time. The result shows that the adhesive prepared in this study exceeds the requirement of European standards for producing interior and exterior grade plywood.

Bio-base plywood adhesive from *Acacia mangium* bark extracts co-polymerize with phenol-formaldehyde (PF) for bonding mempisang (*Annonaceae spp.)* veneers. Beng Hoong, Y., Md Tahir, P., Abdullah, L. (*Universiti Putra Malaysia, Malaysia; frence_yeoh@yahoo.com; parida_introb@yahoo.com; chuah@eng.upm.edu.my)*, Yueh Feng, L. (*Malaysian Timber Industrial Board, Malaysia, Malaysia; Loh@mtib.gov.my*).

The current increase in oil prices has intensified efforts to seek renewable resources to be converted into biopolymers. Phenol, a petroleum-based chemical, is one of the most sought-after chemicals that can be synthesized from the bark of trees. Tannin from bark extracts is rich in polyphenolic compounds and soluble in water. This study evaluates the properties of tannin extracted from *Acacia mangium* tree barks as a partial substitute to commercial phenol-formaldehyde (PF) for plywood making. Results showed that the optimum extraction method of tannin from tree bark to generate acceptable yield amounts of tannin is using a ratio of 600:100:2:0.5 (w/w) for water: bark: sodium sulfite: sodium carbonate, respectively. The yield of tannin (20–25%) and the reactivity toward formaldehyde (85–90%) in this study met the minimum requirement for bio-based plywood adhesive application. In conclusion, *A. mangium* tannin can be used to co-polymerize with PF resin for plywood adhesive up to 90% replacement without additional paraformaldehyde for dry application and with additional paraformaldehyde (up to 3%) for more severe applications, producing acceptably good quality joints such as 24-hour cold water test and 72-hour boiling test (i.e ≥1.0 MPa) according to the European standards EN 314-1 and EN 314-2:1993.

Calorific value of woody biomass as a heating energy source in Korea. Cha, D.S. (*Kangwon National University, Republic of Korea; dscha@kangwon.ac.kr*), Oh, J.H. (*Korea Forest Research Institute, Republic of Korea; jhoh@forest.go.kr*), Hwang, J.S. (*Kangwon National University, Republic of Korea; jinny3879@kangwon.ac.kr*).

Woody biomass, which is produced by forest tending and short-rotation reforestation programs, can be used for home heating energy. However, when woody biomass is used to fuel wood chip boilers, differences of calorific values by moisture contents and tree species should be determined. So this study was carried out to find the calorific values of wood chip by moisture content and tree species. We select six tree species—*Pinus rigida, P. koraiensis, Larix leptolepis, Alnus hirsuta, Liriodendron tulipifera*, and *Quercus mongolica*—as test specimens. The specimens are divided into two wood parts, heartwood and bark. Calorific value by moisture content was the highest when it was fully dried, and went lower as the moisture content increased. In determining calorific value by the part of the wood, the calorific value of bark was higher than heartwood. The heartwood in *Pinus koraiensis* had the highest calorific value at 4,763 kcal/kg when its moisture content was 0%; the highest bark calorific value was in *Liriodendron tulipifera*, at 4,972 kcal/kg when its moisture content was 0%.

Life cycle inventory and cost analysis of wood pellets in South Korea. Cha, J., Youn, Y.C. (*Seoul National University, Republic of Korea; jhcha74@snu.ac.kr youn@snu.ac.kr*).

The production and use of wood pellets has been increasing greatly in South Korea. Wood pellets provide carbon-neutral energy and can be made from wood resources of sawmill residues, roundwood, and wood residues collected from forestry practices. The energy consumption and greenhouse gas emissions of three types of wood pellet production were compared using a life cycle analysis (LCA). LCA is a useful tool to evaluate the environmental performance of a product. This study showed that the use of wood pellets as biofuels substituting fossil fuels such as natural gas and kerosene for boilers has positive effects both in reducing greenhouse gas emissions and in decreasing the cost for house heating. The life-cycle environmental impacts of wood pellets were mainly coming from the transportation of wood resources and pellet products to the final consumer. Better utilization of forest residues that have not been collected and used much for biomass, increasing pellet-boiler efficiency, and improving regional biomass utilization system such as a decrease in transportation distance, can be measured to reduce greenhouse gas emissions in the forestry sector for climate change mitigation.

Production of high concentration of monosaccharides from yellow poplar by concentrated sulfuric acid hydrolysis. Cho, N.S. (*Chungbuk National University, Republic of Korea; nscho@chungbuk.ac.kr*), Cho, D.H., Kim, Y.H. (*Kwangwoon University, Republic of Korea; daehaeng@gmail.com; metalkim@kw.ac.kr*), Shin, S.J. (*Chungbuk National University, Republic of Korea; soojeongesf@hanmail.net*).

Concentrated acid hydrolysis of woody biomass has many advantages, such as higher conversion rate of monomeric sugars and lower processing expenses because of mild reaction condition. Acid hydrolysis characteristics of yellow poplar woodmeal with concentrated sulfuric acid for high concentration of monosaccharides production were investigated. Woodmeal to sulfuric acid ratio (w/v), 2nd hydrolysis temperature, and time were the main variables to find out the optimum reaction condition. Optimum ratio of woodmeal to sulfuric acid was 1:1.6 (w/v), and 2nd hydrolysis temperature and time were 105 °C and 40 min. as 44.8 g/L of glucose and 25.2 g/L of xylose in hydrolyzates. In this acid hydrolyzates, furfural, 5-hydroxymethyl furfural (5-HMF) and low molecular weight phenolic compounds were identified. Furfural and 5-HMF concentration were increased as increasing 2nd hydrolysis time. After more than 40 min. of 2nd hydrolysis at 110 °C, xylose concentration decreased, but glucose concentration leveled off because xylose to furfural reaction was faster than xylan to xylose. But cellulose to glucose conversion reaction was similar with glucose to 5-HMF at that 2nd hydrolysis reaction condition.

Saccharification properties of wood under high temperatures and pressures in the presence of an acid catalyst. Choi, S.H., Lee, O.K., Lee, S.M., Ahn, B.J., Cho, S.T. (*Korea Forest Research Institute, Republic of Korea; choish@forest.go.kr; oklee@forest.go.kr; lesoomin@forest.go.kr; bjahn@forest.go.kr; chost@forest.go.kr*), Choi, J.W. (*Seoul National University, Republic of Korea; cjw@snu.ac.kr*).

Saccharification properties of wood were investigated using high temperature and pressure in the presence of 0.05% nitric acid (HNO_3). *Liriodendron tulipifera* and *Populus alba* × *glandulosa* were dried and ground to powder, and were suspended in aqueous 0.05% HNO_3 solution. This suspension was pumped into the reaction tube at a speed of 100 mL per one minute, which is the reaction time. The reactions were run at three different temperature levels (350°, 380°, and 400 °C) with at a fixed pressure of 23 MPa. The degradation rate of the samples determined by measuring solid residue after the reaction was 63–88%. Based on the calibration equation, yield of monomeric sugars in the reaction solution was 26.5–34.0% at 350° and 380 °C and 7.4–17.4% at 400 °C, respectively. The highest yield was determined at 350 °C in both cases, and the yield of glucose and xylose occupies around 17.6 and 12.0% for *P. alba* × *glandulosa*, respectively, whereas 14.6 and 17.0% for *L. tulipifera*. Results suggests that 29–34% glucose in wood cellulose hydrolyzed in the shortest reaction time and stayed undegraded.

Use of the green foliage of different plant species in the development of new value-added products. Cordero, E., Orea, U., González, I. (*Ministerio de Educación Superior, Cuba; ecordero@af.upr.edu.cu; orea@af.upr.edu.cu; iselys@fcsh.upr.edu.cu*).

The use of green foliage of different plant species in the development of new products and combinations of naturally occurring chemicals with potential application in the pharmaceutical, food, chemical, cosmetics, and perfumery industries, promoted research towards a detailed study on the technological parameters that allow scaling to obtain the derivatives, facilitating the research-development and university-industry interaction in order to demonstrate that obtaining final products from te foliage may be drawn to industrial scale. The aim of this study is the use of green foliage of plant species in the Pinar del Rio, province of Cuba, to obtain wax, essential oils, sodium chlorophyllin, provitamin concentrate, balsamic past, chlorophyll-carotene past, and cattle food residue. Methods used were solid-liquid extraction, gravimetric, potentiometric, spectroscopic; and TAPPI International Standards Methods and SPSS methods for statistical analysis of results. Yields of the products were slightly higher than those obtained from the species in this genus in cold areas, which should be associated with soil and climate factors; and quality indicators of the products were maintained within the range established internationally.

Analysis of the oil content and its fatty acid composition of fruit kernels for soapberry cultivars in China. Du., M.H., Zhang. J.P., Wang, J.W. (*Research Institute of Subtropical Forestry, China; xiaoduchongcn@yahoo.com.cn; jinpingzhang@126.com; wjw40@tom.com*).

Soapberry is widely distributed and various cultivars are present in producing areas; therefore, the identification of the oil content of different species of soapberry is important base work for selection as a resource for producing biodiesel. The oil content and fatty acid composition of the fruit kernels of 46 soapberry cultivars in 10 provinces of China were measured in this study. The results showed that the average fresh fruit kernel oil content of all soapberry cultivars in China were in the range of 34.23%–46.60%. The oil content was similar to that of olive oil. The soapberry oil fatty acids were mainly composed of palmitic, stearic, oleic, linoleic, linolenic, eicosenoic, and palmitoleic acid accounting for 99% of the total fat content; and unsaturated fatty acid content was more than 85%. Based on the oil content of fruit kernels and fatty acid composition, of the 46 soapberry cultivars with higher oil quality, we selected 2 in Hangzhou, 1 in Ruichang, and 1 in Guangxi, by using hierarchical cluster analysis. The results indicated that the fruit kernels of soapberry may be an excellent resource for producing biodiesel.

Densification of Hyunsasi poplar and Japanese larch using a cylindrical briquetting press. Han, G.S. (*Chungbuk National University, Republic of Korea; ilovewood@naver.com*).

Hyunsasi poplar and Japanese larch are representative fast-growing species in Korea. Densification of these woods is one of solution to difficulties in handling, transporting, storing, and using as a fuel. Densification characteristics of Hyunsasi poplar and Japanese larch were studied using a lab-scale cylindrical briquetting press (Ø40 mm). Wood species, particle size, pressure, and pressure holding time affected density. Densities of briquettes of Japanese larch were higher than those of Hyunsasi poplar. Wood particles ground by hammer mill with Ø4 mm screen produced better quality briquettes than with Ø2 mm and Ø1 mm screen. Briquettes with densities of 800–1040 kg/m^3 were produced under 110–170 MPa. Densities of briquettes were increased with increase of pressure holding time and leveled off at 12 seconds. Densities of briquettes were decreased with increase of storage time. Density of briquettes that were produced under 110–170 MPa changed from 880–1040 kg/m^3 to 670–960 kg/m^3 after a week stored at room temperature. Bulk density of poplar briquettes that were made under 150MPa, was 390 kg/m^3 and that of larch briquettes was 530 kg/m^3. Durability of poplar briquettes that were made under 150 MPa, was 62.1%, and that of larch briquettes was 54.1%.

Effect of pyrolysis condition on the properties of fast-pyrolysis carbon from larch. Han, Y.X., Chang, J.M., Gou, J.S., Xu, S.Q. (*Beijing Forestry University, China; hyx.m.s@163.com; cjianmin@bjfu.edu.cn*; *jinshenggou@gmail.cn; supershewa@163.com*).

Pyrolysis carbon is an important product of fast pyrolysis from larch, which can be changed into activated carbon for the initial pore structure and adsorption capacity of certain. As raw material, the characteristics of pyrolysis carbon have a great effect on the performance of activated carbon, and the material properties and pyrolysis conditions have a significant affection on the characteristics of pyrolysis carbon. This study investigated the relationship between the properties of pyrolysis carbon from larch and the raw material characteristics (particle size, moisture) and the pyrolysis reaction conditions (pyrolysis temperature, gas residence time). We measured and analyzed the moisture, ash, fixed carbon content, and heating value of the pyrolysis carbon from larch reacted on a spouted circulating fluidized bed, and we detected the microstructure with scanning electron microscopy, to apply a theoretical basis for the effect on the preparation of activated carbon. The results show that the temperature and raw material particle size have a significant effect on the characteristics of pyrolysis carbon, while the impact of moisture of raw materials and gas residence time is weaker.

Utilization of non-woven fabric mixed with charcoal for reduction of harmful gas emitted from new cars interiors. Jo, T.S., Ahn, B.J., Lee, O.K. (*Korea Forest Research Institute, Republic of Korea; tscho@forest.go.kr; bjahn@forest.go.kr; oklee@forest.go.kr*).

A charcoal-containing non-woven fabric was evaluated for its potential to reduce emission of harmful gas from the interior of new cars. It was prepared with PE (Polyethylene) followed by treatment with charcoal suspended in distilled water. The charcoal content was 5% based on the dry weight of the fabric. The reduction effect was determined by sensory test and GC/MSD-TD analysis. The charcoal containing non-woven fabric showed 55.2% of removal effect in the sensory test on the harmful gases. In the results of TVOC (total volatile organic compounds) test, it was determined that emission of TVOC was reduced to 0.006 mg/m^2·h, whereas the fabric without charcoal emitted 0.022 mg/m^2 h. In the gas adsorption test, the charcoal containing non-woven fabric removed 61% and 53% of formaldehyde and toluene gas, respectively, but there was almost no more adsorption after the second day of exposure to these gases. According to these results, it is strongly suggested that the charcoal embedded in non-woven fabric could reduce emission of harmful gases from the fabric itself as well as remove gases from the outside of non-woven fabric. As a conclusion, the charcoal containing non-woven fabric could have high potential for reducing harmful gases in new cars.

Comparison of growth periods on enzymatic hydrolysis of fast-growing wood. Jung, J.Y. (*Gyeongsang National University, Republic of Korea; charmhanjjy@nate.com*), Yeo, J.K. (*Korea Forest Research Institute, Republic of Korea; jkyeo@forest.go.kr*), Kim, Y.W., Yoon, B.T. (*Korea Research Institute of Chemical technology, Republic of Korea; ywkim@krict.re.kr; btyoun@krict.re.kr*), Choi, M.S., Yang, J.K. (*Gyeongsang National University, Republic of Korea; mschoi@gnu.ac.k; jkyang@gnu.ac.kr*).

To investigate the possibility of using core woods as a biomass resource for alternative energy production, the chemical composition and carbohydrate composition of *Populus alba* × *P. glandulosa* (3 years) and *P. alba* × *P. glandulosa* (3 years) were examined. The *P. alba* × *P. glandulosa* (3 years) sample shows high cellulose as glucose and hemicellulose content (48.6% and 19.9%, respectively) and low-acid insoluble lignin (20.6%). The *P. alba* × *P. glandulosa* (12 years) was found to contain 47.3% cellulose as glucose, and 15.1% xylose, respectively. This showed that approximately 63 wt. % of *P. alba* × *P. glandulosa* (12 years) is potentially available carbohydrate, which can be converted to ethanol by pentose and hexose fermenting organisms. *P. alba* × *P. glandulosa* (3 years), *P. alba* × *P. glandulosa* (12 years) were used as the substrates for enzymatic hydrolysis. The highest concentration of glucose reached 1.63 and 1.29 g l^{-1} after 72 h enzymic hydrolysis for *P.s alba* × *P. glandulosa* (3 years) and 72 h for *P. alba* × *P. glandulosa* (12 years). *P. alba* × *P. glandulosa* (3 years) had a higher hydrolysis rate than *P. alba* × *P. glandulosa* (12 years).

Effect of growth periods and pretreatment on enzymatic hydrolysis of fast - growing wood. Jung, J.Y. (*Gyeongsang National University, Republic of Korea; charmhanjjy@nate.com*), Yeo, J.K., Kim, Y.W., Yoon B.T. (*Korea Research Institute of Chemical Technology, Republic of Korea; jkyeo@forest.go.kr; ywkim@krict.re.kr; btyoun@krict.re.kr*), Choi M.S., Yang J.K. (*Gyeongsang National University, Republic of Korea; mschoi@gnu.ac.kr; jkyang@gnu.ac.kr*).

In this study, we evaluated the effectiveness of growth periods and microwave/alkali pretreatment for conversion of fast-growing *Populus euramericana* to sugar. The substrates for enzymatic hydrolysis were *P. euramericana* (3 years), *P. euramericana* (12 years), *P. euramericana* (3 years, microwave/alkali pretreatment), *P. euramericana* (12 years, microwave/alkali pretreatment). The microwave/alkali pretreatment was performed at 700 W, 1% NaOH solution, 3 h. Firstly, the effect of growth periods of *P. euramericana* on its chemical composition and sugar concentration was examined. *P. euramericana* (12 years) had higher

hydrolysis rate than that of *P. euramericana* (3 years). The sugar concentrations after enzymatic hydrolysis were 4.99 g l^{-1} in the *P. euramericana* (3 years), and 5.44 g l^{-1} in the *P. euramericana* (12 years). Secondly, the effect of microwave/chemical pretreatment processes of *P. euramericana* on its sugar composition was examined. The results showed that the *P. euramericana* pretreated by microwave/alkali had the highest sugar concentration. The sugar concentrations after enzymatic hydrolysis were 10.20 g l^{-1} in the *P. euramericana* (3 years, microwave/alkali pretreatment), and 11.56 g l^{-1} in the *P. euramericana* (12 years, microwave/alkali pretreatment). We found that growth periods and microwave/alkali pretreatment showed positive effect on enzymatic hydrolysis.

Determining the smallest scale of production for raw materials used in production of wood pellets. Kim, J.S., Choi, Y.S. (*Kangwon National University, Republic of Korea; jskim@kangwon.ac.kr; zigoo0402@hanmail.net*).

Although residual logs are gathered and used to produce wood pellets in Korea, this is inefficient due to high gathering costs. Rather than using expensive residual logs, low quality timber logs or by-products from saw mills such as long side-splits or sawdust can be used as the main raw materials. In this paper, the production costs and incomes of wood pellets were measured in proportion to the scale of the factories to calculate profits and break-even points. The profit was twice as high when by-products were used instead of timber logs in a factory with 12,000 tons of production capacity. The break-even points for by-products and timber logs were 4,000 tons and 6,000 tons respectively. Considering the domestic market price of wood pellets, which is $300 per ton and $40 per ton for transporting cost within a 62-mile radius, it is not possible to make a profit when the production cost of wood pellets exceeds $260 per ton. Base on this fact, more than 6,000 tons of production for using by-products, and more than 10,000 tons of production for using timber logs, are needed to to yield profits.

A study of the essential parameters in fast pyrolysis system to convert lignocellulosic biomass to liquid biooil. Kim K.H. (*Seoul National University, Republic of Korea; kkh7381@snu.ac.kr*), Lee S.M. (*Korea forest research institute, Republic of Korea; lesoomin@forest.go.kr*), Cho S.T. (*Korea forest research institute, Republic of Korea; chost@forest.go.kr*), Choi J.W. (*Seoul National University, Republic of Korea; cjw@snu.ac.kr*).

Fast pyrolysis of yellow poplar wood (*Liriodendron tulipifera*) was performed under different temperature ranges and residence times to maximize the yield of bio-oil using fluidized bed reactor. In this study, the pyrolysis temperature ranged between 400 °C and 550 °C, and residence time was controlled between 1.0 and 7.5s by inert nitrogen gas flow. At 400 °C, biooil was produced only to 50.2% (wet basis), while over 28% of biomass was turned to char. When the pyrolysis temperature rose up to 500 °C, the yield of biooil was gradually increased, whereas char formation was retarded. Residence time was also important factor in the fast pyrolysis of woody biomass. At residence time 7.5s at 500 °C, the composition of char, biooil, and gases were determined to 17.9%, 51.6%, and 30.5%, respectively. However, when residence time was reduced to 1.0s, the composition changed to 8.9%, 68.3%, and 22.8%, respectively. The chemical composition of biooil was identified by GC-MS. In overall, the biooil was composed of mainly aliphatic, aromatic, and low-molecular polar fractions. Water content, determined by Karl Fischer titration, was ca. 20–25% (w/w) in the biooil. In addition, elemental analysis and viscosity of biooil were determined.

Purification and characterization of a xylanase from *Fomitopsis pinicola.* Kim, Y.S. (*College of Foresty, Republic of Korea; yskim@kookmin.ac.kr*), Shin, K., Cho, M.J., Kim, H.J. (*Kookmin University, Republic of Korea; ccyskdw@hotmail.com*), Lee, J.K. (*Konkuk University, Republic of Korea*).

An efficient xylanase-producing strain, *Fomitopsis pinicola* KMJ812, was isolated and identified based on morphological features and sequence analysis of internal transcribed spacer rDNA. An extracellular xylanase was purified to homogeneity by sequential chromatography of *F. pinicola* culture supernatants on a DEAE-sepharose column, a gel filtration column, and then on a MonoQ column with fast protein liquid chromatography. The relative molecular weight of *F. pinicola* xylanase was determined to be 58 kDa by sodium dodecylsulfate polyacrylamide gel electrophoresis, or 110 kDa by size exclusion chromatography, indicating that the enzyme is a monomer. The hydrolytic activity of the xylanase had a pH optimum of 4.5 and a temperature optimum of 70 °C. The enzyme showed high substrate specificity and high catalytic efficiency (k_{cat} = 30.02 s^{-1}, K_m = 2.1mM, k_{cat}/K_m = 14.29 mM^{-1} s^{-1}) for *p*-nitrophenyl-β-d-xylopyranoside. Its internal amino acid sequences showed a significant homology with hydrolases from glycoside hydrolase family 10, indicating that the *F. pinicola* xylanase is a member of glycoside hydrolase family 10.

Evaluation on the properties of pine trees for wood pellets. Kwon, S.M., Jang, J.H., Kim, N.H., Cha, D.S. (*Kangwon National University, Republic of Korea; ksm7689@kangwon.ac.kr; jhtojh@kangwon.ac.kr; kimnh@kangwon.ac.kr; dscha@kangwon.ac.kr*).

World wood pellet production has increased from 100 thousand tons in 1980 to 10 million tons in 2008. In 2020, total world demand of wood pellets would be 140 million tons. In Korea, the wood pellet market is still in the early stage. However, there may be explosive potential demand in the future according to the UNFCCC negotiation for post-2012, the energy situation, and government policy. The purpose of this study is to determine the characteristics as ash content, mineral components, and heating values of *Pinus koraiensis*, *P. densiflora*, and *P. rigida*, which are the most important commercial wood resources in Korea, for wood pellet material. Pine cone, pine nut shell, wood bark, wood stem, and needles of both species were used. Pine nut shell has the lowest ash content (0.64%) among the materials. Except for pine cone, all materials included high mineral content of calcium and potassium. Pine cone showed the highest heating value (5,523 cal/g) and the bark had much higher heating value than stem wood. The result of some oak trees also will be discussed.

A simple and rapid saccharification method of wood using high temperature and pressure. Lee, O.K., Choi, S.H., Lee, S.M., Ahn, B.J., Cho, S.T. (*Korea Forest Research Institute, Republic of Korea; oklee@forest.go.kr; choish@forest.go.kr; lesoomin@forest.go.kr; bjahn@forest.go.kr; chost@forest.go.kr*), Choi J.W. (*Seoul National University, Republic of Korea; cjw@snu.ac.kr*).

Saccharification of wood using a single-step process was studied as one of the processes in bioethanol production. Wood powder of *Pinus rigida* and *Populus alba* × *glandulosa* underwent thermochemical treatment using a flow-type reactor at 350, 380, 400,

and 425 °C with the pressure of 23 MPa. Wood powder was suspended in distilled water with or without 0.05% HCl before having a reaction. The suspension was pumped into the reaction tube at a speed of 100 mL/min. The reaction time was only 1 minute. The results showed that the yield of monomeric sugars, in the reaction without the addition of the HCl, increased as the reaction temperature increased. Therefore, the yield of monomeric sugars from *P. rigida* and *P. alba* × *glandulosa* were between around 1.7–6.7 and 2.9–7.3%, respectively, based on the dry weight of wood. However, the yield was significantly higher when 0.05% HCl was added in the reaction. Also, the yield was not proportional to the reaction temperature so that the highest yield was obtained at 380 °C and was approximately 23.2–25.1% for both of *P. rigida* and *P. alba* × *glandulosa*. As a result, this simple thermochemical method can be suggested as a rapid saccharification process.

Development of a high viscosity pulping method for Korean traditional paper (*hanji*). Lee, S.H., Choi, T.H. (*Chungbuk National University, Republic of Korea; popple77@naver.com; tchoi@cbnu.ac.kr*).

Pulping of paper mulberry (*Broussonetia kazinoki*) bast fiber has been examined by most of the conventional pulping methods and novel pulping methods. The viscosity of paper mulberry bast fiber has been found to be highly sensitive and variable with different pulping methods; therefore, it is important to choose proper chemicals and conditions for pulping and bleaching of paper mulberry bast fiber. Two processing steps were employed for high viscosity pulping: treatment with (A) ammonium oxalate, (B) sodium chlorite and acetic acid. Variations in the order, conditions, and duration of their application resulted in different pulp characteristics. After manufacturing Korean traditional paper (*hanji*), its physical properties and color were evaluated. The paper mulberry bast fiber treated with acidified sodium chlorite generated the high whiteness index; whereas the sample treated with only ammonium oxalate generated the high yellowness index. The highest viscosity pulp from paper mulberry bast fiber demonstrated a high tensile strength index. Paper mulberry pulp with high-viscosity could be used in the production of high-quality currency paper or high-longevity paper for special uses.

Effect of pyrolysis temperature on the production of pyroligneous acid from oil palm trunk sawdust. Lee, S.H., H'ng, P.S., Lee, A.N., Tey, B.T. (*Universiti Putra Malaysia, Malaysia; elvinklg@yahoo.com; ngpaiksan@gmail.com; evelynklg@yahoo.com; btey@eng.upm.edu.my*).

We will discuss a replanting scheme in oil palm plantation (*Elaeis guineensis* Jacq.) to produce a massive unutilized lignocellulosic material in the plantation area. It has been estimated that the availability of oil palm residues in 2008 was about 11,000 million tonnes of trunk. Based on those figures, Malaysia has great potential for turning its abundant oil palm trunks (OPT) into valued-added products. OPTs are capable produced into wood composite products without any modifications on the resin formulation. There are other usages of this OPT, and one of those is chemicals obtained using pyrolysis method. In this study, pyrolysis of OPT sawdust was performed to identify the optimum temperature for the yield of pyroligneous acid (PA). OPT sawdust was pyrolyzed under varies temperature (room temperature-300 °C, 300–400 °C, and 400–500 °C). Functional group compositional analysis of PA was carried out using Fourier Transform Infrared Spectrometry (FTIR). The maximum PA yield of 12.89% was obtained at temperature of 400–500 °C. PA yield increased with increasing of temperature from room temperature to 500 °C. Spectroscopic studies on the PA showed that PA obtained from OPT sawdust can be used as chemical feedstock.

Fermentation efficiency of bioethanol using oil palm trunk hydrolysate. Lih Jiun, W., Paik San., Kit Leng, C. (*Universiti Putra Malaysia, Malaysia; jessey86_827@hotmail.com; ngpaiksan@gmail.com; dwinackl@hotmail.com*).

Environmental concerns as well as rapid depletion of fossil fuels and global warming have re-introduced bioethanol produced from sugar, starch, and biomass into the energy market. Oil palm trunks, which are abundantly available through the replanting scheme after being planted for 20 to 25 years, serve as potential materials for glucose to produce bioethanol. The objective of this study was to produce bioethanol from oil palm trunk through concentrated acid hydrolysis followed by fermentation using the yeast, *Saccharomyces cerevisiae*, at different fermentation pH and temperatures. The average glucose yield was 5.35 g/l (w/w) from the hydrolysis of oil palm trunk; 60% concentrated sulphuric acid reacted for 1 hour and then diluted to 30% and reacted for another 1 hour. From the results, the fermentation efficiency is highly dependent on the pH of the hydrolysate and temperature during fermentation carried out in anaerobic conditions. Conclusively, oil palm trunk glucose can be fermented to ethanol satisfactorily at pH 4 or pH 6 and a temperature of 30 °C using *Saccharomyces cerevisiae* whose fermentation efficiency reached 72.549% (w/w).

Effect of multiple-step carbonization on the basic properties and adsorption capacities of moso bamboo (Phyllostachys pubescens) charcoals. Lin, S.M. (*National Pingtung University of Science and Technology, China-Taipei; lsh@mail.npust.edu.tw*).

We studied the effect of multiple-step carbonization processes on the basic properties and adsorption capacities of bamboo charcoals, which are manufactured from 4- to 6-year-old moso bamboo (*Phyllostachys pubescens*) planted in Taiwan. Bamboo charcoals obtained by one-, two- and three-step carbonization, the carbonization temperature of each step was 400–800 °C, 500–900 °C, and 1,000 °C, respectively. The basic properties of bamboo-specific charcoals including charcoal yield, ash content, pH, elemental compositions, surface area, and iodine number was also investigated. Furthermore, the removal efficiency of chemical oxygen demand (COD) using 15 kinds of bamboo charcoals adsorption was also examined. The BET surface area increased with increasing steps of carbonization. Bamboo charcoals by three-step carbonization had the highest surface area of 330.4–493.0 m2/g. At the liquid phase adsorption, the iodine number bamboo charcoals in this study could be increased over 600 mg/g, except for charcoals carbonized at 400 °C using one-step carbonization process that belonged to activated carbon grade. The iodine number of bamboo charcoals by three-step carbonization had the highest one and could be increased over 900 mg/g. Bamboo charcoals by three-step carbonization had the best removal efficiency of COD, being able to reach 54%.

Physical and rheological properties of logging slash. Oh, J.H., Kim, J.W. (*Korea Forest Research Institute, Republic of Korea; jhoh@forest.go.kr; jaewkim@forest.go.kr*), Cha, D.S. (*Kangwon National University, Republic of Korea; dscha@kangwon.ac.kr*).

Large volumes of forest biomass should be available from implementation of the forest tending and short-rotation reforestation program in Korea. However, the actual operations of harvesting, collecting, processing, and transporting loose forest residues are

costly and have an economic barrier to recovery and utilization of wood for energy. For many years, it has been understood that finding an effective method of densifying residues would be a key development to reduce the costs of biomass collection systems. This study was carried out as basic research to develop a logging slash densifying machine mounted on tractor. As a first step, this study investigated physical and rheological properties of logging slash for designing the densifying machine. Stress-strain behavior and stress relaxation for logging slash were analyzed using a simple Maxwell model. Physical and rheological properties of the logging slash were investigated by repeated compression and relaxation using UTM. As result, to densify the logging slash up to 450 kgf/cm3, about 4,000 kgf of compression force are required. With increasing number of times compression and relaxation were repeated for logging slash, relaxation rate was decreased.

Organosolv pretreatment with various catalysts for enhancing enzymatic hydrolysis of pitch pine (*Pinus rigida*). Park, N.H., Kim H.Y., Kim H.Y., Yeo H.Y., Choi J.W., Choi, I.G. (*Seoul National University, Republic of Korea; usiel05@snu.ac.kr; hjl7@snu.ac.kr; daegil2@snu.ac.kr; hyeo@snu.ac.kr; cjw@snu.ac.kr; cingyu@snu.ac.kr*).

Three different types of catalysts were evaluated for organosolv pretreatment with pitch pine. Sulfuric acid, magnesium chloride, and sodium hydroxide for acid, neutral, and base catalysts, respectively were used; ethanol was used for the organic solvent. The pretreatment process was conducted at different temperatures and times, and an enzymatic hydrolysis process was followed to estimate digestibility of biomass. Each catalyst was evaluated by digestibility, pretreated material yields, and H-factor, and compared to others at the condition which produces similar digestibility level. Digestibility of pitch pine by 1% sulfuric acid catalyzed pretreatment process at the optimal condition was approximately 55–60%, and that by 1% magnesium chloride was nearly 60%. A 1% sodium hydroxide catalyzed pretreatment had no effect on digestibility, at 10%, but the digestibility improved significantly, more than 80%, when concentration was increased from 1% to 2%. Pretreated material yield was the highest at magnesium catalyzed pretreatment, nearly 70%, and that of sulfuric acid and sodium hydroxide catalyzed pretreatment were comparatively low, at 60%. Lignin content did not decrease by sulfuric acid and magnesium catalyzed pretreatments, but sodium hydroxide-catalyzed pretreatment decomposed lignin in biomass effectively. Ethanol yield was highest from organosolv pretreatment with sulfuric acid and lowest with sodium hydroxide.

Curing kinetics of phenolic resin mdified by bio-oil. Ren, X., Chang, J., Gou, J., Si, H., Li, Q., Xu, S., He, W., Zhang, H. (*Beijing Forestry University, China; rxueyong@bjfu.edu.cn; cjianmin@bjfu.edu.cn; jinsheng@bjfu.edu.cn; sihui@bjfu.edu.cn; liqiang@bjfu.edu.cn; supershewa@163.com; hewenvictory@gmail.com; xiaozhang1234@126.com*).

Modifying phenolic resins with low-cost bio-oil can not only reduce its cost, but also improve its curing properties, which has good potential for development. The objective of this research is to compare the curing kinetics of standard phenolic resins (SPF) and phenolic resins modified by bio-oil (BPF). SPF and BPF were prepared in our lab, and bio-oil was produced from fast pyrolysis of larch bark in a spout-fluidized reactor at 520 °C. Differential thermal analysis (DTA) was performed to measure the thermal behavior of both resins. The Kissinger equation, Ozawa-Flynn-Wall equation, and Crane equation were used to calculate the curing kinetic parameters of both resins. Results showed that reaction order of the SPF and BPF were 0.95 and 0.92, the average activation energies were 118.74 kJ / mol and 83.67 kJ / mol, and pre-exponential factors were $1.5 \times 1012\ s^{-1}$, and $2.7 \times 107\ s^{-1}$, respectively. By analysing these kinetic parameters, it can be concluded that both reaction orders are close, which indicates that the reaction modes of SPF and BPF are basically the same in curing activities. Also the energy consumption of BPF is relatively lower than that of SPF during curing.

Gross calorific value of coniferous bark chips as boiler fuel, and their characterization in terms of elemental and chemical composition. Sekino, N., Kofujita, H. (*Iwate University, Japan; sekino@iwate-u.ac.jp; kofujita@iwate-u.ac.jp*).

Sugi (*Criptomeria japonica* D.Don), Akamatsu (*Pinus densiflora* Sieb. et Zucc.), and Karamatsu (*Larix leptolepis* Gordon) bark chips as boiler fuel were divided into outer bark, inner bark, and adjoining sapwood, and they were determined for gross calorific value. The gross calorific values without water were found to be significantly different among the three parts for each species. To investigate the reason for the differences, ash contents were measured. When the effect of ash content on calorific value was excluded, an obvious relationship that bark possesses calorific values greater than sapwood was obtained. Further investigations on the reason for calorific differences were conducted in terms of differences in elemental composition and chemical composition. Calorific values of each part were calculated by the use of elemental analysis results, and these values were compared with the ones experimentally measured. Correlation between the two clarified that the superiority of bark to wood in calorific value was derived from its larger carbon content and smaller oxygen content. From a chemical point of view, the superiority was explained by the fact that bark contains less carbohydrate than wood because carbohydrate was calculated to have the least calorific value of all chemical components of bark and wood.

Utilization of oil palm biomass as materials and energy resources. Tanaka, R. (*Forestry and Forest Products Research Institute, Japan; ryohei@affrc.go.jp*), Mori, Y. (*Japan International Research Center for Agricultural Sciences; ymori@affrc.go.jp*).

Oil palm is one of the most important and useful plants in Southeast Asian countries such as Malaysia and Indonesia, because of its oil production. There are various types of woody biomass from oil palm left after the oil processing, which have not been fully utilized so far. We have been carrying out several research works in collaboration with Malaysian research institutions to develop technologies for the utilization of these abundant biomass resources. One example is the production of pulps from oil palm empty fruit bunches (EFB). During the collaborative studies, several new technologies for producing various types of pulp have been developed for EFB, including environmentally friendly pulping and bleaching processes. Moreover, we have carried out research studies on composite board production from EFB and palm oil-based chemicals. Studies on the oil palm trunk have been also carried out to investigate the possibility for biomass energy resource. In this presentation, our achievements in research studies will be introduced and the possibility for further development will be discussed, which may lead to a healthy environment in the area with oil palm oil plantations and tropical forests.

Biomass production from Holm oak (*Quercus ilex*) open forests pruning in Spain: weight equations and harvesting productivity and cost. Tolosana, E., Ambrosio, Y., Laina, R., Martín, M. (*Madrid Polytechnic University, Spain; eduardo.tolosana@upm.es; yolanda.ambrosio@upm.es; ruben.laina@upm.es; marina.m.s.@hotmail.com*).

Chips production for energy was studied on different pruning types over *dehesa* Holm oak (*Quercus ilex*) Spanish open forests, whose main use is acorn production for cattle feeding, trying to evaluate biomass yield from branches, separating those with diameters greater than 10 cm, usually sold as firewood, and the smaller ones, usually left piled on the terrain, to estimate productivity and cost of obtaining chips and to characterize their quality from these branches types. Five different forest strata were studied in 2008, getting green and dry weight equations for total and small branches. Pruning, biomass hauling off with forwarders, and chipping with drum chippers were time-studied. Biomass yield ranked from 12.0 to 21.7 green tons per hectare for fine branches fraction, up to 31.3 for small and large branches together, with 30 to 40% moisture-humid basis. Direct cost of chips at landing without including the pruning operation cost, as long as it must be performed anyway, varied between 31,5 €/gt for small and large branches together and 38 €/gt for small branches only. Final supply costs, without considering stumpage price, for a 50-km transport distance, varied from 48.5 to 57.2 €/best quality chips green tone.

Biomass and firewood harvesting from holm oak (*Quercus pyrenaica*) coppice thinning: weight equations and harvesting productivity and cost. Tolosana, E., Ambrosio, Y., Laina, R., Martínez-Ferrari, R., Martín, M. (*Madrid Polytechnic University, Spain; eduardo.tolosana@upm.es; yolanda.ambrosio@upm.es; ruben.laina@upm.es; rociomartinezferrari@hotmail.com; marina.m.s.@hotmail.com*).

Chip and firewood harvesting was studied on thinning of *Quercus pyrenaica* coppices in northwestern Spain, to evaluate biomass from whole trees and stems and to estimate harvesting productivity and cost using different systems. These included whole-tree mechanized felling, piling, forwarding and chipping, on the one hand; and motor-manual or mechanized felling and processing followed by forwarding of firewood (2.4 m logs), on the other hand. Seven forest sites with different dbh and slopes were studied from 2006 to 2008. Green/dry weight equations for stem and whole tree biomass were fitted. Software designed by the authors was used, and some productivity equations were developed. For 10-cm dbh and 50-km transport distance, whole tree chip's final supply cost was estimated as 38.1 €/green tone for best quality chips without stumpage price. Felling and processing cost of firewood using chainsaw and forest harvester were compared. The mechanized cost equals only for the motor-manual one with the wood dbh greater than 9 cm. Also without stumpage price and for 50-km transport distance, the supply cost of firewood is ranked from 62.5 (using a chainsaw) to 35.0 (using a harvester) €/ green tone of firewood, corresponding to dbh of 6.1 and 9.8 cm, respectively.

A study of pyrolysis of bio-oil based wood adhesives in OSB. Xu, S., Chang, J., Gou, J., Huang, Y., Zhang, L., Han, Y. (*Beijing Forestry University, China; supershewa@163.com; cjianmin@bjfu.edu.cn; jinsheng.gou@gmail.com; annabelleyu@163.com; zhanglita@gmail.com; hyx.m.s@163.com*).

The bio-oil produced from fast pyrolysis of biomass has been investigated as a renewable fuel and a source of industrial chemicals. The bio-oil product has the considerable advantage of being a storable and transportable fuel as well as a potential source of valuable chemicals that have a much higher added value than fuels. Using bio-oil as phenol replacement in phenol-formaldehyde resins is one of the most promising directions. In this study, bio-oil was used to replace part (35%, 45%, and 55% by weight) of the phenol in phenol-formaldehyde (PF) resin formulations. Some parameters (e.g., F/P and NaOH/P molar ratios) were investigated in developing the new type of adhesive. These preliminary results showed that under commercial board manufacturing conditions (e.g., 2.5 wt. % resin content; oven dry wood basis, etc.), the mechanical properties (modulus of rupture, modulus of elasticity, and internal bond) and thickness swelling of boards using homogeneous resins (phenol replacement) exceeded minimum requirements set by GB/T 4897–2003 test. It was concluded that bio-oil can replace up to 45% of phenol in PF surface resin formulation for OSB. Post-treatment (2 hr at 150 °C in the oven) significantly improved the internal bond strength and thickness swelling of the board.

A fundamental study of production of "hyper wood pellets": effects of heat treatment conditions on pellet fuel properties. Yoshida, T., Sano, T. (*Forestry Forest Products Research Institute, Japan; tyoshid@ffpri.affrc.go.jp; tsano@affrc.go.jp)*, Nomura, T., Gensai, H. (*Fukui Prefectural Green Center, Japan; takashinomura@fklab.fukui.fukui.jp; hgensai@fklab.fukui.fukui.jp*), Ohara, S. (*Forestry Forest Products Research Institute, Japan; oharas@ffpri.affrc.go.jp*).

Wood pellets have advantages of higher energy density, constant caloric value, and easy handling (round shape) compared to wood chips. However there are several disadvantages of wood pellets—much lower caloric value than fossil fuels like kerosene, difficulty in producing pellets with good qualities from hardwood and forest residues, weakness in water, and so on. To improve such disadvantages, we are developing "hyper wood pellet" by implementation of mild heat treatment. The wood chip or conventional wood pellet was subjected to heat-treatment around 250–300 °C under inert atmosphere. Then the heat-treated wood chip was pelletized by a conventional wood pelletizer. The caloric value of "hyper wood pellet" can be upgraded with no significant weight loss. In addition, hydrophobic properties can be also improved by dehydration of wood during heat treatment. In this study, Japanese cedar (*Cryptomeria japonica*) chips and its pellets were used as raw materials, and then heat treatment was conducted under different temperature conditions. In the workshop, effects of heat treatment condition on the hyper wood pellet properties such as caloric value and elemental composition will be discussed.

Isolation and purification of hemicelluloses from alkali pre-extract for their value-added utilization. Youn, H.J., Shin, H.N., Sim, K.J., Lee, H.L. (*Seoul National University, Republic of Korea; page94@snu.ac.kr; heenaisn@naver.com; blaze86@snu.ac.kr; lhakl@snu.ac.kr*).

Hemicelluloses, which are polysaccharides of C5 and C6 sugars, are very useful natural materials. Despite their usefulness, a considerable amount of hemicelluloses burn out in a boiler in kraft pulping processes. Therefore, pre-extraction and isolation of hemicelluloses from wood is necessary for further utilization as value-added products. The goal of this study was to isolate hemicelluloses from alkali pre-extract as pure as possible. We pre-extracted hemicelluloses from mixed hardwood chips using

sodium hydroxide solution prior to kraft pulping, and we isolated hemicelluloses from pre-extractives by precipitation with using organic solvents such as 1,4-dioxane, ethanol, and isopropanol. We evaluated the isolation performance by analyzing the characteristics of isolated hemicelluloses, and compared it with the results of hot water pre-extract. About 26% of the hemicelluloses were extracted from the initial wood chips through alkaline pre-extraction in this experiment. The isolation yield was higher for alkali pre-extract than hot water pre-extract for all kinds of solvents. Most precipitates were yellow colored, except hot water precipitate using 1,4-dioxane. The magnitude and purity of isolated hemicelluloses were affected by solvent types.

Effect of various reaction parameters on molecular weight and polydispersity in bamboo powder liquefaction with polyhydric alcohols. Zhang, J., Du, M., Wang, J. (*CAF, China; jinpingzhang@126.com; xiaoduchongcn@yahoo.com.cn; wjw40@tom.com*).

Molecular weight and its distribution have remarkable effects on properties of the product liquefied from bamboo powder. To determine the effects of the reaction condition on molecular weight of liquefied product of bamboo powder, a single factor experiment was conducted with polyalcohol and glycerin as liquefier and sulphuric acid as catalyst. The factors were sulphuric acid concentration, ratio of liquid to solid, reaction temperature, and reaction duration, each with five levels. The weight-average molecular weight (MW) and polydispersity of the copolymer decreased with increased concentration of sulphuric acid until sulphuric acid concentration reached 4%, where MW and polydispersity began to rise. As the ratio of liquid to solid increased, MW and polydispersity decreased continuously. MW and polydispersity decreased when the reaction temperature increased from 130 °C to 150 °C and then increased till the temperature reached 170 °C. MW and polydispersity decreased when the reaction duration increased from 15 min to 60 min, and increased a little until the reaction duration reached 140 min, implying that degradation reaction dominated at the initial stage and polymerization reaction dominated at the ending stage of bamboo powder liquefaction.

The utilization of modified hemicelluloses extracted from the pulping process in papermaking as natural dry strength additives. Zhu, H. (*Guangxi University, China; zhx747@gmail.com*), Lee, S.H. (*Seoul National University, Republic of Korea; gotz97@hanmail.net*), Lee, H.L., Youn, H.J. (*Seoul National University, Republic of Korea; lhakl@snu.ac.kr; page94@snu.ac.kr*).

The characteristics of cationic hemicellulose additives affect their efficiency in improving fiber bonding. In this work, the influence the charge density and molecular weight, Mw of cationic hemicellulose in improving the strength of papers was investigated at the equilibrium level of cationic hemicellulose adsorption. Even though native hemicellulose improved the physical properties, paper treated with cationic hemicellulose exhibited an increase in physical properties such as tensile strength and internal bond over those of unmodified hemicellulose. At the saturation level of adsorption, fiber bonding improvement was influenced by the total charges introduced on fibers, which affect the fiber chemistry, and also the charge density of cationic hemicellulose, which affects the configuration of cationic hemicellulose adsorbed on the fiber surface. From these results, modifying fibers with the cationic hemicellulose method is a new environmentally friendly biomass treatment that will save pulp resources and effectively increase the strength of paper.

E-04 Integrating engineered biocomposites from wood and other bio-based materials to promote sustainability

Organizers: Marius Barbu, *Transilvania University of Brasov, Romania; marcat@gmx.at;* Salim Hiziroglu, *Oklahoma State University, USA; salim.hiziroglu@okstate.edu.*

Development of hydroxyapatite-wood composites by reusing of wood ashes. Akaki, T. (*Miyazaki Prefectural Wood Utilization Research Center, Japan; pakakiqw@yahoo.co.jp*).

Wood ashes produced by combustion in wood-fired biomass plants are a major problem with environmental regulations, and the problems related to the disposal of wood ashes provide a motivation to develop new solid waste utilizing methods. The aim of this work was to synthesize microcrystalline hydroxyapatite (HAp) from wood ashes and stabilize them within wood. HAp is a well-known eco-friendly biomaterial widely used for industrial applications and has useful properties such as fire resistance and formaldehyde absorbance. Therefore the HAp-wood composites would have those practical functions. In order for a HAp generation to be effective within wood, the calcium hydrogen phosphate dihydrate solution was first prepared by the addition of phosphoric acid into wood ash suspension, and then wood specimens were prepared and soaked into the solution. After the penetration and drying, the HAp generation was confirmed within the woods by using of reflection electron imaging and powdered X-ray diffraction analysis. Through the above treatment, no striking discoloration of the wood specimens was observed. After the leaching operation of the HAp-wood composites, the mass increase of them was evaluated 3.1–3.5% compared with those of the woods before the treatment with HAp.

The use of coconut husk in HPL production. Barbu, M. (*Transylvania University of Brasov, Romania; marcat@gmx.at*), Glowacki, R. (*Glunz AG, Germany; romann.glowacki@glunz.de*), Van Wijck, J. (*Trespa International B.V., the Netherlands; J.van.Wijck@trespa.com*).

Coconut-husk-based boards for exterior use are already produced at industrial level. The cooperation partners for this Dutch-German research investigated possibilities of applying coconut husk in the fibreboard dry production process. The goal of the trials was to reduce the amount of PF-resin in highly water-resistant fiberboards, similar to high pressure laminates (HPL). Fundamental information about the curing reactions of lignin and actual research results are described, followed by facts and analyses concerning coconut husk and its properties. The milling process of coconut husk was analysed and carried out at industrial scale. Based on these results, recommendations are given on the storage, transportation, and preparation of coconut husks before further processing. The main process steps cover preparation of the raw material including application of resin, forming, and pressing the boards; their influences on the performance concerning mechanical strengths and water resistance after

a 2-h boiling test were analysed. Finally, experimental HPL boards were manufactured and tested based on the EN 438 standards. Different particles size of coconut husk and blending ratio to wood fibers were chosen. Their influence on mechanical and physical properties of HPL was investigated and compared. The results showed different and partially contrary trends.

On the suitability of an Asian bamboo for structurally oriented boards. Barbu, M. (*Transylvania University of Brasov, Romania; marcat@gmx.at*), Malanit P. (*Walailak University, China-Taipei; mpannipa@hotmail.com*), Frühwald, A. (*University of Hamburg, Germany; arno.fruehwald@vti.bund.de*).

The use of bamboo for products has a long tradition at the level of craftsmanship, but industrial based products still have not gained a real breakthrough. A Thailand-German-university-project investigated the technological potential of *Dendrocalamus asper* for manufacturing of structural lumber for building elements. As a lead product, oriented structural lumber (OSL) was selected to investigate the potential. Anatomical, chemical, and physical/technological properties of the material were tested, including the distribution of properties along the axis of the culm and the wall thickness. Strands were produced and their dimensions/quality evaluated against strands from traditional wood species. The gluing behavior of bamboo strands was investigated, using the ABES-system while using all the relevant glue types for wood based panels used for structural applications. The gluing tests in general showed acceptable results but for some glue types a more clear insight is necessary to increase bond quality towards the level of "normal wood." The properties of the boards produced in the laboratory in Hamburg are close to the requirements to the type OSB 3 according to CEN-EN 300 and OSL and to ASTM D standards. We conclude that further improvements will lead to a concept of using bamboo to manufacture OSL/OSB-type structural products.

Wood composites from wheat straw: challenges and opportunities. Bekhta, P. (*National University of Forestry and Wood Technology of Ukraine, Ukraine; bekhta@ukr.net*), Hiziroglu, S. (*Oklahoma State University, USA; salim.hiziroglu@okstate.edu*).

Consumption of wood composites increases approximately 4 percent annually in the world. Although wood remains a traditional raw material for manufacturing, agricultural resources such as wheat straw are becoming popular to produce composite panels with the objective of sustainable forest management. Cereal straw as an annually renewable fiber is one of the most important agricultural residues because of its abundant availability in many countries. The worldwide annual production of cereal straw is estimated at 1.5 billion tons. This study will review utilization of wheat straw in manufacturing of various types of wood composites, and the main advantages and disadvantages of wheat straw over solid wood and other non-wood species. Physical and mechanical properties including bending strength, internal bonding strength, dimensional stability, and density profiles of experimental particleboard panels made from wheat straw will be compared to those made from different wood species. Past and current technologies developed to use wheat straw as raw material in wood composite industry will also presented. Finally, the future of wheat straw as raw material in wood composite industry will be projected.

Herbaceous plants as alternative lignocellulose material in UF resinated particleboards. Dukarska, D., Czarnecki, R., Dziurka, D. (*Poznań University of Life Sciences, Poland*; *ddukar@up.poznan.pl; rczarnec@up.poznan.pl; ddziurka@up.poznan.pl*).

Seasonality of harvest of most annual plants hinders considerably their application as lignocellulose materials alternative to wood in particleboard production. The study investigated the use of waste of annual plants—evening primrose (*Oenothera paradoxa Hudziok*) and white mustard (*Sinapis alba*)—as wood chip substitutes. These plants are harvested at the turn of September and October, that is, outside the primary harvest season in moderate climates. These plants, in contrast to cereal straw, have no hydrophobic wax layer on stem surface, facilitating application of condensation adhesives traditionally used in wood-based material industry. The effect of wood chip substitution in the core layer with evening primrose and mustard particles on properties of particleboards resinated with UF resin was investigated. The substitution range was 0–100%. Boards were tested according to respective standards for their bending strength and modulus of elasticity, internal bond, swelling in thickness, and absorbability after 24 h, and free formaldehyde content in the perforator test. Tests showed that evening primrose and white mustard particles may constitute a valuable wood chip substitute in the production of general purpose particleboards. At an adequate degree of substitution with such wastes, boards meet respective technical standards.

Properties, applications, and markets for oriented structural straw board. Han, G. (*Northeast Forestry University, China; guangpingh@hotmail.com*), Leendertse, K. (*Panel Board Holding BV, the Netherlands; krijn.leendertse@panelboardholding.com*), Wasylciw, W. (*Alberta Research Council, Canada; Wayne.Wasylciw@arc.ab.ca*).

Efforts have been made to manufacture non-structural straw panels with mixed degrees of success in past. Raw material and binder costs as well as technical challenges have hampered commercial viability of such production. More attractive areas for straw-based panels would be considered to target the structural panel market. Making straw-based oriented strand board has proven to be a daunting task. However, creating an "open" strand, or split tubule, with any degree of length is difficult but a necessary task to produce structural panels from straw. In comparison, tensile strength of straw perpendicular to the tubule is very low; consequently, straw is susceptible to shear either longitudinally or through the cross-section of the tubule. In this study, a whole range of panel production strategies were attempted to ascertain the limits to which structural panels from split straw could be applied. Straw length, panel resin content, and panel density were different variables used in this study to quantify oriented structural straw board (OSSB) performance. OSSB has recently been proposed for use in China as building materials. The applications of OSSB will open a new era in building products. This paper will outline the properties of OSSB panels and its application in China.

The state-of-the-art of biocomposites made of natural fiber reinforcements and polymer matrices. Han, S.O. (*Korea Institute of Energy Research, Republic of Korea; sohan@kier.re.kr*).

This presentation will give an overview of ongoing research and development on biocomposite products. In general biocomposite consists of natural fiber reinforcement and polymer matrix that can be used as an alternative to glass fiber reinforced polymer composite. Currently, biocomposites are used in the manufacture of different members of the automobile worldwide because of its excellent strength and stiffness properties. Natural fibers as reinforcements of biocomposites offer several advantages compared to

the glass fiber reinforcement of polymer composites. They are non-abrasive to processing equipment, CO_2 neutral, and perform well as acoustic and thermal insulators because of their hollow and cellular nature. The hollow tubular structure also reduces their bulk density, making them lightweight and resulting in energy saving for automobiles. Also, the worldwide research on biocomposite leads to nano-bio hybrid composites because the incorporation of nano materials into polymer composites can improve mechanical, thermal, and also barrier properties. The state-of-the-art of biocomposites will be introduced in terms of development of green materials for one of the solutions for growing global environmental awareness, high rate of depletion of petroleum resources, concepts of sustainability, and new environmental regulations.

Engineered composite panels from under-utilized species and agricultural resources. Hiziroglu, S. (*Oklahoma State University, USA; salim.hiziroglu@okstate.edu.*), Wu, Q. (*Louisiana State University, USA; wuqing@lsu.edu*).

This study presents some of the findings of various past and ongoing projects related to manufacture of engineered composite panels from under-utilized wood and non-wood species including eastern redcedar (*Juniperus virginiana* L), osage orange (*Maclura pomifera*), eucalyptus (*Eucalyptus camaldulensis*), bamboo (*Dendrocalamus asper*), and rice straw (*Oryza sativa*). Experimental particleboard, fiberboard, and strandboard panels were manufactured from such species. Physical and mechanical properties of experimental panels were evaluated. Average values of modulus of elasticity and modulus of rupture of eastern redcedar particleboard samples were determined as 1,752 MPa and 12.86 MPa, respectively. In the case of particleboard panels made from eucalyptus and bamboo, modulus of elasticity of the samples were 1,860 MPa and 2,424 MPa. Most of the properties of both the particleboard and fiberboard samples made with addition of rice straw in bamboo material were adversely influenced. Overall properties of strandboard panels made from eastern redcedar were acceptable and comparable to the results of those of past studies that used other species to produce a similar type of product. It appears that under-utilized species presented in this study have potential as raw material to manufacture different types of engineered wood composite panels with an environmentally friendly approach.

Investigation of flexural properties of cellulose film-faced and balsa-cored sandwich panels. Hüsnü, Y. (*Artvin Coruh University, Turkey; yel33@hotmail.com*), Wolfgang, G. (*University of Natural Resources and Applied Life Sciences, Austria; wolfgang.gindl@boku.ac.at*), Hülya, K. (*Karadeniz Technical University, Turkey; khulya@ktu.edu.tr*).

The objective of this study was to produce biodegradable and high strength-to-weight-ratio sandwich panels using cellulose films on balsa wood. Cellulose films were prepared by dissolving lyocell fibers in LiCl/*N*,*N*-Dimethylacetamide solvent and subsequently coagulating and drying them under ambient conditions. Some of the films produced were uniaxially drawn under rewetted conditions to 1.5 draw ratios. Balsa sheets were coated by the undrawn or drawn cellulose films by using polyvinylacetat (PVAc), biodegradable glue. Two type thicknesses and density levels of balsa sheets were used. According to wood fibre direction, films were glued on the sheets in five different angles. Flexural properties were characterized by using bending test. Bending properties, MOE, and MOR values of sandwich-type samples coated by the drawn films at 0 degree to fibre direction were twice higher than those of balsa sheets and 1.5 times higher than those of undrawn films-coated balsa sheets. Values at 90° to fibre direction were five times higher than those of balsa sheets. For 0.11 mm cellulose film, best values were found in samples with 4-mm-thickness balsa core. Furthermore based on all raw material and manufacturing parameters, including the glue type, lightweight sandwich samples produced in this study were found to be biodegradable.

Production of plastic-bonded panels from waste materials. Kehinde, A. (*Forestry Research Institute of Nigeria, Nigeria; sesan_toy@yahoo.com*), Babatunde, A. (*Federal University of Technology, Nigeria; babatundeajayi2000@yahoo.com*).

Wood-plastic panels 10 mm in thickness were produced from coffee chaff wastes with high density polyethylene (HDPE) pellets and recycled low density polyethylene (LDPE) plastic binder. Panels were produced at three levels of mixing ratio (1:1, 2:1, and 3:1), and three levels of board density (500 kg/m^3, 600 kg/m^3, and 700 kg/m^3), given 9 treatment combinations for each plastic binder respectively. The strength and physical properties of the boards, namely modulus of rupture (MOR), modulus of elasticity (MOE), water absorption (WA), and thickness swelling (TS) were investigated to examine the effects of production variables on the panel products. As the mixing ratio (MR) and board density (BD) increased, MOE and MOR increased, whereas TS and WA decreased. This shows that the higher the board density and plastic/coffee-chaff ratio, the stronger, stiffer, and more dimensionally stable the panels. Panels produced at the highest level of MR and BD exhibit highest resistance to bending and dimensional movement. The MR and BD have significant effect on the properties under investigation. Study shows that coffee and plastic are suitable for production of plastic-bonded panels and as a base line strategy for research efforts in sourcing and utilization of alternative raw-materials for value added panel production.

Some properties of polyethylene bonded rice husk composite panels. Lee, S.H. (*University of Tokyo, Republic of Korea; mokuzo118@gmail.com;*), Ando, N. (*University of Tokyo, Japan; andon@mail.ecc.u-tokyo.co.jp*).

Experimental composite panels were manufactured from rice husk by using three types of thermoplastic adhesives in the form of polyethylene powder. Rice husk was grounded and classified into three particle sizes: original size, below 2 mm, and below 1 mm on a screen. Carton pack, corrugated papers, and thick papers were also added on bottom face layer of the panels to enhance their mechanical properties. Based on the findings from the experiments, modulus of elasticity (MOE) and modulus of rupture (MOR) of the samples increased as the amount of polyethylene powders was increased from 20% to 25% and 30%. However, such properties of the panels decreased with increasing particle size. Samples having paper fiber layers on their bottom face resulted in better strength properties than those of without backing. Panels made from fine particles had improved dimensional stability in terms of their thickness swelling. It appears that panels manufactured from rice husk without using any formaldehyde-based adhesives may have potential in the composite panel industry, not only having satisfactory mechanical properties but also avoiding any adverse effects on the environment due to formaldehyde emissions.

Properties of molded products from *Acacia mangium* bark and malic acid. Munawar, S. (*Indonesian Institute of Science, Indonesia; sasasofyanm@yahoo.com*), Kawai S., Umemura K. (*Kyoto University, Japan; skawai@rish.kyoto-u.ac.jp; umemura@rish.kyoto-u.ac.jp*).

Molded products made from *Acacia mangium* bark flour and malic acid was manufactured. *A. mangium* bark (Ab) and malic acid (Ma) with sizes of 90–150 m were vacuum-oven dried at 50 °C for 15 hr. Ab and Ma were mixed in weight ratio of 2:1 (2AbMa), 1:1 (AbMa) and 1:2 (Ab2Ma). About 15 g of Ab and Ma mixture was put into a stainless steel cylindrical die (70 mm inner diameter) and hot-pressed at a temperature of 180 °C and a pressure of 4 MPa for 5, 10, and 15 minutes. For comparison, molded products made from Ab only were prepared. Specimens were conditioned at a temperature of 20 °C and 65% relative humidity for 1 week, prior to boiling treatment for 4 h and a three-point bending test. Water resistance and bending properties of molded products were improved by adding malic acid. 2AbMa molded products showed good values in water resistance and bending properties according to the JIS standards for wood-plastic recycle composites. Therefore, malic acid seems to be a promising substitute for binder in producing of molded products, perhaps due to the carboxylic acid groups in the malic acid moieties that get bound to the hydroxyl group on the bark.

Physical and mechanical properties of particleboard panels made from wood industry waste. Nuryawan, A., Azhar, I., Situmorang, R. (*University of North Sumatera, Indonesia; arifnury@yahoo.com; irfari@yahoo.com; sonrim1_strg@yahoo.com*).

Sawdust from sawmill waste was used as raw material to manufacture isocyanate-bonded particleboard panels. Four different treatments were evaluated—control, samples soaked in cold water for 48 hours, samples soaked in hot water for 3 hours, and samples soaked in flowing water for 3 hours. Average target density of panels was 0.80 g/ cm^3. Resin content based on oven-dry particle weight for the experimental panels was 8%. Samples were pressed at 25 kg/cm^2 pressure for 10 minutes at 140 °C. Results showed that physical properties of samples (density, moisture content, and thickness swelling) met Indonesian standards (SNI 2105-03-2006). Water absorption values of the samples ranged from 5.71 to 10.72% for 2 hours, and from 15.06 to 23.24% for 24-hour exposure times. Mechanical properties, wet MOR, internal bond, and screw holding strength also met the Indonesian standard (SNI 2105-03-2006). These results suggest that such particleboard panels could be suitable for sheathing or door manufacture. However, dry MOR and MOE of the samples failed. It can be concluded that such particleboard panels are suitable to be used for constructional purposes. Based on statistical analysis the quality of particleboard without soaking showed better properties than those of than tested after soaked in water.

Properties of particleboard panels produced from agricultural residues. Okai, R. (*University of Education, Ghana; reynoldsokai@yahoo.co.uk*).

Agricultural residues such as corn stalk (*Zea mays*) and sugar cane bagasse (*Saccharum officinarum*) are usually burned on farms with their inherent pollution of the environment and reduction of soil nutrients. This study examined the potential of utilization of agricultural residues as supplements for wood-based particleboards manufacture. Particleboard panels were produced from agricultural residues such as corn stalk, elephant grass, empty fruit bunch of the oil palm, and sugar cane bagasse using industrial standards. A three-point static bending test was used to determine strength properties of the samples compared to those of panels manufactured of 100% wood particles Experimental results indicated that samples made from all the three agricultural-bases had higher modulus of elasticity (MOE) than the wood-based medium density particleboards, with the exception of the empty fruit bunch of the oil palm. It was also found that overall modulus of rupture of the samples made from agricultural raw material was 8.8 N/mm^2 which is about twice of the MOR of the wood-based particleboards (3.71 N/mm^2). Based on statistical analysis there were no significant differences in the MOR values of the panels made from agricultural-based panels and the wood-based panels.

Utilization of waste wood as raw material to manufacture structural composite products. Shibusawa, T., Miyamoto, K. (*Forestry and Forest Products Research Institute, Japan; t_shibusawa@ffpri.affrc.go.jp; mkohta@ffpri.affrc.go.jp*), Alpár, T.L. (*University of West Hungary, Hungary; atibor@fmk.nyme.hu*), Korai, H., Hatano, Y. (*Forestry and Forest Products Research Institute, Japan; korai@ffpri.affrc.go.jp; hatano@ffpri.affrc.go.jp*).

Recycling of waste wood from demolition sites is very important issue and is mandated under the Construction Material Recycling Law in Japan. This law encourages the utilization of waste wood as raw material for manufacturing of various types of wood-based panels. This study reviews some basic aspects of important issues including the current status of waste wood and some factors that need to be taken into consideration to have an efficient recycling program to use such resources effectively in the form of value-added panel products. Classifications as well as eliminating methods of undesired materials such as nails and other metals from the waste wood were analyzed. Efficiency of using steam and hydrolysis techniques to delete adhesives in the waste wood was investigated. Also structural products, oriented strand lumber from waste wood from the housing construction, were manufactured and their properties were examined. As a result, the performance of oriented strand lumber having a density of 740 kg/m^3 was equal to that of structural solid lumber, and there was little fluctuation in its physical properties. Based on these findings, it appears that recycled waste wood could have potential as raw material to manufacture structural composite products with acceptable properties.

Improvement of adhesion properties of chitosan by glucose addition. Umemura, K. (*Kyoto University, Japan; umemura@rish.kyoto-u.ac.jp*), Mihara, A. (*Kurabo Industry Ltd., Japan; Ayako_Mihara@kurabo.co.jp*), Kawai, S. (*Kyoto University, Japan; skawai@rish.kyoto-u.ac.jp*).

The utilization of synthetic resin adhesives derived from fossil resources will be inhibited in the future due to the decrease of fossil resources. The development of natural adhesives derived from renewable sources is an important research subject. Chitosan is considered a promising biomass resource, and can be used as a wood adhesive. In this study, the effects of glucose addition on the resultant chitosan films and the bonding properties of chitosan were investigated. In film preparation, chitosan and glucose were dissolved in 1% acetic acid, and were dried at 50 °C. The bonding properties of the glucose-added chitosan in three-ply plywood were evaluated by using tensile shear test. As for film properties, the weight, color, free amino group, insoluble material, and tensile strength of the samples changed significantly as the addition amount of glucose was increased. The dry- and wet-bond strengths enhanced with increasing glucose addition. The good bonding strength was maintained even in 1% acetic acid solution. It was thus clarified that the bonding properties of chitosan were improved remarkably by the environmentally safe method of glucose addition.

Effect of oil palm particles on oriented strand board properties. Wan Andul Rahman, W.M.N., Jamaludin K. (*Universiti Teknologi MARA, Malaysia; wmdnazri@pahang.uitm.edu.my*).

The use of fast-growing species (such as the sentang tree, *Azadirachta excelsa*) and agriculture wastes (such as oil palm trunks) are considered both environmentally friendly and economical for production of wood composites. The objective of this study was to evaluate the potential of using oil palm particles from oil palm trunk as a raw material with sentang wood to produce oriented strand board under laboratory conditions. Board quality was evaluated by determining bending properties, including modulus of elasticity (MOE), modulus of rupture (MOR), internal bond (IB) strength, and thickness swelling (TS). Generally the mechanical strength of the samples increased with increasing of board density and decreased with higher percentage of oil palm particle. All mechanical properties of the panels met the minimum requirements of standard EN 300 OSB/1. Thickness swelling increased with increasing board density and percentage of oil palm particle but still below the maximum requirement of 25% for all board treatments except for treatments from with 50% oil palm particle. It appears that treatment with 30% oil palm particle and 70% sentang wood with board density of 700 kg/m^3 has a potential to manufacture OSB panels with acceptable properties.

Phenolic foam preparation from liquefied product of phenolated bamboo powder. Zhang, J., Du D., Wang, J. (*Chinese Academy of Forestry, China; jinpingzhang@126.com; xiaoduchongcn@yahoo.com.cn; wjw40@tom.com*).

Phenolic foam plastic, environment friendly and biodegradable, can be prepared by bamboo powder through thermochemical liquefaction. Bamboo powder was liquefied with phenol with sulfuric acid as catalyst and the liquefied product was used as a bonding agent for preparing phenolic foam plastic. The liquefaction conditions include mass ratio of 3:1 for phenol to bamboo powder, sulfuric acid concentration of 3%, reaction temperature of 140 °C and reaction duration of 120 min. The resinfication conditions include molar ratios of 0.5 for NaOH to liquefied product, 0.5 for HCHO to phenol, 8 for H_2O to Phenol, reaction temperature of 70 °C and reaction duration of 90 min. The effects of foaming agent (n-pentane), surface active agent (tween 80) and curing agent (p-toluenesulfonic acid) as well as phosphoric acid and foaming temperature on the property of the samples were determined. It was found that curing and foaming were synchronized when tween 80 was 4–8% of the resin in mass, p-toluenesulfonic acid 12–20%, phosphoric acid 12–24%, n-pentane 10–16%, and with foaming temperature at 70 °C. The foam materials, prepared from bamboo powder, has a density between 22.4 and 68 kg/m^3, and compressive strength ranging from 3.2 to 55 N/cm^2.

Posters

Mechanical properties and durability performance of cement bonded particleboard made from *Leucaena leucocephala* wood particles. Ab.Rahman, M., M.Saman H., M.Ridzuan A. (*Universiti Teknologi MARA, Malaysia; marzukiar@pahang.uitm.edu.my; hamid922@salam.uitm.edu.my; ruslanridzuan@yahoo.co.uk*), Sudin, R. (*Forest Research Institute of Malaysia, Malaysia; rahims@frim.gov.my*), W.A. Rahman, W. (*Universiti Teknologi MARA, Malaysia; wmdnazri@pahang.uitm.edu.my*).

A study was carried out to explore the potential use of *Leucaena leucocephala* (*LL*) and durability of cement-bonded particleboard (CBP) after exposure to external shading (free from direct sunlight and raining) and without shading (direct to natural weathering) conditions prevalent in Malaysia for producing wood-cement composite as a building material. The three-layered CBP boards were manufactured in the laboratory using 16-year-old *LL* species at wood-to-cement ratio of 1:2.0. Boards were made to target density of 1,300 kg/m^3. All boards were made using combination of aluminium sulphate and sodium silicate. The effects of exposure duration and condition on modulus of rupture (MOR), modulus of elasticity (MOE), and internal bond (IB) were evaluated at 30, 60, 120, and 300 days. The results showed that the MOR, MOE, and IB values at different duration and exposure were significantly different. From this study, *LL* proved to be suitable for the manufacture of CBP for external exposure.

Cement-bonded wood shavings earth bricks in core housing delivery for low-income public servants in Nigeria. Babatunde, A., Abraham T. (*Federal University of Technology, Nigeria; babatundeajayi2000@yahoo.com; abraham_taiwo@yahoo.com*).

There is inadequate low-cost housing in urban and rural centres in qualitative and quantitative terms in Nigeria. The efforts made by the government to deliver decent housing massively have hitherto not achieved significant success. This study looks into alternative and affordable building materials for construction of low-cost houses particularly for low-income public servants. Homogeneous cement-bonded stabilized earth bricks were made from 5% wood shavings and 5% cement stabilizer by weight. They were thoroughly mixed together in order to avoid the formation of wood shavings/cement stabilizer lumps. The mixture was manually poured inside wooden formworks measuring 240 mm × 150 mm. After 28 days of casting, the compressive strength, abrasion, and water absorption of the earth bricks were examined with the aim of determining their effects on strength properties and dimensional stability. The study revealed average compressive strength of 2.9 N/mm^2, abrasion action of 2.6 mm depth, and water absorption of 16.1%. The study proposed that the cement-bonded wood shavings stabilized earth bricks can be used in construction of core houses for low-income public servants in Nigeria.

Effects of continuous press speed on thickness swell, water absorption, and vertical density profile of medium density fiberboard panels. Candan, Z., Akbulut, T. (*Istanbul University, Turkey; zekic@istanbul.edu.tr; takbulut@istanbul.edu.tr*), Hiziroglu, S. (*Oklahoma State University, USA; salim.hiziroglu@okstate.edu*).

Density distribution in the direction of thickness in wood based composites is called vertical density profile (VDP), which is one of the most effective panel attributes. Thickness swell (TS) and water absorption (WA) are important performance properties of the composites. TS, WA, and VDP characteristics of medium density fiberboard (MDF) panels in relation to continuous press speed were examined in this study. The MDF panels used in this study were produced using a commercial continuous press (Siempelkamp) line at Kastamonu Integrated Wood Industry and Trade Inc. located in Kocaeli, Turkey. Totally nine panels bonded with urea formaldehyde were produced using various press speed. They were performed for VDP, TS, and WA tests. The VDPs of the panels were obtained by an X-ray density profiler (GreCon Measurement Systems, Germany). Results showed that the VDP was influenced by continuous press speed. Reduced press speed generated an enhanced peak density (PD), which is a

characteristic of VDP. The TS and WA values obtained after 2-h and 24-h water soaking period decreased with decreasing press speed, which caused densification on the surface layers of the panels. Continuous press speed might be used to obtain improved TS and WA in the panel production.

Investigation of the strength and dimensional stability of wood plastic composites produced from *Ceiba pentandra* sawdust. Dare-Abel, L., Adelusi, E., Ajayi, B., Aruwajoye, A. (*Federal University of Technology, Akure, Nigeria; abiodunsoye@yahoo.com; adelusi_ade@yahoo.com; babatundeajayi2000@yahoo.com; angelicbimng@yahoo.com*).

Wood plastic composite boards 6 mm in thickness were produced using low density polyethylene (LDPE) and *Ceiba pentandra* sawdust made up of fine and coarse particles. Boards were manufactured at three levels of board density (500 kg/m3, 600 kg/m3, and 700 kg/m3) and three mixing ratio levels (1:1, 2:1, and 3:1) (a measure of LDPE in boards), giving 18 treatment combinations. The modulus of rupture, modulus of elasticity, thickness swelling, and water absorption properties of the boards were determined to find the effects of the particle size, mixing ratio, and board density on strength and dimensional movement of the boards. From this study, the modulus of rupture and modulus of elasticity increased with increase in production variables, that is, particle size, mixing ratio, and board density; whereas thickness swelling and water absorption decreased. Boards produced from the highest density (700 kg/m3) and at mixing ratio (3:1) for both fine and coarse particles had the best strength and dimensional stability properties. Study revealed that low density polyethylene (LDPE) and *C. pentandra* sawdust are suitable raw materials for the manufacture of wood plastic composites. This will provide solutions to climate change by providing value-added alternative panel products to sawn timber.

Wood flour reinforced polypropylene composites: effects of wood species, filler loading, and filler size. Doh, G.H., Lee, S.Y., Kang, I.A., Chun, S.J. (*Korea Forest Research Institute, Republic of Korea; ghdoh@forest.go.kr; nararawood@forest.go.kr; iakang@forest.go.kr; sangjinchun@hanmail.net*).

WPCs have sort of a standard list of advantages such as dimensional stability, excellent thermal properties, moisture resistance, recycling, compressive-tensile-shear strength, and high impact resistance. Wood species can affect final color and durability of resultant composites because of wood's natural pigmentation and reactivity. Water absorptive behavior may cause major problems for users of the WPCs. The poor compatibility of hydrophilic wood flours and hydrophobic thermoplastic matrix results in poor dispersion, inadequate reinforcement, and low mechanical properties. Therefore, wood flour/polymer matrix systems require the addition of coupling agents for final applications in composite materials. The most common method is to increase interfacial adhesion between the wood flours and the base polymer chain by associating polar groups, such as maleic anhydride (MA), onto the polymer backbone. Very few works have investigated the effects of wood species and particle size on the resultant WPCs. Further research was needed to understand the relationship between chemical composition and wood species. Therefore, the main objective of this study was to understand how wood species, particle size and coupling agent affect the mechanical, water absorption, and morphological properties of polypropylene (PP) based composites.

Properties of particleboards produced from *Sida hermaphrodita* with use of MUPF resin depending on the substitute degree. Dukarska, D., Czarnecki, R. (*University of Life Sciences, Poland; ddukar@up.poznan.pl; rczarnec@up.poznan.pl*).

The work investigates the possibility of applying stems of *Sida hermaphrodita* Rusby reduced to chips as a substitute for wood particles in the process of manufacturing single-layer particleboards glued with MUPF resin. The research was conducted at two stages. At the first stage, the influence of particles substitution degree (0, 25, 50, 75, and 100%) upon basic properties of the boards was determined, i.e. bending strength, modulus of elasticity at bending, internal bond before and after boil test, swelling and thickness and absorbability after 2 and 24 hours of soaking in water, and formaldehyde content. The obtained results lead to the conclusion that it is possible to substitute chips of *S. hermaphrodita* for wood particles in the process of producing particleboards glued with MUPF resin. Based on these findings, at the other stage of investigations, an attempt was made to determine the optimum resination degree for boards produced entirely from this material. The following resination degrees were investigated: 10, 12, and 14%. The manufactured boards were subjected to the same tests as at the first stage of the research; the obtained results prove that it is possible to produce particleboards with the lowest applied resination degree (10%).

Green building materials from spinifex. Gamage, H., De Silva, S., Flutter, N., O'Rourke, T., Memmott, P., Martin, D., Schmidt, S. (*University of Queensland, Australia; h.gamage@uq.edu.au; sujeewa@kln.ac.lk; flutter.n@gmail.com; t.orourke@uq.edu.au; p.memmott@uq.edu.au; darren.martin@uq.edu.au; Susanne.schmidt@uq.edu.au*).

Spinifex grasslands dominate arid and semi arid Australia, covering ~27% of the continent. Traditionally, Aboriginal people used spinifex grass (*Triodia* species) resin and shoots for hafting, cladding, and medicine. We are evaluating material properties of spinifex shoots and resin for use as a sustainable building material by combining indigenous and western scientific knowledge. We focused on widespread species *T. pungens* (resinous) and *T. longiceps* (non-resinous). Leaf cross sections show that *T. longiceps* and *T. pungens* contain 47.5% and 30.4% fibres, respectively. Fibres of *T. longiceps* had greater tensile strength and aspect ratio than *T. pungens*. A resinous leaf epidermis is unique to *Triodia*, and resin cells are in the outer epidermis of leaves from tip to base and also in the leaf sheath. Vigorous resin production occurs at certain times of the year. Thermal and volatile properties were analysed using GS/MS, ATR-FTIR, H and C NMR, TGA, DSC, and head space SPME techniques. Plant-derived resin melts at ~60 °C and we identified 38 volatile compounds. Here we present results from insulating batts and earth blocks with resin and shoots for use as building materials. Futher work is currently underway that examines material properties and sustainability of these products.

Preparation and performance of composite membrane of nanocellulose and polyethersulfone. Huanwei, T., Ping, Q., Yuan, G., Guofeng, W., Liping, Z. (*Beijing Forestry University, China; tanghuanwei@126.com; qupinghappy@163.com; 1986gy@sina.com; wu_guofeng@yahoo.cn; zhanglp418@163.com*).

Polyethersulfone (PES) is still the common material for the ultrafiltration (UF) membrane in membrane technology, with the advantages of good chemical resistance, high mechanical property, and wide temperature tolerances. However, its limited

hydrophilic nature usually results in severe membrane fouling and decline of permeability, which restricts the application of PES membrane. Nanocellulose, with exposed hydroxyl groups, has high hydrophilicity, strength and biodegradable. The objective of this study was to improve the hydrophilic property of PES composite membrane by adding to naocellulose. Blending with nanocellulose had much interest, because of the composite materials' good and stable anti-fouling performances. The nanocellulose was uniformly dispersed into casting solution by ultrasonic treatment. The composite membrane of nanocellulose and PES was prepared by phase inversion with immersion process. Hydrophilic property and anti-fouling property were measured. The composite membrane was characterized by Fourier transform infrared spectroscope (FTIR), scanning electron microscope (SEM), and atomic force microscope (AFM). The hydrophilicity of composite membrane was improved by the existence of nanocellulose. In addition, mean fouling degree (FR value) and attenuation coefficient of fouling (m value) were 22.0% and 35.8%, respectively.

Effects of zinc borat on cellulose films. Hüsnü, Y. (*Artvin Coruh University, Turkey; yel33@hotmail.com*), Wolfgang, G. (*University of Natural Resources and Applied Life Sciences, Austria; wolfgang.gindl@boku.ac.at*), Hülya, K. (*Karadeniz Technical University, Turkey; khulya@ktu.edu.tr*).

In this study, zinc borate was added to cellulose-LiCI/DMAc solution to increase fire retardancy of cellulose film. Effects of zinc borate on fire retardancy and tensile properties of cellulose film were determined. Cellulose films were prepared by dissolving lyocell fibers in LiCl/*N*,*N*-dimethylacetamide solvent and subsequently coagulating and drying them under ambient conditions. While lyocell fibers are dissolving in LiCI/DMAc, zinc borate was added to the solution in five different ratios (0.35%, 0.75%, 1.5%, 2.5%, and 3.5%). Zinc borate was allowed to be dissolved completely in LiCI/DMAc solution. Tensile properties of the zinc borate-added cellulose films were determined by means of Zwick Roell universal testing machine. Fire-retardant tests were performed by a thermogravimetric analysis (TGA) device. Compared to reference cellulose film, tensile strength values were found to be 42% and 33% higher in 0.35% and 0.75% zinc borate-added cellulose films, respectively. Values of elasticity of modulus of cellulose films in all zinc borate ratios were found higher than that of reference cellulose films. According to fire-retardant test results, fire-retardant values of cellulose films increased with increasing zinc borate ratio.

The physical and mechanical properties of com-ply made from waste of palm oil trunk with isocianat, pf, and uf resins. Iswanto, A., Sucipto, T., Apri Heri Iswanto (*University of North Sumatera, Indonesia; apriheri@yahoo.com; titomedan@yahoo.com*), Effendi, K. (*Forestry Department, Indonesia*).

The trend of wood supply for wood industries from natural forest in Indonesia in the past decade showed a sharp decrease. A solution was to utilization non wood or other lignocellulosic materials such as palm oil trunk waste as raw material. Because of biocomposite technology, this goal could be realized. The objective of this research was to study physical (water absorption, thickness swelling) and mechanical (modulus of rupture, modulus of elasticity, internal bond, and screw withdrawal) properties of com-ply made from palm oil stem waste with used urea formaldehyde (UF), phenol formaldehyde (PF) and MDI-isosianat resin. Materials used in the manufacturing of the board included sawdust of palm oil trunk, meranti veneer, and resin. The board was manufactured with a hot press machine. Target density of the board was 0,75 g/cm3. The board size was 25 × 25 × 1 cm. The results of this research showed that in general, using isosianat and PF resin for manufacturing of boards could result in boards that fulfill requirement in JIS A5908 (2003) standard as structural material. The board with urea formaldehyde resin still does not fulfill the requirement standard.

Application of recycled polyethylene in combination with urea-formaldehyde resin to produce water-resistant particleboard. Kargarfard, A. (*Iran Research Institute of Forests and Rangelands, Iran; a_kargarfard@yahoo.com*), Jahan-Latibari, A. (*Islamic Azad University, Iran*).

Furniture grade particleboard always suffers from severe thickness swelling and water absorption, which limits its utilization in humid places such as bathrooms. This is the main problem in countries that do not produce water-resistant panels. To overcome this limitation, addition of recycled polyethylene (PE) in the surface layer of three-layer particleboard is investigated. The amount of UF resin used in surface layer was 10% and 4%, and recycled polyethylene consumption was adjusted at either 5% or 15%. Three-layer boards had applied press temperature of 185 °C and 6 minutes pressing time, and after conditioning, boards were tested according to EN standard. When either 5% or 15% PE was added to the surface layer, MOR and MOE were increased by almost 50% compared to control boards. Combination of 15% PE and 4% UF resin produced similar MOR and MOE compared to 15% PE and 10% UF resin. IB was improved as well, as the initial value of 0.326 MPa for control boards was raised to 0.537 and 0.466 MPa for combination of 15% PE and 10% UF and 15% PE and 4% UF resin, respectively. As expected, both thickness swelling and water absorption were reduced by almost 50%.

Properties of medium density fiberboard produced from wood and non-wood fibers. Kargarfard, A. (*Iran Research Institute of Forests and Rangelands, Iran; a_kargarfard@yahoo.com*), Jahan-Latibari, A. (*Islamic Azad University, Iran*), Nourbakhsh, A. (*Research Institute of Forests and Rangelands, Iran*).

Interest in using non-wood fibers to produce MDF is expanding, and various attempts in fiber deficient locations are observed. However, application of non-wood fibers is faced with limitation especially, fiber weakness. To fulfill the fiber needs of MDF panels, available alternatives can include combined utilization of both wood and non-wood fibers. In this study, to identify suitability of non-wood fibers and possible mixing of these fibers with wood fibers, the properties of MDF from wood (beech, hornbeam, alder, eucalyptus) and corn stalks were determined, and compared fibers were generated using steaming of 175 °C for 10 minutes; chips were then refined. Dry fibers were blended with 12% (dry based) UF resin, and 700 boards Kg/m3 were produced at 180 °C for 4 minutes, and after conditioning were tested according to EN standards. MOR was measured as 22.16, 26.5, 20.14, 18.10 and 14.27 MPa for corn stalks, alder, beech, hornbeam, and eucalyptus wood respectively. MOE followed the same trend as MOR. IB of MDF board produced from corn stalks fiber (0.523 MPa) was higher than beech and horn beam, but lower than either alder or eucalyptus. Results of thickness swelling showed lower values for boards produced from corn stalks and eucalyptus.

Properties and formaldehyde emissions of domestic and imported particleboards. Kim, J.I., Park, S.B., Lee, S.M., Park, J.Y. (*Korea Forest Research Institute, Republic of Korea; jikim99@forest.go.kr; sbpark@forest.go.kr; sml5@forest.go.kr; jypark99@forest.go.kr*).

This study was conducted to investigate the quality, such as formaldehyde emission levels, and physical and mechanical properties, of particleboards manufactured in Korea and imported from the early 1990s to the end of 2007. Thickness swelling (TS) of domestic particleboards varied depending on manufacturers, and was ranged from 12 to 15% for all samples tested. The TS of particleboards imported from European countries was lower than 10%. The internal bond (IB) strengths of both domestic and imported particleboards from European countries was generally greater than that of the required level (3.1 kg f/cm^2) of the 18.0 type of KS standard (KS F 3104). The modulus of rupture (MOR) of domestic particleboards was somewhat greater than that of imported particleboards. The formaldehyde emission levels of domestic particleboards were higher than the E_2 grade (below 5.0 mg/ℓ) of KS standard before 1995, but it decreased gradually to the E_1 grade (below 1.5 mg/ℓ) by the end of 2003. With the Indoor Air Quality Law for public health implemented in 2004, the formaldehyde emission levels of particleboards have been lowering even more and now have reached between E_1 and E_0.

Relationship between accelerated aging treatments and outdoor exposure tests on the mechanical properties of commercial wood-based panels. Kojima, Y., Suzuki, S. (*Shizuoka University, Japan, ykojima@agr.shizuoka.ac.jp; s-suzuki@agr.shizuoka.ac.jp*).

The durability of wood-based panels is one of the most important properties when they are used in residential construction. The objectives of this study were: (1) to evaluate the effect of aging treatments on mechanical properties of some structural use panels; (2) to evaluate 5-year degradation caused by an outdoor exposure test conducted in Shizuoka, Japan; and (3) to establish a correlation in aging effects between accelerated aging treatments and outdoor exposure tests. The panels tested were eight types of commercial wood-based panels for construction use. To evaluate the durability performance of wood-based panels, five accelerated aging treatments were conducted: (1) cyclic JIS-B treatment, (2) cyclic APA D-1 treatment, (3) V313 treatment, (4) ASTM 6-cycle test, and (5) VPSD treatment. Thickness swelling (TS), bending properties, and internal bond strength (IB) were measured. The results of five accelerated aging treatments are summarized as follows. For strength retention, the bending performance, MOR and MOE tended to decrease in a similar manner. The retention for MDI-bonded panels was higher than other panels for every treatment. The ASTM 6-cycle test was the most severe treatment.

Applications of novel techno-economical nanoparticles for removal of 2-chlorophenol from wastewater in forest industry. Kurniawan, T.A., Sillanpää, M.E.T. (*University of Eastern Finland, Finland; tonni696390@yahoo.com; mika.sillanpaa@uef.fi*), Lo, H.M. (*Chaoyang University of Technology, China-Taipei; hmlo@cyut.edu.tw*).

Chlorinated compounds such as 2-chlorophenol (2-CP) are consumed in the forest industry for wood preservation. Its wastewater contains compounds ranging from 100 to 4,000 mg/L. If 2-CP is ingested beyond the permitted concentration (1 mg/L), this can cause cancer. Unless treated, its toxicity poses serious threats to the environment and public health. Fenton's oxidation has been tested to remove 2-CP from wastewater. However, its application generates persistent intermediate species such as quinine that are more toxic than 2-CP. The need for sustainable technologies, which do not generate hazardous by-products, has led to the application of nanotechnology for environmental remediation. Due to their surface reactivity, polyethylene imine (PEI) and polymethyl-methacrylate (PMMA) are promising for environmental applications. These low-cost nano-adsorbents were synthesized via graft copolymerization of methyl methacrylate from branched PEI induced by *tert*-butyl hydroperoxide. Our preliminary studies showed that this nanocomposite was technically applicable in removing 2-CP from synthetic wastewater. About 90% of 2-CP with its initial concentration of 20 mg/L could be removed by 5 g/L of the nanocomposite within 1 hour. Since the treated effluents still could not comply with the limit requirement of less than 1 mg/L, subsequent biological process is required to complement the biodegradation of 2-CP.

Utilization of hemp fiber for a packaging paper. Lee, M.K., Cho, B.U., Chae, S.M. (*Kangwon National University, Republic of Korea; mklee@kangwon.ac.kr; byounguk.cho@gmail.com; x1107@hanmail.net*), Yoon, S.L. (*Jinju National University, Republic of Korea; slyoon@jinju.ac.kr*).

Hemp chemical pulp has received a great attention as a substitute for wood chemical pulp. It can be characterized as a longer fiber length than softwood chemical pulps, which could provide stronger paper. Moreover, hemp itself has lower lignin content than wood and hence it requires less chemicals to cook and to bleach, which makes the hemp chemical pulp an environmentally friendly raw material for papermaking. The objective of this research was to examine the possibility of producing a packaging paper using hemp chemical pulps. Hemp chemical pulps were produced with hemp bast fiber by a soda pulping process in a lab-scale digester. Handsheets were prepared with hemp chemical pulps and wood chemical pulps by varying the mixing ratio between them, and physical properties of the handsheets were tested. It was found that hemp chemical pulps can be utilized as a substitute of softwood kraft pulp and to reinforce hardwood kraft pulp. Using hemp chemical pulp can increase strength properties of paper. However, it was also found that there is a certain limitation in increasing the hemp chemical pulp contents due to the impaired formation of paper.

Design of wood composite flooring by the finite element method. Lee, S.H., Wang, Y. (*National Chiayi University, China-Taipei; shlee@mail.ncyu.edu.tw; woody@mail.ncyu.edu.tw*).

Hygroscopic warping of wood composite flooring due to the moisture content gradient between layers is a critical problem associated with the use of wood composite flooring. Warping, defined as the out-of-plane deformation of an initially flat panel, is a critical problem associated with the dimensional stability of wood composite flooring. This phenomenon causes considerable decrease in product value, frustration for manufactures, and loss of confidence for consumers. Therefore, there is a strong need for knowledge on how to design high-quality wood composite flooring. A three-dimensional finite element model was proposed to predict hygroscopic warping of wood composite flooring. Geometrical parameters and wood species properties were used to evaluate the different construction of wood composite flooring. Detailed model development and computer simulation results are

presented. The results show that the proposed model can be successfully used to simulate hygroscopic warping of wood composite flooring resulting from moisture content change of each layer. It might offer a better understanding of warping behavior and the ideas how to design high-quality wood composite flooring to reduce the magnitude of warping.

Formaldehyde emission of fiberboards fabricated in a laboratory and demonstrated in a production line of factory. Lee, S.M., Park, J.Y. (*Korea Forest Research Institute, Republic of Korea; sml5@forest.go.kr; jypark99@forest.go.kr*), Kang, E.C. (*Sunchang Corporation, Republic of Korea; ec0903@hanmail.net*).

A fiberboard adhesive-type melamine-urea-formaldehyde (MUF) resin was synthesized at a formaldehyde/urea (F/U) molar ratio of 1.10 and added with a melamine content of 15%. The physical properties and the chemical structures of those were analyzed before being applied for making fiberboards. Fiberboards were fabricated in a laboratory and produced in a factory production line. The performance and the formaldehyde emission levels of fiberboards varied with thickness and density of boards as well as with press schedules of manufacturing process. The internal bond strength, thickness swelling, and formaldehyde emission level of thick fiberboards showed slightly lower value than thin fiberboards. Fiberboards fabricated in a laboratory showed slightly lower the internal bond strength, thickness swelling, water absorption, and formaldehyde emission level than fiberboards manufactured in a production line of factory. The formaldehyde emission levels of fiberboards fabricated in a laboratory were below 0.3 mg/L. This study proved that the performance and the formaldehyde emission level of fiberboard manufactured with a resin are controllable variables with hot-press schedules. The results would be useful in optimizing handling parameters of fiberboard manufacturing process.

Effects of formaldehyde catcher on formaldehyde emission of particleboard. Loh, Y.W., H'ng, P.S., Lee, S.H., Lum, W.C., Bakar, M. (*University Putra Malaysia, Malaysia; yway86@yahoo.com; ngpaiksan@gmail.com; hua_cai87@hotmail.com; lumweichen@live.com; astroball2003@yahoo.com*).

Formaldehyde, a chemical component in wood adhesive, is regarded as a volatile organic compound (VOC) and human carcinogen. Indoor formaldehyde pollution had become a serious issue due to the presence of wood-panel products, such as particleboard, in modern home furnishings. There are many methods to reduce formaldehyde emission from particleboard, one of which is through the application of formaldehyde catcher. In this study, particleboard was manufactured by using particles of rubberwood (*Hevea brasiliensis*). Liquid urea-based formaldehyde catcher was mixed with urea formaldehyde (UF) resin to produce particleboard. Four different percentages of formaldehyde catchers (0%, 1%, 2%, 3%, and 4% based on resin solid content) were applied. A total of 60 samples were prepared with 12 replicates for each treatment. Formaldehyde emission is determined by desiccator method for 24 hours, according to the Japanese Industrial Standard (JIS A 5908). This study included observation of quantity of formaldehyde emitted from the particleboard after the duration of the 1st month and 2nd month respectively. From this study, formaldehyde emission is reduced when the concentration of formaldehyde catcher is increased. Conclusively, addition of 4% formaldehyde catcher showed the lowest emission of formaldehyde from particleboard for the duration of 1st month and 2nd month.

Determination of formaldehyde and VOC emissions from wood-based materials. Miyamoto, K., Tohmura, S., Inoue, A. (*Forestry and Forest Products Research Institute, Japan; mkohta@ffpri.affrc.go.jp; tomura@ffpri.affrc.go.jp; ainoue@ffpri.affrc.go.jp*).

Indoor air quality problems resulting from formaldehyde and volatile organic compounds (VOC) emitted by building materials have become an issue of increasing concern in Japan. Wood-based materials can be a source of indoor air contamination, so awareness of the importance of evaluating formaldehyde and VOC emissions from wood-based materials has been increasing recently. There are several standard methods of measuring formaldehyde and VOC emissions from wood-based materials, and this study compares formaldehyde emissions determined by three different standard methods. For each wood-based material, the desiccator method gave a good correlation with the JIS small-chamber method. The slope of the correlation equations between both methods depended on the type of materials and the edge sealing. The desiccator method also gave a good correlation with the $1m^3$-chamber method for MDF: the $1m^3$ chamber value of 0.124 mg/m^3 was equal to the desiccator value of 0.46 mg/L. Evaluation of VOC emissions from wood-based materials is also discussed by using the JIS small-chamber method. Both the variety and amount of VOC emissions were affected by various factors such as wood species of raw materials and kind of overlaid materials.

The characteristics of oriented strand board (OSB) made of vascular bundles from residue of oil palm trunk. Nuryawan, A., Hakim, L., Syahputra, R. (*University of North Sumatera, Indonesia; arifnury@yahoo.com; luthfie17@yahoo.com; putra_thh05@yahoo.co.id*).

The utilization of residue of oil palm trunk will give added value. In this research, residue of oil palm trunk, namely vascular bundles, were used as raw materials of OSB (oriented strand board). There were 4 models of OSB produced: 3 layers, 5 layers, and both 3 and 5 layers with face and back veneer layers. Mat-forming methods on the face was lengthwise and the core was widthwise. The board was pressed at 25 kg/ cm^2 for 15 minutes at 160 °C. Level of resin was 7% based on oven dry strands weight. Evaluation of physical and mechanical properties board were based on Japanese Industrial Standard (JIS) A 5908-2003. The results showed: (1) the physical properties of all models of OSB fulfilling the standard were density, moisture content, thickness swelling 2 and 24 hours; (2) generally, the mechanical properties of all models of OSB met the standard, except screw-holding power; (3) OSB 3 layers had >50% strength retention so it could be used as exterior; and (4) the best product in this research was OSB 5 layers with face and back veneer layers.

Manufacture of compressed dowels using sugi wood by hot-extrusion processing method. Ohuchi, T. (*Fukuoka University of Education, Japan; tohuchi@fukuoka-edu.ac.jp*), Fujimoto, Y. (*Miyazaki Prefectural Wood Utilization Research Center, Japan; fujimoto-yoshiyasu@pref.miyazaki.lg.jp*).

The main objective of this study is to examine the performance of binder-less connection with sugi (*Cryptomeria japonica* D. DON) compressed-dowel and moisture for environment. In previous studies, the authors proposed the binder-less connection with

sugi dowel, which was compressed, and moisture as a new type connection that uses power when the compressed-dowel starts absorbing moisture and turns into its original shape without using the adhesive. In this report, manufacture of sugi compressed-dowel by the hot-extrusion processing method was conducted, and the withdrawl strength was examined. That is, the hot-extrusion processing device was developed, and the appropriate manufacturing condition was examined. In addition, the pull-out specimen that was composed of the sugi compressed-dowel and the acrylic material was prepared, and a pull-out test was performed. The main results are summarized as follows. For the appropriate hot-extrusion processing conditions, the temperature and feed speed of the device was 180 °C and 20 mm/min, respectively. It took 20 minutes on the average to manufacture one sugi compressed-dowel. The withdrawal strength showed large value when the diameter of the enhanced hole for the sugi compressed-dowel was set to 19 mm.

Characterization of biocomposites made of kenaf reinforcement and PP/poly(lactic acid) blend matrix. Park, J.H., Han, S.O. (*Korea Institute of Energy Research, Republic of Korea; onoshinge@naver.com; sohan@kier.re.kr*).

This research focused on the manufacturing and characterization of biocomposites made of kenaf reinforcement and poly (lactic acid) (PLA)/polypropylene(PP) blend matrix. PLA is biodegradable thermoplastic derived from renewable resources, such as corn. PLA can be used as alternative of PP; however, the effort to overcome the brittleness of PLA was made with a blending method. The blended fiber of PP and PLA have similar processing temperatures has been tested in terms of improving the environmental friendliness of PP and compensating the brittleness of PLA. The polymer matrix made of PLA/PP showed higher mechanical properties compared to PLA matrix. The mechanical properties were improved with the addition of reinforcements for the biocomposites. Kenaf (*Hibiscus cannabinus* L.) fiber is used as good reinforcement of the biocomposites for the automobiles most frequently. Kenaf fiber grows to more than 3 m within 3 months even in moderate ambient conditions. During the growth phase, kenaf contributes to reduce carbon dioxide at a significantly high rate. The objective of this study is to investigate the characterization of the PLA/PP matrix and its biocomposites reinforced with kenaf fiber. The mechanical properties of PLA/PP biocomposites compared with the PP or PLA biocomposites reinforced with kenaf fiber.

Effects of F/U molar ratio and melamine content on the structures of urea-melamine-formaldehyde (UMF) resins. Park, J. Y., Lee, S.M., Park, S.B., Kim, J.I., Lee, S.H. (*Korea Forest Research Institute, Republic of Korea; jypark99@forest.go.kr; sml5@forest.go.kr; sbpark@forest.go.kr jikim99@forest.go.kr; kori0909@kangwon.ac.kr*).

Melamine-urea-formaldehyde (MUF) resins with different formaldehyde/urea (F/U) molar ratios were synthesized. The physical properties and the chemical structures of those were analyzed. As formaldehyde/urea (F/U) molar ratio and melamine content increased, the solids content of resin increased due to increased polymerization and increased side chain in the resin. At the same F/U molar ratio, free formaldehyde contents, and gel time of resins decreased due to decreased free urea as increased melamine content. Chemical structures of resins were proposed from the results of 13C-NMR and FT-IR analysis. As formaldehyde/urea (F/U) molar ratio and melamine content increased, structures of resins became complicated and more branched due to increased reaction sites in a chain of the resin. Medium density fiberboards (MDF) were fabricated with those resins and the performance test were conducted. Use of lower F/U molar ratios in resins decreased in the formaldehyde emission level but resulted in deteriorated the performance of MDFs. In general, the formaldehyde emission levels of MDFs decreased as melamine contents increased, and the performance of MDFs was better than a commercial resin.

Characterization biocomposites with hardwood pulp reinforcement and poly(lactic acid)/polypropylene blend matrix. Park, R.W., Han, S.O. (*Korea Institute of Energy Research, Republic of Korea; smilepnw@nate.com; sohan@kier.re.kr*).

Biocomposites, generally reinforced with natural fibers, such as flax, kenaf, hemp, have been actively applied to the automobile and construction industries. Also, hardwood pulp is considered one of the reinforcements for biocomposite. The configuration of hardwood pulp consists of about 40–50% cellulose and the rest lignin and hemicellulose. The cell walls of hardwood pulp are composed of multi-layers structured with middle lamella, a primary wall, and a secondary wall. The components and configuration of hardwood pulp are closely related to the performances of biocomposites. In this study, we investigated the structural characteristics of hardwood pulp in terms of utilizing hardwood pulp as a reinforcement of biocomposite. The thermal stability and crystalline properties of hardwood pulp were analyzed by TGA and XRD, respectively. Poly(lactic acid)/polypropylene was used as polymer matrix for the biocomposite. The biocomposites with hardwood pulp reinforcement with different loadings were prepared by hot press molding method. The thermomechanical and dynamic mechanical properties of hardwood pulp reinforced biocomposites were investigated by TMA and DMA methods, respectively. The thermal and mechanical properties of biocomposites were compared to those of polypropylene or poly(lactic acid) biocomposites reinforced with hardwood pulp.

Preparation and performance of poly(lactic acid)/nanocellulose composites. Ping, Q., Lu, B., Yuan, G., Guofeng, W., Liping, Z. (*Beijing Forestry University, China; qupinghappy@163.com; hugongbailu@163.com; 1986gy@sina.com; wu_guofeng@yahoo.cn; zhanglp418@163.com*).

One best way to harness the petroleum-based solid wastes is to develop biodegradable materials. Among these, PLA is the most important, because it is made from a renewable plant. But poly(lactic acid) (PLA) is brittle and has low impact resistance. Nanocellulose is about 5–10 nm in diameter and the length can be from 100 nm to several micrometers depending on the source of cellulose. Nanocellulose can act as efficient reinforcement because of the high aspect ratios, subsantial surface areas, and high modulus. Nanocelluloses are hydrophilic because of the abundant exposed hydroxyl (-OH) groups, and PLA is hydrophobic. So we added the low molecular weight polymeric-poly(ethylene glycol) (PEG) to improve the interaction between PLA matrix and the nanocellulose. The PLA/nanocellulose composites were prepared by casting solution. The tensile strength and the elongation rate of the composites was improved 13.8% and 24%. The FT-IR analysis showed that the level of molecular compatibility was achieved, based on the existence of an inter-molecular hydrogen bond between PLA and nanocellulose, also among PLA, PEG, and nanocellulose. The pictures of SEM and AFM showed that the nanocellulose dispersed evenly in the PLA matrix.

Properties of molded top tables depending on element shapes and conditions of recycled wood wastes. Roh, J.K. (*Jinju National University, Repubulic of Korea; arohjk@jinju.ac.kr*), Park, B.D. (*Kyungpook National University, Republic of Korea; byungdae@knu.ac.kr*), Park, S.B., Park, J.Y. (*Korea Forestry Research Institute, Republic of Korea; parksb@forest.go.kr; jypark99@forest.go.kr*), Doh, J.L. (*Dolim Wood Co. Ltd, Republic of Korea; dlwood@dolim.co.kr*).

About one million table tops are necessary for school students in Korea. Manufacturing of table tops using wood waste that would have been burned or land-filled will be very beneficial in terms of economic and environmental aspects. However, recycled wood wastes have considerable complexity in shapes and conditions, resulting in large variations in their product performance, particularly formaldehyde emission. This study attempted to manufacture molded top tables with three different sources of recycled wood wastes such as wood, plywood, and particleboard; and using two types of size reduction mills (hammer mill and knife ring flaker). Particle sizes and shapes of recycled wood wastes after grinding were also determined. Molded top tables were manufactured using these particles and urea-melamine-formaldehyde resin adhesive, and were used to measure their performance and formaldehyde emission. The effects of different scavengers and two different ways of applying scavengers were also compared. The least and greatest modulus of rupture was found for table tops manufactured with particleboard and wood particles, respectively. Formaldehyde emission was greatest for recycled particleboard particles, which could be due to the presence of adhesive used. Either addition of scavengers into the resin, or spraying scavengers onto particles, was effective in abating formaldehyde emission.

Properties of particleboard produced from admixture of rubberwood and mahang species. Seng Hua, L., Wei Chen, L., Yang Way, L., Paik San, H. (*Universiti Putra Malaysia, Malaysia; hua_cai87@hotmail.com; lumweichen@live.com; yway86@yahoo.com; ngpaiksan@gmail.com*).

Particleboard is one of the major timber products produced by the timber industries in Peninsular Malaysia. The shortage and higher cost of rubberwood has forced manufacturers to search other alternative materials and processes to produce particleboard. The use of mixtures of fast-growing wood species with rubberwood for making particleboards could be a solution. The objectives of this study were to investigate the physical and mechanical properties of particleboard produced from admixtures of rubberwood and mahang at different proportion levels. The mechanical and physical properties of the particleboard produced were evaluated based on the Japanese Industrial Standard (JIS A 5908-1994). The results showed that all the particleboard did not achieve the requirement of the JIS A 5908-1994, where the expansion ratio in thickness due to water absorption should be 12% maximum. From the static bending test results, the particleboards manufactured from mixture of rubberwood and mahang at ratio 90:10, 70:30 and pure mahang particleboards at density 500 kg/m³ can be classified as 8 type according JIS A 5908-1994. Significant effect was observed for variable proportion levels as particleboard produced from pure mahang perform significantly better than other proportions in term of WMOR, WMOE, MOR, and MOE except IB.

The nanoclay effect on the mechanical properties of cellulosic fiber reinforced polypropylene biocomposites. Sim, K.J., Han S.O. (*Korea Institute of Energy Research, Republic of Korea; ppottatto18@nate.com; sohan@kier.re.kr*).

Nowadays, biocomposites have been widely used as environmentally friendly materials for various applications due to serious environmental pollution problems. Recently, research studies have been actively conducted for improving mechanical properties of biocomposites combined with nanotechnologies such as addition of nanoclay. We investigated the improvement of mechanical properties with addition of nanoclay on polypropylene biocomposites reinforced with hard wood pulp or cotton pulp. The hard wood pulp and cotton pulp mainly consisted of cellulose, and the mechanical characteristic of cellulosic fiber is largely dependent on the contents of the cellulose. In this research, organically modified nanoclay was added for improving the mechanical properties of biocomposites. The nanoclay addition effects on mechanical properties of biocomposites such as tensile, flexural, and impact properties were analyzed, respectively. The improvement of mechanical properties of biocomposites was observed with increasing the nanoclay loadings. The mechanical properties of cotton pulp reinforced polypropylene biocomposites showed higher improvement than those of the hard wood pulp reinforced polypropylene biocomposites. From these results, environmentally friendly biocomposites with higher mechanical properties can be developed by applying nanoclay as bionanocomposties. The improvement of mechanical properties of biocomposites could be explained with better dispersion and interaction between cellulosic fibers and nanoclay.

Evaluation of rice hull fibers as an alternative to wood fiber. Sung, Y.J. (*Chungnam National University, Republic of Korea; yosung17@cnu.ac.kr*), Shin, S.J. (*Chungbuk National University, Republic of Korea; soojeongesf@hanmail.net*), Oh, M.T., Kim, D.S. (*Chungnam National University, Republic of Korea; OhMinTack@cnu.ac.kr; KimDongSeop@cnu.ac.kr*).

To find alternative raw materials for papermaking is becoming a very important issue since the demand of paper products and wood fibers as a sustainable material keep in increasing but the supply of wood pulp has more limitations due to global concerns about the environment and the protection of forests. Since rice hull could be the one of the most abundant agricultural wastes in Korea, the properties of rice hull fibers as an alternative to wood fibers were investigated in this study. There was a lot of silica in rice hull, about 13%; the outer surface of the rice hull showed the rugged patterns in which there was most of the silica. Soda and soda anthraquinone pulping resulted in about 33% fiber yield and removed most of silica except around 1% silica. The average fiber length of rice hull fiber was 0.45 mm, which is shorter than that of hardwood fiber. The handsheet papers that were made of mixture of softwood pulp and rice husk pulp showed the rice hull fibers could be used as a potential substitute of low level packaging grade wood pulp.

Recent trend of wood adhesives in Japan. Tohmura, S., Miyamoto, K., Inoue, A. (*Forestry and Forest Products Research Institute, Japan; tomura@ffpri.affrc.go.jp; mkohta@ffpri.affrc.go.jp; ainoue@ffpri.affrc.go.jp*).

Sick-building syndrome has been a serious problem since the late 1990s in Japan; several chemicals such as formaldehyde and other volatile organic compounds (VOC) from building materials are thought to cause health problems. The Building Standard Law was amended in 2003, requiring ventilation facilities to be installed and materials used in rooms to be limited depending on the level of formaldehyde emissions from building materials. Accordingly, both JIS and JAS standards for building materials are

set at F**** (F four star) grade, which is the most stringent in the world. Because it is technically difficult to meet the F**** grade with urea-formaldehyde (UF) resin alone, the production of UF has fallen dramatically in the last decade, being replaced by melamine-urea-formaldehyde resin (MUF) adhesive. The production of both phenol-formaldehyde resin with quite low formaldehyde emission and water-based polymer-isocyanate adhesive with no formaldehyde emission has gradually increased. The other four VOCs—toluene, xylene, ethylbenzene, and styrene—are also voluntarily regulated under the labeling system. In January 2008, legislation on the emission of the four VOCs from decoration panels was enacted. Accordingly, adhesives for decoration panels have been switched to non-solvent type or water-based adhesives.

Effect of wax concentration on formaldehyde emission of f type 8 particleboard.** Wei Chen, L., Seng Hua, L., Yang Way, L., Paik San, H. (*Universiti Putra Malaysia, Malaysia; lumweichen@live.com; hua_cai87@hotmail.com; yway86@yahoo.com; ngpaiksan@gmail.com*).

Urea formaldehyde is normally used as a binder for particleboard. However, urea formaldehyde was found harmful to human health due to formaldehyde emission. Two types of waxes (Emulco wax and Michem wax) were used in this study. The particleboards were produced by using 0.5%, 1%, 1.5%, and 2% of wax respectively while the particleboard produced without additional wax act as control. The particleboards produced were sampled and evaluated according to JIS standard. Their physical and mechanical properties together with the formaldehyde emission were determined. The result shows that all the physical and mechanical properties achieved the minimum requirement of the Japanese Industrial Standard (JIS A 5908). In the mean time, the formaldehyde emission from particleboard increased when higher wax percentage was used. However, no significant difference was observed for the effect of wax on formaldehyde emission. Particleboard produced by using Emulco wax had lower formaldehyde emission than Michem wax. Conclusively, increasing of wax percentage in particleboard increased the formaldehyde emission but the increment is not significance.

Preparation and characterization of salt-tolerant cellulose-modified superabsorbent. Yuan, G., Shuai, L., Ping, Q., Lu, B., Liping, Z., Guofeng, W. (*Beijing Forestry University, China; 1986gy@sina.com; leadswift@126.com; qupinghappy@163.com; hugongbailu@163.com; zhanglp418@163.com; wu_guofeng@yahoo.cn*).

To improve the salt tolerance of cellulose-modified superabsorbent, a series of superabsorbents based on pulp cellulose was prepared by free-radical graft copolymerization of acrylamide in aqueous solution using sodium hydroxide and urea solution as pretreatment activating agent, N,N-Methylene-bis-acrylamide as a crosslinking agent, potassium persulfate as an initiator, and sodium hydroxide as a hydrolytic agent. The effect of variables on the swelling capacity--such as acrylamide/cellulose weight ratio, reaction temperature, concentration of the initiator, crosslinking agent, and hydrolytic agent--are systematically optimized. Fourier infrared (FT-IR) spectroscopy, X-ray diffraction, and scanning electron microscope (SEM) analysis are used to confirm the superabsorbent structure. The highest absorbency for deionized water is 633.3 g/g and the highest absorbency for 0.9 wt% sodium chloride (aq) and artificial urine (1.94 wt% carbamide, 0.08 wt% sodium chloride, 0.11 wt% magnesium sulphate heptahydrate 0.06 wt% calcium chloride) are both 133.3 g/g. The water retention rate under load of the superabsorbent is determined by centrifuge. A preliminary swelling and de-swelling behaviors of the superabsorbent are also studied.

Treatment of veneer with low molecular weight phenol formaldehyde resin to enhance dimensional stability and biological properties of oil palm stem plywood. Yueh Feng, L. (*Malaysia Timber Industry Board, Malaysia; loh@mtib.gov.my*), Paridah, M.T., Hoong, Y.B., Edi, S.B. (*Universiti Putra Malaysia, Malaysia; parida_introb@yahoo.com; frence_yeoh@yahoo.com; edisuhaimi@putra.upm.edu.my*), Jaluddin, H. (*Malaysia Timber Industry Board, Malaysia; dr.jalaluddin@mtib.gov.my)*, Hamdan, H. (*Forest Research Institute Malaysia, Malaysia; hamdan@frim.gov.my*).

The objectives of the study were to evaluate the dimensional stability after being exposed to several climatic conditions and the effectiveness of oil palm stem plywood against subterranean termites (*Coptotermes curvignathus*) and white rot fungi (*Pycnoporous sanguineus*) of OPS plywood that was manufactured using phenolic-treated veneer. Commercially available adhesive such as urea formaldehyde (UF) was used to bond the veneer together and low molecular weight phenol formaldehyde (LMW PF) resin was used to treat the veneers. The results show that treatment of OPS veneer with LMW PF significantly enhanced the dimensional stability of the OPS plywood even at a very severe condition (cold soaking), with 68.8% improvement in thickness swelling and 49.4% in water absorption. The phenolic-treated test samples were significantly more resistant to termites than the untreated samples. The percentage of weight loss for untreated samples were 19.2% (outer veneer) and 23.9% (inner veneer), while for phenolic treated samples were 10.7% and 15.8%, respectively. The result showed there was improvement of 62% for treated OPS plywood towards white rot fungi. Treatment of OPS veneer with LmwPF has significantly enhanced the dimensional stability and biological resistance of the plywood.

E-05 Sustainability impact assessment of the forest-based sector

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Public policies as institutions for sustainability: potentials of the concept and findings from assessing sustainability in the European forest-based sector. Aggestam, F. (*European Forest Institute, Austria; filip.aggestam@boku.ac.at*), Vogelphol, T. (*Institute for Ecological Economy Research, Germany; jauchensen@web.de*), Weiss, G. (*European Forest Institute, Austria; gerhard.weiss@boku.ac.at*), Rammetsteiner, E. (*FAO, Italy; ewald.rammetsteiner@fao.org*).

It is becoming increasingly apparent that the institutional sphere is of critical importance to achieve sustainable development. The institutional dimension thus represents an important challenge to the full integration of economic, social, and environmental sustainability objectives within the necessary institutional setting. Despite its importance, the latter is often neglected when it

comes to scientific assessments of sustainability performance. The aim of the present paper is, therefore, to discuss how the institutional dimension of sustainability can be incorporated into a sustainability impact assessment of the European forest-wood-chain (FWC) by using a policy database developed within EFORWOOD. The database, covering all policies of key relevance to FWC sustainability, was used to connect the EFORWOOD sustainability indicators to its institutional and political background. This connection provides insights into the governance structures prevailing in the European forest-based sector and into the institutional dimension of FWC sustainability. The results illustrate that the issues related to FWC sustainability are governed and regulated inconsistently, with many political institutions involved, various types of policies in force, and different modes of governance applied. The EFORWOOD sustainability indicators and its comprehensive database of sector-related policies thus mark a feasible approach for also considering the institutional sphere of sustainability.

Long-term simulation of forest sustainability under a multifunctionality context. Barreiro, S., Tomé, M. (*Agronomy Superior Institute, Portugal; smb@isa.utl.pt; magatome@isa.utl.pt*).

Sustainable forest management has become imperative in the definition of guidelines to achieve multiple objectives in management. The use of simulators for scenario analysis can be a powerful tool to explore policy options and to illustrate the consequences of different management alternatives on the evolution of forest resources. SIMPLOT—a regional forest simulator—was conceived under the EFORWOOD project to simulate the development of stands in a region, providing as output several forest characteristics and sustainability indicators at social, economic, and environmental levels. Simulation runs are regulated by 5 drivers: wood demand, biomass demand, hazards occurrence, land use changes, and percentage of change among different forest management alternatives and/or options. This user-friendly tool combines forest inventory data with growth models and simulates forest condition over time for the scenarios defined by the user. The scenario files express the quantity and evolution of each of the drivers throughout the simulation period. Together with a set of user-defined simulation parameters, the simulator estimates a collection of sustainability indicators. For an easier analysis of the results, all outputs can be saved in a excel format and some of the indicators can be accessed in a graphical format as well.

Application of Natura 2000 concepts in the context of mountain forestry: assessment of sustainability impacts of different approaches on a regional basis. Becker, G. (*Albert-Ludwigs-University of Freiburg, Germany; institut@fobawi.uni-freiburg*), Brüchert, F. (*Forestry Research Institute of Baden-Württemberg, Germany; franka.bruechert@forst.bwl.de*), Nutto, L. (*Albert-Ludwigs-University of Freiburg, Germany; leif.nutto@fobawi.uni-freiburg.de*), Sauter, U.H. (*Forest Research Institute of Baden-Württemberg, Germany; udo.Sauter@forst.bwl.de*), Fischbach, J. (*Albert-Ludwigs-University of Freiburg, Germany; janine.fischbach@fobawi.uni-freiburg.de*).

Natura 2000 is a European-wide conservation scheme including the protection of forest area in order to prevent loss of species and improve biodiversity. Current conservation level in Europe is about 7% in the strict sense of nature reserves, plus areas with adapted management. Mountainous forest areas are considered as likely conservation areas and discussion is ongoing on the benefits of such protection which effects severe management restrictions. The decision support tool for sustainability impact assessment (ToSIA), which was developed in the frame of the EU-project EFORWOOD, was applied in order to estimate the effects of different actions—such as different levels of forest conservation—on defined economic, social, and ecologic sustainability indicators. The investigations aimed to assess the effects of reduced forest management and harvest activity on defined areas on forest stock, roundwood availability to different sectors of the wood-processing industry, employment, energy use, and other factors. Sensitivity analysis and scenario techniques were used to analyse dynamic relationships between production and trade on a regional level for different reference futures.

Sustainability impact assessment: a useful concept for regional comparative studies? Brüchert, F. (*Forestry Research Institute (FVA) of Baden-Wuerttemberg, Germany; Franka.Bruechert@forst.bwl.de*), Fischbach, J., Nutto, L. (Freiburg University, *Germany; Janine.Fischbach@fobawi.uni-freiburg.de; Leif.Nutto@fobawi.uni-freiburg.de*), Sauter, U.H. (*Forestry Research Institute (FVA) of Baden-Wuerttemberg, Germany; Udo.Sauter@forst.bwl.de*), Becker, G. (*Freiburg University, Germany; institut@fobawi.uni-freiburg.de*).

Multi-functional forestry and diversified, forest-based sectors of Europe can serve as model for other economical sectors how to integrate environmental protection, economic growth and satisfaction of human needs. This target requires integrated tools with built-in sustainability criteria to support politicians, forest owners or companies in their work for a sustainable development. Such a comprehensive tool did not exist until the EU-project EFORWOOD developed a decision support tool for sustainability impact assessment (ToSIA) of the European forestry wood (FW) chain. In this concept FW chains are modelled as a number of interconnected processes between forest, industry, and consumers. For each process, sustainability is expressed as values for a common set of economic, environmental, and social indicators. Using this methodology the approach of multi-functionality of forests can be assessed in detail and process chains can be compared with respect to sustainability. One aim is to apply sensitivity analysis and scenario techniques to analyse dynamic relationships between production and trade in the regional and global forest-based sectors and to learn about the effect of planned and unexpected changes on sustainability as well as trade-offs between alternative FWCs. This approach is applied to a regional case that is characterised by an economically important forest-wood sector.

Incorporating recreational value into sustainability impact assessment of the European forest-based sector. Edwards, D. (*Forest Research, UK; david.edwards@forestry.gsi.gov.uk*), Jay, M. (*Albert-Ludwigs-Universität, Germany; Marion.Jay@ifp.uni-freiburg.de*), Jensen, F. (*University of Copenhagen, Denmark; FJS@life.ku.dk*), Lucas, B. (*CTFC, Spain; beatriz.lucas@ctfc.es*), Marzano, M., Mason, B. (*Forest Research, UK; mariella.marzano@forestry.gsi.gov.uk; bill.mason@forestry.gsi.gov.uk*), Montagné, C. (*INRA, France, montagne@nancy-engref.inra.fr*), Peace, A. (*Forest Research, UK; andrew.peace@forestry.gsi.gov.uk*), Schelhaas, M. (*ALTERRA, the Netherlands; MartJan.Schelhaas@wur.nl*), Weiss, G. (*University of Natural Resources and Applied Life Sciences, Austria; gerhard.weiss@boku.ac.at*).

An approach to assessing the impacts of forest management on the recreational value of forests is demonstrated at the European level. A Delphi survey was used, involving 46 experts in landscape preference research or related fields, to estimate 'recreational scores' on a 10-point scale for 60 forest stand types in each of four contrasting European regions: Atlantic Region; Nordic

Region, Central Europe, and Mediterranean Region. The experts were asked to explain the rationale behind their decisions, which provided additional qualitative insights to help interpret the results. Conjoint analysis was used to explore the extent to which forest management, stand age, and tree species composition can explain the variation between recreational scores for each region. It was concluded that tree species composition had a relatively minor impact on recreational value. The scores were then combined with outputs from the European forest resource projection model, EFISCEN, to assess the impacts of contrasting levels of implementation of the Natura 2000 policy on the recreational value of forests. It is acknowledged that there are risks associated with use of this approach in a European context to guide policy decisions and planning.

ToSIA—a tool for sustainability impact assessment of forest-wood chains. Lindner, M., Suominen, T. (*European Forest Institute, Finland; marcus;lindner@efi.int; tommi.suominen@efi.int*); Verweij, P. (*Alterra, the Netherlands; peter.verweij@wur.nl*), Zudin, S. (*European Forest Institute, Finland; sergey.zudin@efi.int*).

A new software tool—ToSIA—has been developed for assessing sustainability impacts of forest-wood chains (FWCs). FWCs are analysed as chains of production processes (e.g., harvesting, transport) which are linked with wood products (e.g., furniture). Sustainability is determined by analysing environmental, economic, and social sustainability indicators for all production processes along the FWC. The tool calculates sustainability values by multiplying relative indicator values expressed per unit of material flow with the material flow entering a process. Calculated sustainability values are then aggregated for the segments of the FWC or for the complete chain. ToSIA uses a data-oriented approach that is very flexible in the focus of the analysis and the selection of indicators of sustainability. ToSIA provides information for support in strategic decision-making by offering a transparent and consistent methodological framework to assess sustainability impacts of changes in policies, market conditions, or technology in the forest-based sector. The presentation will highlight expected benefits of this tool for the industry to demonstrate sustainability impacts relating to their actions, for decision makers to get ex-ante information on sustainability impacts of policies, and for scientists to conduct detailed scenario analysis on the impacts of a range of changes impacting the FWCs.

Assessing sustainability impacts of forestry-wood chains. Päivinen, R., Lindner, M. (*European Forest Institute, Finland; risto.paivinen@efi.int, marcus.lindner@efi.int*), Rosén, K. (*Skogforsk, Sweden; kaj.rosen@skogforsk.se*), Lexer, M.J. (*University of Natural Resources and Applied Life Sciences, Austria; mj.lexer@boku.ac.at*).

Due to the emerging importance of sustainable use of natural resources, and policies requiring actions towards sustainable development, there is a demand for methodologies and tools that are able to address these new challenges. We present an approach to assess sustainability impacts of alternative production chains of the forest sector. The approach describes the forest sector as a set of processes by which forest resources are used to (i) produce biomass that is routed through different value-adding production chains and converted to products, and (ii) provide other ecosystem services. It is suggested that each production process included in a production chain will be characterised by a set of indicators covering environmental, economic, and social aspects of sustainable development. This approach is compared with other existing sustainability assessment methods and then demonstrated by a numerical example, in which the indicator values are determined based on the volume of wood material flowing through the processes. Sustainability impacts of policy scenarios or technological changes result from changing from one production chain to another; the impacts accumulate along the production chains. Combined cost-benefit and multi-criteria analyses are proposed to evaluate overall impacts and to compare alternative chains.

Criteria of assessment of forest work performance in Polish forestry. Sowa, J. (*University of Agriculture in Cracow, Poland; rlsowa@cyf-kr.edu.pl*), Lubera, A. (*State Forests, Poland; adam.lubera@radom.lasy.gov.pl*).

Poland is one of those European countries where the state owns most forest area. Due to economic changes over the past 20 years, forest work performance has been practically entirely taken over by private transactors hired by the State Forests National Forest Holding. Although economically justified, the process of forest service privatization causes many formal, organizational, economic, technical, and technological complications. A serious issue of forest work performance is quality, significantly affecting forest environmental conditions and production task profitability in forest. The paper attempts to elaborate and analyze the criteria that a state forest district can use to assess forest work performed by private forest service enterprises. The research was conducted in a production forest district in central Poland. The example of timber harvesting service performance was used to show the possibility of description and implementation of assessment criteria for the tasks performed. The research showed that the criteria may serve qualitative quantification of the transactors performing forest work and facilitate assessment, in a forest district, of the economic effects of forest management based on co-operation with outside transactors. The criteria may have a broader application as a state forest management optimization tool.

Posters

Sustainability impact assessment of the European forestry-wood chain: development of transparent calculation modes to acquire process-specific data for ToSIA. Becker, G., Bürzle, B., Fundel, V. (*Albert-Ludwigs-University of Freiburg, Germany; institute@fobawi.uni-freiburg.de; bernhard.buerzle@t-online.de; fundel@hotmail.de*).

The purpose of the EU-project EFORWOOD is to develop a quantitative decision support tool for sustainability impact assessment (ToSIA) regarding the European forestry-wood chain, covering forestry, industrial manufacturing, consumption, and recycling. To develop ToSIA, the structure (processes, products, process inter-correlation, and split ratios) of the country-specific technical timber production chain (TTPC), that is, all relevant felling and hauling processes, are to be identified. Furthermore, data on the quantity of material flows and the values of an approved set of sustainability indicators (SI) are required. We present the data acquisition methods, which were developed on the basis of the example of Poland, which plays a major role in EFORWOOD as representative 'key country' for all other East European countries. The developed modes of calculation are assumed to be applicable to all other EU25+2 countries. Furthermore, the SI values are calculated in relation to a universal reference unit (m^3) and therefore allow the direct comparison of different concepts of the technical timber production, e.g., motor manual compared to fully mechanised harvesting processes, and of different country specific TTPCs, with regard to their impact on sustainability.

Sustainability issues related to European logging practises: a reflection based on EFORWOOD case studies. Berg, S. (*Forestry Research Institute of Sweden, Sweden; staffan.berg@skogforsk.se*), Fischbach, J., Becker, G. (*University of Freiburg, Germany; Janine.fischbach@fobawi.uni-freiburg.de; gero.becker@fobawi.uni-freiburg.de*).

In the framework of the EU-project EFORWOOD, a comprehensive and holistic method to assess the sustainability of the processes along the forest wood chain (FWC) in 27 European countries has been developed, including a software (ToSIA) to support this assessment. This paper is restricted to a detailed assessment of logging chains in cases in three European regions: South (Southwest France/Iberian Peninsula); Center European (Baden-Württemberg, Germany); and North: (Västerbotten County/ Sweden). The sustainability of the chains has been evaluated with a set of 27 indicators, which include economic, ecological, and social aspects. The paper will show results of the evaluation of the cases with the aid ToSIA based on data for 2005. As examples we present the indicator values for gross value added (GVA), costs, energy use, and related emissions, as well as employment. Preliminary results are (i) that there is a variation between cases regarding costs, (ii) the GVA vary within a smaller range, and (iii) energy use and related environment are closely linked to the technical systems that are used in the different cases. This assessment will also demonstrate "weak points." Expected future changes of costs for labour and energy and the consequences for employment and total costs are demonstrated.

Using the method of sustainability impact assessment to compare regional forestry-wood-chains. Fischbach, J. (*University of Freiburg, Germany; janine.fischbach@fobawi.uni-freiburg.de*), Brüchert, F. (*Forest Research Institute of Baden-Württemberg, Germany; franka.bruechert@forst.bwl.de*), Becker, G. (*University of Freiburg, Germany; institut@fobawi.uni-freiburg.de*).

Since 2002, a general impact assessment (IA) must be carried out for every major regulatory proposal in the Commission's work programme. These IAs take place before a proposal is approved. This target requires the use of integrated tools with built-in sustainability criteria and indicators to support decision makers in their work for sustainable development. Several methods have been developed to study environmental impacts of actions, but none addressed all sustainability dimensions of the forest-based sector along the whole forest wood chain (FWC) in a balanced way. The EU-project EFORWOOD developed an integrated tool for sustainability impact assessment (ToSIA) of the FWC. There, a FWC is modelled as a number of interconnected processes between forest, industry and consumers. The sustainability impact assessment (SIA) of each FWC is determined by the aggregation of indicator values along the chain. By using this methodology, the approach of multifunctionality of forests can be assessed and process chains can be compared with respect to sustainability; trade-offs betweendifferent sustainability indicators, for instance, also could be identified. The poster will show the approach of the project by presenting a case study with concrete results of SIAs of different FWCs from the forest to the mill.

Stakeholder interaction in sustainability impact assessment development: a roadshow approach. Gamborg, C. (*University of Copenhagen, Denmark; chg@life.ku.dk*), Rosén, K. (*Skogforsk, Sweden; kaj.rosen@skogforsk.se*).

Interaction with stakeholders in sustainability impact assessment is notoriously difficult—and even more so in the development of tools for such assessment. Questions concerning the representativeness (i.e., who should be involved), issues (i.e., interaction about what) and purpose (i.e., why involve, and for the benefit of whom) need to be addressed and, subsequently, suitable methods must be applied. This paper reports on the methodology and outcome of the main approach used to interact with main stakeholders in the EFORWOOD project; the so-called roadshow–a smaller, dedicated, and targeted two-way discussion meeting at the stakeholder's premises. The conclusion drawn from the roadshows is that this form of stakeholder interaction would appear to be a more 'sustainable' approach than many bigger, multi-stakeholder workshops and written consultations, as are often employed in similar projects. In terms of outcome, the stakeholders visited were interested in and positive about the EFORWOOD project, but they also expressed their difficulties obtaining an overview of the project as a whole, grasping the consequences of the application of the tool and conceptualising the boundaries to the use of the tool. The main topical areas of discussion at the meetings were: ToSIA, indicators, MCA, CBA and scenarios.

Elaboration of forest management plans in the Czech Republic with reference to forest management sustainability. Marusak, R. (*Czech University of Life Sciences, Czech Republic; marusak@fld.czu.cz*).

Forest management planning in the Czech Republic is based on the theory of normal forest. The only limitation for private forest owners is the volume of allowable cut. Two different cutting indicators are used for its determination—cutting percentage and theoretical clearing area (in case of forest area exceeding 500 ha). Both indicators are rules of the Forest Act. This system, according to its basis, prefers clear-cuts and a forest management orientation to wood production. A modern approach gives priority to environmentally friendly methods of management, which means, for example, minimizing clear-cuts in most central European forests and use of shelterwood or selection systems (the area of selection forest is constantly increasing, but it is still only 2.13% of whole forested area in the Czech Republic). Also, other roles of forest (non-wood producing)—such as recreational, water protection, or soil conservation—should not be neglected during the elaboration of allowable cut for each management unit. Other methods are used in different countries to determine the allowable cut, which are more appropriate to actual approaches in Czech forestry. The poster presents alternative solutions of harvest scheduling using classical approaches for current forest conditions.

Forest-timber relationships in the light of sustainability impact assessment. Paschalis-Jakubowicz, P. (*Warsaw University of Life Sciences, Poland; Piotr.Paschalis@wl.sggw.pl*).

It is necessary to further develop methods for evaluating the function, the importance and the benefits derived from the forest. This is due to reorientation of the methods used in the exploration of the forest, both relating to the functions of the forest, its durability, raw materials, and products, as well as, their rational use. We used the theory of sustainable development for the implementation of the analysis of the network connections between forestry and other sectors, primarily the timber industry. The study adopted a multidirectional method of determining the effect of selected criteria and indicators for sustainable development and references to the Millennium Development Goals. That was the basis for the analysis of selected mega trends affecting the changes in global forestry. The paper presents results of studies on synergistic effects of some factors in shaping the forest–wood

relationship. Using advanced methodologies for determining the risk of natural and technological processes, we perceived a certain degree of interaction between forest and wood in relation to the role of forests as a source of energy, the role of forests in climate change processes, and their impact on changes in land use.

Development of forest certification in Japan: comparison between FSC and SGEC. Sakamoto, T., Shiba, M. (*Kyoto University, Japan; Tomomi.Sakamoto.Jasc60@gmail.com; mshiba@kais.kyoto-u.ac.jp*), Schaller, M. (*Technische Universitaet Muenchen, Germany; Schaller@tum.de*), Pakhriazad, H.Z. (*Universiti Putra, Malaysia; azad@kais.kyoto-ac.jp*).

Forest certification is a tool for improving forest management. It also provides incentives for consumers to use "eco-friendly" products. Since Japan is a major timber-consuming country, the development of forest certification in the country has a significant influence on timber market and forests services at domestic and global level. We examined the current situation regarding to the chain of custody (CoC) and forest certification in Japan based on published documents. In addition, we compared major certification schemes in Japan, namely; FSC (Forest Stewardship Council) and SGEC (Sustainable Green Ecosystem Council). The number of CoC-certified companies had reached to 1,419 by November 2009 (FSC: 952, SGEC: 334, PEFC: 133). Paper products companies led the FSC-CoC certification, while wood products dominated the SGEC-CoC. The FSC had certified a total of 282,314 hectares and the SGEC certified 789,228 hectares forest area. According to CARs (corrective action requests) in the forest certification reports, the FSC and SGEC imposed most applicants to improve monitoring systems and riparian management. The SGEC placed importance on biodiversity. However, the FSC placed more emphasis on long-term management plans including sustainable yield and environmental considerations. Results of annual audits showed most FSC- and SGEC-issued CARs had been solved.

Environmental risk assessments (ERA) for certified tropical forests. Synnott, T. (*Estudios Forestales Synnott S.C., Mexico; timsynnott@prodigy.net.mx*), Wenban-Smith, M. (*OneWorld Standards Ltd, UK; mwenbansmith@oneworldstandards.com*), Karmann, M. (*Forest Stewardship Council, Germany; m.karmann@fsc.org*).

Activities in managed tropical forests should never have unacceptably heavy environmental impacts. FSC's monitoring system ensures that this minimum requirement is met in certified forests, and requires, like many governments, environmental impact assessments. But these are often costly and unreliable. An environmental risk assessment (ERA) assumes that monitoring and data collection should mainly concentrate on activities that might have serious impacts on environmental values and values that might be at risk. ERA calculates risk values for environmental values, and for stress factors causing these risks, taking account of mitigation measures, scales, intensities, and linkages among these elements. For main environmental values, ERA identifies goals that correspond to safe, acceptable, or low-risk consequences of forest management. Assessment then focuses on the risks of not achieving these goals, especially the consequences that are considered unsafe, unacceptable, or high-risk. ERA can be easily applied and is using local knowledge along with available information from publications and research. ERA is tailored for FSC requirements; the generic version can be adapted for any tropical forests. Regional elements are verified by stakeholder consultations and can be regularly revised to take account of new information, and adapted for new situations. The paper describes ERA's development and operation.

An analysis and comparison of the European forest-based industries ranking in terms of sustainability. Voces, R., Diaz-Balteiro, L., Romero, C. (*Technical University of Madrid, Spain; roberto.voces@upm.es; luis.diaz.balteiro@upm.es; carlos.romero@upm.es*).

Recently, sustainability has become a relevant issue for forestry industries along the world. However, its characterization is not well-defined because sustainability is an abstract concept that is difficult to conceptualize and measure. Generally a set of indicators has been proposed to make the comparison easy, in terms of sustainability, between industries or industrial sectors. However, some issues regarding the integration of these indicators are not still well-defined in the literature. In this study a synthetic index is proposed in order to compare the sustainability of 17 European forest industries in several countries by using a binary goal programming approach. Fourteen indicators that embrace economic, social, and environment considerations have been defined. They have been quantified by using EUROSTAT data for three forest industries following NACE classification; that is, timber, paper, and the more closed NACE code to wooden furniture at the same level. In order to apply the binary goal programming methodology, different preferential weights have ben applied to each indicator. These weights have obtained by means of judgements from several international experts using a pairwise comparison procedure.

Sustainability impact assessment of the integration of forest-pulp-paper production in China by using life cycle assessment (LCA). Xu, W., Becker, G. (*University of Freiburg Institute of Forest Utilization, Germany; wei.xu@fobawi.uni-freiburg.de; institut@fobawi.uni-freiburg.de*).

China emerged as the second largest producer of pulp and paper products in the world, and the Chinese pulp and paper industry is recognizing the concept of sustainable development. To secure a sufficient wood supply, some large-scale pulp and paper producers integrate plantation operations into their own production processes, which is called integrated forest-pulp-paper production. This study aims to identify and quantify the sustainability impact associated with the entire chain of forest-pulp-paper production from three aspects in terms of environmental performance, economic profitability, and social benefits by using sustainability indicators as follows: raw material flow, energy demand and efficiency, GHGs emissions, productivity, cost, employment, etc. The research system of forest-pulp-paper integration was divided into three sub-systems for better analysis: plantation operations, pulp manufacturing, and paper making. A Chinese pulp and paper producer with its own eucalyptus plantations located in southwestern China was considered as a case study, while some data from a German pulp mill was applied as benchmark. The life cycle assessment (LCA), which is also called cradle-to-grave approach, was applied in this study as an analytical tool. This study will enable the Chinese pulp and paper industry to gain a better sustainability performance by using life-cycle thinking.

E-06 Properties and utilization of plantation timbers

Organizers: KeeSeng Gan, *Forest Research Institute Malaysia, Malaysia, ganks@frim.gov.my;* Pekka Saranpää, *Finnish Forest Research Institute, Finland, pekka.saranpaa@metla.fi.*

Recent developments in resource characterisation in plantation radiata pine in New Zealand. Cown, D. (*Scion/New Zealand Forest Research Institute, New Zealand; dave.cown@scionresearch.com*).

The performance and value of plantation softwoods is increasingly important as such material continues to become a larger proportion of the global wood supply. Recent research in New Zealand has focused on improving the understanding of factors affecting wood quality in radiata pine and developing tools for more accurate resource description and material segregation. Characteristics of importance include the appearance of clear wood from pruned stands and the stiffness and stability of wood which is predominantly juvenile in nature. The costs involved in managing for clearwood in particular mean that blemishes such as resin defects and intra-ring checks must be detected at the earliest possible opportunity, and material segregated to avoid further unnecessary processing costs. For stiffness and stability, a range of approaches have been examined to determine whether material will meet industrial requirements. Focus here has been on wood density, acoustic properties, compression wood, knots and spiral grain. There is now much more interest in predicting wood quality as well as growth in plantation forests.

Effect of wood species and layer structure on physical and mechanical properties of strand board. Febrianto, F. (*Bogor Agricultural University, Indonesia; febrianto76@yahoo.com*), Heri Iswanto, A. (*University of Sumatera Utara, Indonesia; apriheri@yahoo.com*), Hidayat, H. (*University of Lampung, Indonesia; away_rie@yahoo.com*), Jin, H.K., Nam, H.K. (*Kangwon National University, Republic of Korea; kwon@kangwon.ac.kr; kimnh@kangwon.ac.kr*).

The objectives of this research were to evaluate the effect of wood species and layer structure on the physical and mechanical properties of strand board made from *Paraserianthes falcataria*, *Maesopsis emini*, and *Acacia mangium* woods collected from planted forest in Bogor district, West Java, Indonesia. The densities of *P. falcataria*, *M. eminii*, and *A. mangium* woods were 0.36, 0.41, and 0.46 g.cm^{-3} respectively. Three (3) types of layer structure—perpendicular, parallel, and random orientation—were applied. Methylene diisocyanate (MDI) resin with 7% resin amount (w/w) was used. The physical and mechanical properties of strand board were evaluated based on CSA 0437.0 standard. Results indicated that strand board manufactured from wood with lower density (*P. falcataria*) had higher mechanical properties (modulus of rupture, modulus of elasticity, and internal bond) and lower dimensional stability (water absorption and thickness swelling) compared to strand board manufactured from higher density (*A. mangium*). Strand orientation strongly affected the physical and mechanical properties of boards, with perpendicular orientation showing superior performance compared to parallel and random orientation. Physical and mechanical properties of OSB made from fast-growing tree species met the requirement of CSA 0437.0 standard for grade O-1 OSB panels.

Opportunities for improving the utilisation of the UK's plantation resource. Moore, J. (*Edinburgh Napier University, UK; jmoore@napier.ac.uk*), Gardiner, B. (*Forest Research, UK; barry.gardiner@forestry.gsi.gov.uk*), Ridley Ellis, D. (Edinburgh *Napier University, UK; d.ridleyellis@napier.ac.uk*), Macdonald, E. (*Forest Research, UK; elsepth.macdonald@forestry.gsi.gov.uk*).

The annual harvest from the United Kingdom's forests is approximately 8.5 million tonnes. Approximately 65% of this goes to domestic sawmills which collectively produce ~2.9 million m^3 of timber each year, enough to meet ~30% of the UK's annual demand for sawn wood. Most sawn timber produced in the UK is Sitka spruce (*Picea sitchensis*), while a substantial amount is Scots pine (*Pinus sylvestris*). However, of the material sold as construction timber, very little is used for producing the prefabricated timber frames and trussed rafters used in mainstream house construction. To improve the value of the UK's forest resource, it is important to get more locally produced timber into this higher value component of the construction market. This paper summarises a number of studies that have been conducted to characterise the wood properties of Sitka spruce and Scots pine and to understand the influence of environment, silviculture, and genetics on these properties. The increased pressure on the UK's wood resource, coupled with higher product performance requirements from the timber construction sector, means that the UK must continually work to improve timber quality if locally produced timber is to maintain, and ideally grow, its share of the construction market.

Increasing the processing yield of plantation hardwoods through innovative processing method. Ratnasingam, J. (*Universiti Putra Malaysia, Malaysia; jegaratnasingam@yahoo.com*), Pew Ma, T. (*Wood Saw Sdn. Bhd., Malaysia; tpma@woodsaw.com.my*).

The presence of juvenile wood and tension wood in plantation hardwoods is a common phenomenon, affecting processing yield. A regional study was undertaken in Malaysia, Indonesia, and Thailand to evaluate the influence of these wood abnormalities on the processing yield of rubberwood (*Hevea brasiliensis*). Further, the rotating saw-dry-rip (SDR) technique was implemented to assess its effectiveness in minimizing the effects of these wood abnormalities on the resultant yield. Detailed volumetric production data were collected from 150 saw mills for 6 months. The study found that the average saw milling yield ranged between 29% to 40%. Upon implementing the SDR technique, saw milling yield was significantly improved by almost 5%. It was apparent that by rotating saw logs 180 degrees between cuts, the stresses in the juvenile wood that often lead to warp-causing imbalances were reduced. The subsequent drying of the wood reduces growth stresses by balancing with drying stresses, and, when dried at high temperature (over 85 °C), the fibre arrangement in the wood was altered by lignin plasticization, which markedly reduced the incidence of fuzzy grain on the machined surfaces of wood with such abnormalities. This technique offers great potential to increase the processing yield of plantation hardwoods.

Mechanical stress grading of Chinese fir dimension lumber for light frame wooden houses. Ren, H.Q. (*Chinese Academy of Forestry, China; guowei2000@126.com*), Guo, W., Fei, B.H. (*Beijing Forestry Machinery Research Institute of State Forestry Administration, China; guowei2000@126.com; fbh@caf.ac.cn*), Wang, Z.H., Luo, X.Q. (*Chinese Academy of Forestry, China; zhwang@caf.ac.cn; lxq@caf.ac.cn*).

As one of the main planted forest tree species and a common natural structural material, Chinese fir (C*unninghamia lanceolata* (Lamb.) Hook) was quite widely used in Chinese traditional wooden houses. Recently, as light frame house imports increased and

developed rapidly in China, there is a need for the Chinese wood construction industry to exploit new uses of Chinese fir lumber in modern wood construction. In this research, mechanical properties of Chinese fir dimension lumber were obtained using full-size specimens to establish different grades for mechanical stress grading (MSG). The coefficient of determinations of regression relationship between mean values of strength and modulus of elasticity (MOE) were higher as MOE were divided into intervals, and the relationships among strengths can be used to guide MSG. Lumbers were sorted into three grades: M10, M18, and M26 by MSG without considering the requirement for air-dry density of wood, because the 5% percentile value of air-dry density cannot be gained since the sample size was not large enough and the value of air-dry density (mean value is 0.39 g/cm^3) was low. The relationship of the 5% percentile ultimate compression strength value ($UCS_{5\%}$) and that of modulus of rupture ($MOR_{5\%}$) was $UCS_{5\%} = 0.343MOR_{5\%} + 15.39$.

Posters

Variation of tracheid biometry and wood properties of *Pinus caribaea* var. *caribaea* Morelet. Alvarez Lazo, D.A. (*University of de Pinar del Río, Cuba; daniel@af.upr.edu.cu*), Quilhó, T., Bessa, F., Tavares, F., Pereira, H., Alves, A., Rodríguez, J.C. (*Lisbon University, Portugal; terisantos@isa.utl.pt; ana@isa.utl.pt; jose.rodrigues@iict.pt*).

Pinus caribaea var. *caribaea* is one of the major indigenous species in Cuba used for the wood industry.Variability in anatomical characteristics has profound influence on the properties of the wood as a raw material and its physical and the mechanical properties can be best understood by reference to its structure. Trees of *P. caribaea* var *caribaea* (29 years old) were felled in each of three different sites within Cuba (Malas Aguas, Cajalbana, and Marbajita). Measurements were made at three different radial positions—near the pith, at 20 mm, 40 mm of the radius—and mean tracheid length, diameter and wall thickness, density, compression strength, and modulus of elasticity were recorded. This research indicates that wood characteristics vary between sites and within trees and show that *P. caribaea* var. *caribaea* trees coming from the Malas Aguas site would be preferred to trees coming from Marbajita and Cajalbana sites because it has better wood characteristics. On the other hand the results show a strong effect of the distance to pith parameter on all the wood characteristics studied, corresponding to an increase of wood characteristics from pith to bark.

Deposition of lignin during early and late xylem formation in Scots pine. Antonova, G., Jeleznichenko, T., Varaksina, T. (*V.N. Sukachev Institute of Forests, Russian Federation; antonova_cell@mail.ru; institute_forest@ksc.krasn.ru*).

Deposition of lignin during early and late wood formation in pine (*Pinus sylvestris* L.) stem was studied. Cells at successive developmental stages of secondary thickening were sampled from the trunk under morphological and histochemical control. The content of phenolic acids, their fractions, ascorbate, and dehydroascorbate in the extracts was estimated. Amounts of components and lignin at each developmental stage were calculated per dry weight and per cell. The content of free and bound phenolic acids, ascorbate, and dehydroascorbate changed in the course of tracheid maturation depending on the type of forming cells. Lignin deposition intensity was opposite in early and latewood; maximum rate was observed at the end maturation of early tracheids and in the outset of latewood lignification. The ratio of syringyl- and guaiacylpropane units in lignin preparations changed during lignification and was higher in early than that in late xylem. Lignin molecular weights at the first maturation stages were higher and more homogeneous. Intensity of lignin deposition during earlywood tracheid formation increased gradually, reaching maximum by the end of cell maturation. In contrast, the lignification rate of latewood was highest in the outset of the process and dropped towards mature xylem.

Life-cycle inventory for heat treatment of pitch pine: major plantation species in Korea. Chang, Y.S., Park, J.H., Eom, C.D., Choi, I.G., Lee, J.J., Yeo, H.Y. (*Seoul National University, Republic of Korea; jang646@snu.ac.kr; gentleice@snu.ac.kr; willyeom@gmail.com; cingyu@snu.ac.kr; junjae@snu.ac.kr; hyeo@snu.ac.kr*).

Wood has many applications, and it is often in competition with other materials such as iron and plastic. The use of wood capable of sustained production as well as fixing CO_2 in the air could play a role in the prevention of global warming. The objective of this study was to produce a life-cycle inventory (LCI) database for production processes. We aimed to estimate the amount of consumed energy and CO_2 emission while delivering pitch pine (*pinus rigida*) produced in Jangheung-gun to Seoul and processing it into structure material—from sawing in Chodang Sawmill, delivering to Seoul for kiln drying, and planing into structural material. The drying process consumed the most energy, accounting for about 90% of the total required energy. Accordingly, it is important to develop efficient drying schedules capable of completing the drying process without any defects within a short time, as well as increasing energy efficiency. LCI built in this study will be used, as a database for the nation, to make a criterion of energy consumption and CO_2 emission in forest products industries. Based on this, the competitiveness of wood products as eco-friendly materials against climate change is expected to be enhanced.

An analysis of the yarding operation system with a swing-yarder in Korea. Cho, K.H., Oh, J.H., Song, T.Y., Kim, J.W., Han, W.S. (*Korea Forest Research Institute, Republic of Korea; khcho@forest.go.kr; jhoh@forest.go.kr; ukeun319@forest.go.kr; jaewkim@forest.go.kr; wshan@kookmin.ac.kr*), Park, S.J. (*Kyungpook National University, Republic of Korea; sjupark@knu.ac.kr*).

This study was conducted to investigate the efficiency of yarding operation systems, in particular the optimum set-up spacing in order to establish an optimum yarding operation system with a swing-yarder (IWAFUJI TW-232) in Korea. The study area is located Gapyung-Gun, Gyenggi-Do in the middle of Korea. The forest is artificial forest of *Pinus koraiensis*, which is a popular species in Korea. In line thinning yarding operations by swing-yarder (IWAFUJI TW-232), the ratio of choker setting and lateral time was 18% of total yarding time. And the ratio of choker setting and lateral yarding time among productivity time element was the highest. An average yarding productivity of a swing-yarder in the line thinning operation was 33.89 m^3 per day and 8.47 m^3 per man-day. As the results of the simulation of yarding operation by swing yarder (IWAFUJI TW-232), the total yarding time for one corridor with 4 planting rows of one block and 1 ha took about 1 day and 4 days, respectively. And in the yarding operation of the line thinning and clear cutting with a swing-yarder, optimum setting-up spacing was 20 m and 10 m, respectively.

Physical and mechanical properties of flakeboard made from mixed fast-growing tree species. Febrianto, F., Panca Nur Alam, S. (*Bogor Agricultural University, Indonesia; febrianto76@yahoo.com*), Hidayat, W. (*University of Lampung, Indonesia; away_rie@yahoo.com*), Jin, H.K., Nam, H.K. (*Kangwon National University, Republic of Korea; kwon@kangwon.ac.kr; kimnh@kangwon.ac.kr*).

The objectives of this study were to determine physical and mechanical properties of particleboard made from mixed flakes of *Paraserianthes falcataria, Maesopsis eminii*, and *Acacia mangium* woods with and without pre-treatment in cold water immersion. The densities of *P. falcataria*, *M. emini*, *i* and *A. mangium* woods were 0.36, 0.41, and 0.46 g.cm^{-3} respectively. Sixteen (16) mixed combinations of homogenuous flakeboards were produced. Methylene diisocyanate (MDI) was used as a binder with 8% resin content. Physical and mechanical properties of flakeboard were evaluated based on JIS A 5908:2003. The results indicated that mixing higher flake density with lower flake density improved the dimensional stabilisation (water absorption and thickness swelling) of flakeboard, and vice versa. Immersing flakes in cold water prior to being manufactured also improved the dimensional stability of flakeboard. Mixing lower flake density with higher flake density improved modulus of elasticity (MOE) and modulus of rupture (MOR) values of flakeboard. On the other hand, immersing flake in cold water tend to resulted in lower MOE and MOR values. Almost all physical and mechanical parameters except MOE met the JIS A 5908: 2003 standard. Flakeboard made from whole *A.mangium* wood pretreated with cold water immersion yielded superior properties.

Chipping energy of woody biomass: effect of species and dimension. Fujimoto, K., Ikami, Y., Yoshida, T., Takano, T. (*Forestry and Forest Products Research Institute, Japan; kiyopi@ffpri.affrc.go.jp; ikami@ffpri.affrc.go.jp; tyoshid@ffpri.affrc.go.j ttakano@ffpri.affrc.go.jp*).

To clarify the chipping energy of woody biomass, we investigated the effect of species and dimensions of specimens on power consumption during chipping using a disk chipper. As specimens we used: the lumber of sugi (*Cryptomeria japonica*), hinoki (*Chamaecyparis obtusa*), karamastu (*Larix kaempferi*), and kunugi (*Quercus acutissima*); culm of moso bamboo (*Phyllostachys heterocycla*); and trunk of oil palm (*Elaeis guineensis*) trunk. In addition, we also measured chipping time and particle size distribution of chips. Power consumption was increased with the width and thickness of the specimen, while the integrated power consumption per dry weight (Wh/kg) was decreased with the width and thickness of the specimen. The integrated power consumption per dry weight of hinoki and kunugi of 30 mm in thickness and 120 mm in width were 6.7 and 6.0 Wh/kg, respectively. The average value of the integrated power consumption per dry weight of oil palm and moso bamboo were 6.1 and 6.6 Wh/kg, respectively. Chipping efficiency was 1.0 t/h for moso bamboo; 2.0 t/h for hinoki, sugi and oil palm; and 3.5 t/h for kunugi.

Preliminary research on tension properties of metal-plate connected larch dimension lumber joints. Guo, W. (*Chinese Academy of Forestry, China; guowei2000@126.com*), Fei, B.H. (*Beijing Forestry Machinery Research Institute of State Forestry Administration, China; fbh@caf.ac.cn*) Zhao, R.J. (*Chinese Academy of Forestry, China; rongjun@caf.ac.cn*).

This study was conducted to obtain load-deformation curves, evaluate the effects of metal-plate connector (MPC) MPC length and MPC area on the ultimate tensile load, and investigate the effect of MPC size on tension strength and failure modes. The results indicated that the shapes of load-deformation curves were similar to former studies, and consisted of linear section and nonlinear part. The MPC size was a key factor to both the tension mechanical properties and the failure mode of MPC joint. There was a good positive linear relationship between ultimate load and MPC area, with a high coefficient of determination of 0.7725. Large enough MPC size and reasonable layout method (the single tooth of MPC parallel or vertical to the wood fiber direction) were effective methods to enhance the tension property of MPC joints. Finally, three main failure modes of metal-plate connected larch dimension lumber were found. This preliminary research on tension properties of MPC connected domestic planted larch dimension lumber not only laid the foundation for further research in this subject, but also had great significance to develop domestic tree species for structural timber.

Initial results of clonal selection for teak (*Tectona grandis*) in Côte d'Ivoire. Kadio, A. (*SODEFOR, Côte D; kadio.aime@Gmail.com*).

The program of clonal breeding of teak (*Tectona grandis Linn. f.*) improved by SODEFOR has achieved important results in vegetative propagation, initial growing, and qualitative traits for stem conformation and branches fixing. The best conditions for root initiation have been drawn up by characterizing the substratum and plant material to be used for rooting and also by determining the right time in the year to carry out these activities. The rooting rates stand between 89 and 95 percent. At age six, the best clones measure 19.5 m for total height 57 cm for mean dbh at average, corresponding to a gain of 35 percent compared to a progeny from open fertilization in a clonal seed orchard set up in 1982 in Côte d'Ivoire. The heritabilities of these traits are medium for the total height ($h^2 = 0.44 \pm 0.07$) and high for the circumference ($h^2 = 0.72 \pm 0.09$). For the stem and branches, the variables studied are strongly correlated ($0.74 < r < 0.90$) and present also high heritability ($h^2 = 0.94$ to 0.96). These clones are at present using as "multiclonal variety" for afforestation and provide higher productivity than any other plant material used in Côte d'Ivoire.

Promoting sustainable utilization of low-medium density tropical wood species as structural materials. Karlinasari, L., Surjokusumo, S. (*Bogor Agricultural University, Indonesia; l_karlinasari@yahoo.com; dhht@ipb.ac.id*).

Nowadays, consumers in the tropics must shift their way of thinking with regard to the use of timber for daily structural uses. The new paradigm is to utilize tree species having low-medium strength grade, i.e., low-medium density instead of well-known tree species with high strength (high density). This paper reports a comparative study on wood properties of some tree species growing in plantation forests and outside forests including community forests. Small specimens were used to evaluate the mechanical properties of wood in accordance with ASTM D 143 standards. Four commonly available tree species—mangium (*Acacia mangium*), African wood (*Maesopis eminii*), nangka (*Artocarpus heterophyllus*), and Durian (*Durio zibethinus*)—were examined for wood property tests. The results showed that the densities of the wood species studied were about 0.4–0.6 g/cm^3. The mechanical properties, bending strength, MOE and MOR, tension strength, and shear strength obtained were comparable with

wood of moderate quality from existing commercial species such as meranti (*Shorea* spp.) and kamper (*Dryobalanops* spp.). Promoting sustainable utilization of wood from these promising species is regarded as a key strategy to reduce the dependency on high-quality wood harvested from depleting natural forests.

Properties of phenol formaldehyde particleboard from oil palm trunk particles. Kasim, J., Mahmud, S.Z., Ahmad, N., Tamiran, S.N.A., Shahriman, N.S., Razak, N. A. (*Universiti Teknologi MARA, Malaysia; djamal@pahang.uitm.edu.my*).

The oil palm trunk (25 yrs old) was supplied by MPOB, Bangi, Selangor. The trunk was converted into flakes using a disk flaker and into particles by passing through a dust extractor. Particleboard was produced using phenolic resin at 7, 9, and 11%. Particle size was varied from 1.0 mm to 2.0 mm, while the board density varied from 500 to 700 kgm^{-3}. No significant improvement in MOR, MOE, and IB was observed when PS was changed from 1 mm to 2.0 mm. However, with larger particle size the water absorption and thickness swelling decreased. Increasing the resin content from 7% to 11%, significantly increased the mechanical properties, while the physical properties of water absorption and thickness swelling improved. With increase in board density, the MOR, MOE, and IB increased and the water absorption and thickness swelling decreased. Particleboard with a high board density and resin content of more than 9% was able to meet the minimum requirement of the British standards.

Near-infrared spectroscopic observation of the deterioration on the surface of sugi (*Cryptomeria japonica D. Don*) boxed-heart timber treated with superheated steam. Kobayashi, I. (*Forestry and Forest Products Research Institute, Japan; kobayas@ffpri.affrc.go.jp*), Tsuchikawa, S., Inagaki, T. (*Nagoya University, Japan; st3842@agr.nagoya-u.ac.jp; inagaki.tetsuya@e.mbox.nagoya-u.ac.jp*), Hayashi, K. (*Ehime University, Japan; hayashi@agr.ehime-u.ac.jp*).

Boxed-heart timber from sugi (*Cryptomeria japonica D. Don*) is widely used as structural columns for traditional wooden houses in Japan. It is well-known that boxed-heart timber, which has a pith surrounded by juvenile wood, is susceptible to severe drying checks, and that it is difficult to reduce the drying time in the conventional kiln-drying process, which can take as long as 3 weeks. To solve this problem the superheated steam treatment method was developed, where boxed-heart timber is treated before the drying process at a temperature of 140–160 °C and absolute pressure 0.15 MPa (boiling point is about 111.4 °C). Occurrence of surface check is reduced by this pre-treatment but excessive treatment causes checks during the pre-treatment process. Therefore, it is important to know the influence of superheated steam treatment on wood to find the appropriate condition. In this study, we investigated the relation between the superheated steam condition and the degree of disintegration of chemical structure on the surface of wood by use of near-infrared spectroscopy (NIRS). Degree of disintegration of hemi-cellulose on the surface of wood treated in superheated steam with higher temperature was more notable.

Wood properties of rubber tree (*Hevea brasiliensis*) planted in Cambodia. Koga, S. (*Kyushu University, Japan; skoga@forest.kyushu-u.ac.jp*), Khun, K., Pheng, M. (*General Directorate of Rubber Plantations, Cambodia; khunkakada@yahoo.com; phengmuthavy@yahoo.com*), Chhek, C. (*Cambodian Rubber Research Institute, Cambodia; chhekchan@yahoo.com*), Mizoue, N., Yoshida, S. (*Kyushu University, Japan; mizoue@ffp.kyushu-u.ac.jp; syoshida@ffp.kyushu-u.ac.jp*).

Rubber tree (*Hevea brasiliensis*) is an important species for natural rubber production. The plantation area covers approximately 7 million hectares in Southeast Asia, accounting for more than 90% of the world's total rubber plantation area, now expanding rapidly in Southeast Asia countries. In general, the trees are removed after 25 to 30 years and the wood (rubberwood) has been used for fuelwood and charcoal. However, recently the utilization as value-added wood products such as sawn timber, plywood, OSB, MDF, and furniture, has become of major interest. We investigated the wood properties of rubber trees planted in Cambodia (three clones: GT1, PB235, PR107; ages 8–50), as one of the projects on evaluation of multiple functions of rubber plantations for forest and wood resources. The main results are as follows. Basic wood properties such as wood anatomy, wood density, and MOE depended a great deal on the clone. Pin penetration depth measured by Pilodyn wood tester was negatively correlated with wood density, and longitudinal ultrasonic velocity of the stem in standing tree was highly correlated with dynamic MOE of log. Thus, it was shown that these non-destructive techniques are applicable to wood quality assessment of standing rubber trees.

Simulation of hygroscopic warping of yellow birch sawn timber by finite element analysis. Lee, S.H., Yiren Wang (*National Chiayi University, China-Taipei; shlee@mail.ncyu.edu.tw; woody@mail.ncyu.edu.tw*).

Anisotropy and non-homogeneity of solid wood make the behaviors of timber subjected to moisture variation more complicated. The shape stability is of most concern and is very significant in the use of solid wood. Warping, defined as the out-of-plane deformation of an initially flat panel, is a critical problem associated with the shape stability of solid wood. The objectives of this study are to describe the analysis method and develop a three-dimensional finite element model applied in warping behavior of solid wood. A three-dimensional finite element model was developed to predict the hygroscopic warping of sawn timber by the commercial software ANSYS. This specially developed finite element analysis is applied here to predict warping due to moisture content gradient of solid wood (yellow birch). The formulation of governing equations and detailed model development and computer simulation results are presented. This simulation was sucessfully done. The finite elememt models as well as the deformed geometry were demonstrated graphically. The results of this study might offer a better understanding of timber warping and the ideas how to reduce the magnitude of timber warping.

Development of hybrid beams consisting of timber and steel for guardrails using domestic pitch pine. Lim, J.A., Park, C.Y., Kim, H.K., Yeo, H.Y., Lee, J.J. (*Seoul National University, Republic of Korea; jinlibra@snu.ac.kr; babo007@snu.ac.kr; oddysseus@naver.com; hyeo@snu.ac.kr; junjae@snu.ac.kr*).

Pitch pine has been planted to 4.8 million ha in Korea. Now it is being used in low-value-added products, as raw material of pulp and board. So, in order to use pitch pine in high-value-added products, it is necessary to develop application technologies and secure new markets. Increasing concerns have been generating new needs not only for construction materials, but also for changing steel guardrails installed at tourist destinations, such as national parks. This study aims to evaluate the strength performances of hybrid guardrail beams consisting of timber and steel. According to the prior bending performance tests on timber, the guardrails made only of timber have not shown sufficient strength required to be used for highway installation. In this study, a

new kind of guardrail beam was designed to reinforce timber guardrails with steel. For the evaluation of strength, static bending tests were carried out. The increment of bending strengths for hybrid beam was showed and their fracture mode was investigated. The behaviors of timber and steel were analyzed and compared to solid timber.

Estimation of carbon dioxide emission of kiln-dried lumber production. Matsumura, Y., Saito, S. (*Forestry and Forest Products Research Institute, Japan; myukari@ffpri.affrc.go.jp; shoechan@ffpri.affrc.go.jp*), Ikeda, K., Hoshikawa, T. (*Shizuoka Research Institute of Agriculture and Forestry, Japan; IZX01361@nifty.ne.jp; hoshikawa.t@gmail.com*).

To evaluate the environmental load of production of wood products, it is important to increase inventory analyses of wood products. The purpose of this study is to evaluate the environmental load of lumber production. We estimated carbon dioxide (CO_2) emission for kiln-dried lumber production by dehumidification and steam-heated kiln dryers. CO_2 emitted during production of hinoki (*Chamaecyparis obutusa* Endl.) squared lumber in a sawmill using dehumidification kiln dryer was examined. The system boundary was from the arrival of logs to the shipment of dried lumber. The process in the sawmill was divided into four processes: debarking, sawing, drying, and finishing. CO_2 emission was calculated from power outputs of machines, the operating rate, and energy consumption. The CO_2 emission rate was the largest in the drying process among the four processes. During production of 1 m^3 kiln-dried lumber, the energy consumption of the sawing process was 35%, that of the drying process was 59%, and that of the other processes was 6%. The results suggest that reduction of CO_2 emission during kiln-dried lumber production can be achieved by improving the drying process with respect to less energy consumption.

Development of laminated wood for sill plates using Japanese cedar (sugi). Morita, H., Aratake, S. (*Miyazaki Prefectural Wood Utilization Research Center, Japan; morita_hideki3@yahoo.co.jp; aratake-shiro@pref.miyazaki.lg.jp*).

The purpose of this study is to develop a novel product using sugi timbers with pith. Since sugi timbers with pith have low bending strength and cannot be used efficiently for structural use, boosting yield rate of log could be difficult. The density of sugi timbers with pith is generally higher than that without pith, and it correlates well with partial compressive strength perpendicular to grain and shearing strength. Therefore, it is reasonable to utilize sugi timbers with pith under situations requiring partial compressive performance. Besides, obi-sugi, a major group of sugi cultivars planted in southern Kyushu, is known as timber having high essential oil yield and durability. From this background, we developed laminated wood using obi-sugi timbers with pith for sill plates in Japanese wooden houses. The experiments showed that partial compressive performance of laminated wood with pith was over that of laminated wood without pith, and the experiments using timbers were similar results as well. Several factors are likely to have an effect on results obtained by these experiments; especially, density and direction of annual rings seem to be very influential.

Conversion of sugi logs into sawn lumber: sawing yield of medium quality middle and large logs. 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 mature sugi (*Cryptomeria japonica* D. Don) planted forest, the main supply of sugi logs today is shifting from small and middle logs to middle and large logs. Sugi high-quality large logs have been converted into high quality sawn lumber, which is used for decorative columns, finishing, ceilings, etc. in Japanese traditional houses, with Japanese traditional sawing methods; however, sugi medium quality large logs have not been converted into sawn lumber so much since the amount of its supply has been little. In order to utilize sugi medium quality large logs, it is necessary to convert them into sawn lumber in multi-item bulk production. In this study, we examined the sawing yield of sugi medium quality logs sawn with sawing patterns for in multi-item bulk production. Sugi medium quality middle and large logs (24–40 cm diameter) were converted into sawn lumber for structural and non-structural members of buildings, temporary constructions, and laminae for glue laminating with different sawing patterns: "Hirakaku," "Hikiwari," and "Shokaku." Both volume and value yields were the greatest with "Hirakaku," followed by "Shokaku" and "Hirawari." This order corresponded with the order of number of sawing passes.

Evaluation of energy consumption in kiln drying of yellow poplar: major next generation plantation species in Korea. Park, J.H., Eom, C.D., Chang, Y.S., Son, K.Y., Choi, I.G., Lee, J.J., Yeo, H.Y. (*Seoul National University, Republic of Korea; gentleice@nate.com; willyeom@gmail.com; jang646@snu.ac.kr; Son7100@naver.com; cingyu@snu.ac.kr; junjae@snu.ac.kr; hyeo@snu.ac.kr*).

Yellow poplar, recognized as a next-generation species of tree for afforestation in Korea, has a superior growth increment and carbon dioxide absorption, so its area of afforestation is growing. Effort to reduce energy consumption has been continued, as a lot of energy is required for drying wood. This study simulated the drying process of yellow poplar and measured the energy consumption. From moisture content of 105%, the numerical simulation of yellow poplar during 120 hours showed a similar tendency with the reduction of moisture content in the actual drying process. The energy for drying wood was first classified in thermodynamic energy required for removing moistures from wood, the thermal energy required for heating the materials existing inside the dryer, and the thermal energy to compensate the heat loss in the system during drying process and each of them were estimated. This study provides an efficient drying schedule and a way to reduce drying energy consumption. The results of required energy evaluation and simulated MC decrement carried out in this study are expected to be used as an objective and quantified data proving competitiveness of emerging forest products as a material against climate change.

Effect of pruning on growth and wood quality of eucalypt clone planted in Brazil. Reis, G., Reis, M., Monte, M., Souza, F., Lopes, H., Alves, F. (*Universidade Federal de Viçosa, Brazil; greis@ufv.br; mgfreis@ufv.br; marco.monte@ufv.br; felippeenf@yahoo.com.br; hnslopes@yahoo.com.br; fredfa2003@yahoo.com.br*), Almado, R. (*ArcelorMittal BioEnergia, Brazil; roosevelt.almado@arcelormittal.com.br*).

Eucalypt species, widely planted in Brazil, can substitute for good quality wood exploited from native forest, maintaining biodiversity, if adequately managed by pruning and thinning. This study was undertaken to evaluate the effect of cloned eucalypt pruning on growth and wood quality. Treatments included different pruning intensity, frequency, and plant age at the first

intervention (16, 20, and 28 months) to obtain a 3-m log without branches. At the age of 55 months the first thinning was applied. At the age of 102 months, it was observed that pruning did not affect ($p>0.05$) plant growth, taper, flatness, and bow of the basal log. As a consequence of dead knot reduction with pruning, it was observed that the average longitudinal clear wood extension for all pruned treatments was 139, 125, and 118 cm when first pruning was applied, respectively, at the ages of 16, 20, and 28 months; while clear wood (control) reached only 81 cm These overall results indicate that by managing eucalypt through pruning there is a substantial increase in its wood quality, especially if applied at earlier ages, being a good substitute of wood from native forest.

Development of an energy saving lumber kiln dryer by applying CO_2 refrigerant heat pump. Shuetsu, S. (*Forestry and Forest Products Research Institute, Japan; shoechan@ffpri.affrc.go.jp*), Shida, S. (*University of Tokyo, Japan; ashida@mail.ecc.u-tokyo.ac.jp*), Kato, Y. (*Tokyo Institute of Technology, Japan; yukitaka@nr.titech.ac.jp*), Matsumura, Y. (*Forestry and Forest Products Research Institute, Japan; myukari@ffpri.affrc.go.jp*), Machida, A., Nishida, K., Kadowaki, K. (*Mayekawa Mfg. Co.,Ltd., Japan; Akito machida@mayekawa.co.jp; kousaku-nishida@mayekawa.co.jp; kimitaka-kadowaki@mayekawa.co.jp*), Ikeda, K., Hoshikawa, T. (*Shizuoka Research Institute of Agriculture and Forestry, Japan; IZX01361@nifty.ne.jp; hoshikawa.t@gmail.com*).

We proposed a new type of heat pump that did not use Freon refrigerants but rather used CO_2 refrigerant heat pump devices, to develop an energy saving pump with a low environmental load for kiln drying. Heat pumps are mechanisms that pump up a lot of heat with a little power. They have been used as cooling components of air conditioners for a long time. Freon refrigerants of R-22 components have a problem in that they cannot raise up over 50° in a kiln. The applications of heat pumps now have been expanded to heating components that use CO_2 refrigerant. CO_2 refrigerant components are designed for operating temperatures to 80° in a kiln. Heat pumps are expected to bring about much effect of energy conservation and low environmental load. Results of our calculation, in the case of a new type of heat pump with COP = 3, showed that it saved 58% of running cost and reduced carbon dioxide emission 64%. Primary energy consumption is 42% less than a combustion type boiler. This is a research and development projects for application in promoting a new policy for agriculture forestry and fisheries.

Survey the production of timber of *Pinus* spp., in the state of Parana, Brazil, from 1998 to 2008. Tetto, A.F. (*SEAB-PR/ Universidade Federal do Paraná, Brazil;*), Fialho, J.T. (*SEAB-PR, Brazil; alexandretetto@seab.pr.gov.br; fialho@seab.pr.gov.br*), Hoeflich, V.A. (*Universidade Federal do Paraná, Brazil; vitor.ufpr@gmail.com*).

The state of Paraná, in southern Brazil, has the third largest area of forest plantations and the largest area planted with *Pinus* (701,578 ha or 38.8%) in the country. In 2008, forest products presented 6.82% of the gross value of production (GVP) in the state. This work aimed to quantify and localize the production of logs of the genus *Pinus*, in the period 1998 to 2008, in Paraná. For this, the data from the Department of Agriculture, collected in the 20 regional centers through the state, were analyzed. The results showed that the production is specified in terms of genera, only for sawmill and mill logs. In 1998, there was no record of production of logs to mill. However, in 2008, there was a production of 4,798,540 m^3 for this purpose. The production of timber for sawmills, which in 1998 was 5,132,890 m^3, developed in 2008 to 10,658,160 m^3, representing an increase of 107.6%. The participation of these two categories accounted for 46.7% of the logs of all tree species in 2008, with most production concentrated in the south and southeast of the state.

Chemical modification of sesenduk *(Endospermum malaccense)* using pryponic anhydride: its dimensional stability. Uyup, M., Husain, H., Ramly, A., Abdullah Siam, N., Mahmud, S. (*Forest Research Institute Malaysia, Malaysia; mkanwar@frim.gov.my; hamdan@frim.gov.my; anaazrena@frim.gov.my; nordahlia@frim.gov.my; rafidah@frim.gov.my*).

Sesenduk (*Endospermum malaccense*) is classified as light hardwood and fast-growing species. Because of this advantage, this species is introduced as a plantation species. However, the dimensional stability of this species is low and not suitable for architectural applications. The present study was carried out is to improve the dimensional stability of sesenduk using chemical modification. The samples were modified using proponic anhydride. The samples were divided into two groups—extract and modify, and direct modification. In the former, the samples were extracted followed by chemical modification using acetic anhydride; in direct modification, the extraction process was eliminated. The weight percent gain (WPG) for extract and modify was 12% and 25% for direct modification when using 15% sodium formate as catalyst. The dimensional stability of modified samples improved significantly when compared to control samples. The modification improved the dimensional stability of sesenduk.

E-07 Sensing wood properties and allocation of round wood with respect to product requirements

Organizer: Gero Becker, *University of Freiburg, Germany, institut@fobawi.uni-freiburg.*

Wood properties and use of near infrared spectroscopy and terrestrial LiDAR to improve optimal bucking and wood value recovery. Acuna, M (*University of Tasmania, Australia; Mauricio.Acuna@utas.edu.au*), Murphy, G. (*Oregon State University, USA; glen.murphy@oregonstate.edu*).

In many parts of the world log markets are becoming increasingly competitive and complex. Wood properties—such as stiffness, density, spiral grain, and extractives content—are now being considered by log buyers. Assessing these properties in real-time will be a challenge for log supply managers. The utility of near infrared (NIR) technology for predicting wood density in Douglas-fir stems was examined. In this first study, wood disks were collected from 17 sites around Oregon. Each disk was cut with a chain saw, of similar gauge to that used on mechanized harvesters/processors, to provide saw chips. Near infrared spectra were then obtained for the chip samples. Multivariate techniques were used to correlate wood properties with the NIR spectra. The preliminary research results showed that NIR could be used to predict density. The density predictions should allow logs to be segregated into several density classes. In a second study, 18 plots in three radiata pine stands of different tree sizes were scanned

using terrestrial LiDAR systems. Tree locations were automatically detected using commercially available software. Stem profiles were measured using three methods: (1) from LiDAR scans, (2) by the harvester, and (3) manually after felling.

Analysis of moisture movement in wood using NIR spectroscopy and strain-stress occurrence in wood during drying. Eom, C.D., Chang, Y.S., Park, J.H., Yeo, H.Y. (*Seoul National University, Republic of Korea; willyeom@gmail.com; jang646@snu.ac.kr; gentleice@snu.ac.kr; hyeo@snu.ac.kr*).

For efficient use of wood, it is important to control moisture on and in wood. The near infrared ray (NIR) is applied to analysis of physical-chemical properties on the surface of wood rapidly in nondestructive way without pretreatment. In this study, it was intended to measure the moisture change on wood surfaces for analysis of moisture movement mechanism using peaks within 900–1,700 nm of range in steady and unsteady states. The drying stress generated on wood during drying was estimated by semi-experimental equation, with deformation measured with strain gauge. The remained stress in wood after drying was evaluated with destructive methods such as slice test. During the drying process, there occurred great surface strains along tangential and radial direction due to development of surface and cross-sectional checks. After the drying process finished at an early drying state, stress distribution showed tensile stress on the surface layer, while compressive stress in the core part. It is expected this high technique for measuring surface moisture content using NIR spectra can reduce the occurrence of surface-drying stress and control the development of wood checks. It also is expected to enhance the durability of wood and promote high added value to eco-friendly wood products.

Characterisation of tracheid cross-sectional dimensions of Scots pine and Norway spruce. Havimo, M., Rikala, J. (*University of Helsinki, Finland; mikko.havimo@helsinki.fi; juha.rikala@helsinki.fi*), Sirviö, J. (*VTT Technical Research Centre, Finland; jari.sirvio@vtt.fi*), Sipi, M. (*University of Helsinki, Finland; marketta.sipi@helsinki.fi*).

Mechanical and optical properties of papers depend, to a large extent, on the cross-sectional dimensions of fibres. The papermaking raw material in Finland mainly consists of Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), and variation in the tracheid cross-sectional dimensions of these two species has a large practical importance. In this study the variation in one stand was mapped, and distributions were created for different raw material assortments, like top pulpwood and sawmill chips. The data were obtained from a mixed stand of Scots pine and Norway spruce. Five spruces and five pines were felled, and ten disks were taken from each trunk. From each disk, tracheid cross-sectional dimensions were measured from pith to bark with SilviScan device. A new computer program was created to handle the large measurement data obtained with SilviScan. The program creates distributions and averages of cross-sectional dimensions for different wood assortments. There was only moderate difference between top pulpwood and sawmill chips with regard to tracheid cell wall thickness, or radial and tangential diameters. The largest differences were between earlywood and latewood. If earlywood tracheids can be separated after pulping, for example with a hydrocyclone, one would get very homogenous fibre raw material.

Improved wood allocation with respect to product requirements and sustainability based on property measurements, models, and forest resource databases. Lundqvist, S., Grahn, T., Olsson, L. (*Innventia, Sweden; svenolof.lundqvist@innventia.com; thomas.grahn@innventia.com; lars.olsson@innventia.com*).

Wood shows large variation in properties among species, trees growing under different conditions, and parts of trees. The allocation of suitable materials to mills, processes, and products is crucial for product quality, production efficiency, and sustainability. Information about properties of wood in available forest resources has to be related to product requirements, considering also other constrains. To provide this, forest resource databases are built, where conventional forest inventory data are complemented with predicted property data. First, property models are developed from measurements on samples reflecting major property variations in the resource and integrated with growth models. Then inventory data for large numbers of trees representing the resource are used as input data to successive simulation of size, shape, internal growth patterns; and variations in wood, fibre, and knot properties within the stems. Next, the simulated stems are cross-cut in the computer into logs and other parts related to potential products. Volumes and properties of all units are calculated and compiled in the database. Forest resource databases have been built for geographic areas of various sizes: from supply areas of mills to the whole country of Sweden. They have shown useful both in industrial applications and a sustainability study.

Improving the efficiency of the wood supply chain in the United Kingdom by segregating logs based on their mechanical properties. Mochan, S., Connolly, T. (*Forest Research, UK; shaun.mochan@forestry.gsi.gov.uk; tom.connolly@forestry.gsi.gov.uk*), Moore, J. (*Edinburgh Napier University, UK; j.moore@napier.ac.uk*).

In the production of sawn timber, strength grading of the product typically occurs at the end of the process. Unfortunately, with the inherent variability of wood, this can cause significant reduction in value as unsuitable timber is detected late in the conversion process, incurring unnecessary financial and environmental costs. In the United Kingdom, most of the sawn construction timber produced by local mills is Sitka spruce (*Picea sitchensis*) and this timber meets the requirements for the C16 strength class (BS EN 338, 2003). Pass rates of approximately 90% are generally obtained when timber is graded to C16; however, there is concern that this pass rate may decline as rotation lengths decrease and material from stands established at wider initial spacing is harvested. Therefore, it would be advantageous if those trees and logs that are likely to produce timber that fails to meet the requirements for the C16 strength class could be identified. One approach to this is through the use of portable acoustic tools that allow non-destructive assessment of wood properties before or after a tree is felled, so it can be allocated to a particular use before processing; trees and logs with poorer mechanical properties would not be processed.

Matching forest raw material with industrial requirements to enable optimal wood allocation to the industry: decision support system based on quality information derived from airborne LiDAR. Opferkuch, M., Smaltschinski, T., Becker, G. (*University of Freiburg, Germany; martin.opferkuch@fobawi.uni-freiburg.de; thsm@gmx.de; gero.becker@fobawi.uni-freiburg.de*).

Development of forest utilization concepts relies on spatially actual and precise techniques, considering both forest structures and industrial requirements. We discuss an approach for an industry-specific allocation of wood regarding quality, quantity, and

location, the so called "forest warehouse" allowing for efficient measurement, data management, and sound decisions through different methods and systems such as LIDAR, GIS and GPS. This GIS-supported management and decision support system is the interface between the diverse forest resource and a production-oriented and product-specific wood allocation to the industry. It allows the assessment of cutting volumes giving at the same time precise information about wood location and properties in order to enable matching of raw material with industrial requirements. This ensures optimized industrial processing design with minimized quality failures, sorting procedures, culls, and breakdowns. The objective is the development of concepts and instruments for achieving a product-specific allocation of wood, optimizing supply chain management, and ensuring just-in-time delivery. This includes logistical aspects such as the selection of suitable harvesting systems, stack management, or routing, as well as the application of different methods of operations research and the optimization of process chain information flow. Applied data are industrial requirements, forest inventory data, and spatial information.

Towards a quality-optimised timber production: measurements of knots in roundwood prior to sawing using CT technology. Sauter, U.H., Breinig, L., Brüchert, F. (*Forest Research Institute of Baden Württemberg, Germany; udo.sauter@forst.bwl.de; lorenz.breinig@forst.bwl.de; franka.bruechert@forst.bwl.de*).

Computed tomography has proven to be a non-destructive method well-suited for imaging internal properties in roundwood. Knots are of major relevance for the quality and the value of sawn products. Hence it is desired to design a CT-based computer vision system that automatically detects knots in sawlogs prior to sawing and allows for determining an optimised sawing pattern by rendering geometrical models of the knots. Image analysis algorithms processing CT images acquired by a CT scanner custom-built for roundwood have been developed that segment and measure knots. In order to validate these measurements and to determine the accuracy of the image analysis algoritms, a method has been developed for accurately reproducing the virtual cross sections, i.e., CT images, as physical cross-sections and thus allow for a direct comparison with manually acquired measurements. The comparison performed showed that both measurements were in accordance with the measurements obtained by the image analysis algorithms exhibiting a slight tendency towards overestimation. It was concluded that the image analysis method developed is in principle suitable for knot detection and measurement. The algorithms developed allow one to quantify knots in any potential plane, which leads towards the requirement for sawing optimisation.

Posters

Expansion factors between byproducts and solid pine wood at Durango, Mexico. Hernández-Díaz, J.C., Nuñez-Sarabia, M.Y., Aviña-Berumen, L.J., Corral-Rivas, J.J., Pinedo-Álvarez, A. (*Universidad Juárez del Estado de Durango, México; jciroh@ujed.mx; yolis_sarabia@hotmail.com; lavina@ujed.mx; jcorral@ujed.mx; apinedo@ujed.mx*).

This work aimed to foster sustainability by facilitating monitoring of the process of manufacturing pine trees for the sawmilling industry. Samples of "solid wood" consisted of extracting little cylinders with a Pressler drill at a height of 1.30 m from pine trees of forests in Canelas, San Dimas, Pueblo Nuevo, and Durango municipalities. A second sampling phase was performed in forestry firms located in the cities of Durango, El Salto, and Santiago Papasquiaro, where most of the state's sawmilling enterprises are located. Samples were taken of byproducts such as sawdust, chips, and shavings. First the masses of 19.295 dm^3 of sampled byproducts (type 1 samples) were measured; then, a small amount of byproduct (type 2 sample) was taken from each type 1 sample and analyzed at the Wood Technology Laboratory of the Instituto de Silvicultura e Industria de la Madera (ISIMA-UJED) in Mexico. Based on these field and industry samples, calculations were made of pine wood density at different humidity levels, and expansion factors were estimated ranging from 2.3 to 3.3, which represent equivalence coefficients between byproduct mass and volume and the corresponding mass and volume of solid wood, considering that both wood presentations have a similar humidity contents.

Development of microwave sensing technique for measuring internal moisture profile in wood. Son, K.Y., Chang, Y.S., Park, J.H., Choi, I.G., Lee, J.J., Yeo, H.Y. (*Seoul National University, Republic of Korea; son7100@snu.ac.kr; jang646@snu.ac.kr; gentleice@snu.ac.kr; cingyu@snu.ac.kr; junjae@snu.ac.kr; hyeo@snu.ac.kr*).

Moisture content significantly affects the mechanical properties of wood, so measuring moisture content is the first step to understand wood. The most widely used method is the oven- dry method, which is known to have the highest accuracy. However, for this method, material loss is inevitable, and it takes long time. In this study, to overcome demerits, moisture content in wood was measured using microwave, based on the fact that attenuation and phase shift happens as the moisture content varies when microwaves go through dielectric substances. In addition, the portability of microwave equipment was evaluated. Using 10.5 GHz microwave, chosen after analyzing wood at various frequency levels, moisture content was measured as the thickness of wood board changes. Thinner boards had higher accuracy of measurement. Microwave changes sensitively below the fiber saturation point; however, when higher than saturation point, the sensitivity of microwave drops rapidly. There seemed to be limits in measuring moisture content using microwave that should be covered. The microwave CT scanning technique is developed for measurement and control of internal moisture profile in wood in this study. It is expected to be ranked as an environmentally friendly technique for control of wood and enhancement of wood durability.

E-08 Surface processing and treatment technologies for wood and wood based materials to enhance durability and performance

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Effects of intumescent formulation of vinyl acetate-based coating on flame-retardancy of thin painted red lauan (*Parashorea* spp.) plywood. Chuang, C. (*National Taiwan University, China-Taipei; r91625012@ntu.edu.tw*), Tsai, K. (*National*

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Using intumescent coatings on wood-based materials is an effective method for fire safety. The intumescent coatings consist of four major components: (1) binder resin (BR), (2) carbonizing substance (CS), (3) foam-producing substance (FPS), and (4) dehydrating agent (DA). Previous studies have demonstrated that the formulation of the four components strongly influences the performance of coatings. This study investigated the effect of intumescent formulation of vinyl acetate-based coating on flame-retardancy of plywood. Two sorts of widely used binder resin (BR) for vinyl acetate-based coating, ethylene vinyl acetate copolymer (EVAc) and vinyl acetate acrylic copolymer (VAC), were used. The fire retardancy of coatings on plywood was assessed by a cone calorimeter. Total heat release and time to peak heat release rate are the two primary parameters. The data showed that lower BR and FPS content decreased total heat release and lengthen time to peak heat release rate. This mechanism to achieve better fire performance was verified by using oxygen bomb calorimeter and thermogravimetrical analysis, exhibiting lower heat of combustion and weight loss. Moreover, evaluated by ^{31}P NMR, the lower BR and FPS content can extend the survival duration of phosphor-carbonaceous chars. The results provide information for designing vinyl acetate-based coating.

Manufacture of ultrastrength nanopapersfrom cellulose nanofibrils. Lee, S.Y., Chun, S.J., Doh, G.H. (*Korea Forest Research Institute, Republic of Korea; nararawood@forest.go.kr; sangjinchun@hanmail.net; ghdoh@forest.go.kr*).

Cellulose nanofibrils with diameters below 100 nm were isolated by a chemical or mechanical treatment. Mechanical treatment with acid hydrolysis results in even finer cellulose nanofibril structures with diameters below 50 nm. Prior to the homogenization process as a mechanical treatment, the fibril bundles of dispersed cellulose in deionized water are separated from the fiber wood cell wall with a homogenizer. Thereafter, dispersion and homogenization of the cellulose fibrils were carried out by application of a high pressure homogenizer. Nanopapers were made by removing water from cellulose nanofibril suspension on filter paper. The main objectives of this study were to examine the effects of the homogenization process on the morphology and particle size of cellulose nanofibrils and to investigate the effects of the degree of homogenization and the alkaline and silane treatments for cellulose nanofibrils on the mechanical properties of the resultant nanopapers.

Effect of heat treatment on the dimensional stability and surface properties of rubberwood (*Hevea brasiliensis*). Ratnasingam, J. (*Universiti Putra Malaysia, Malaysia; jegaratnasingam@yahoo.com*), Ioras, F. (*Buckinghamshire New University, UK; florin.ioras@bcuc.ac.uk*).

Heat treatment is often used to improve the dimensional stability of wood. In this study, the effects of heat treatment on the dimensional stability and surface roughness of rubberwood (*Hevea brasiliensis*), subjected to heat treatment at varying temperatures and for different durations, were examined. The oven-dry density, air-dry density, and swelling properties of the heat-treated and control rubberwood samples, were determined. A stylus method was used to evaluate the surface smoothness of the samples. Roughness measurements were made in the direction perpendicular to the fibre. Four main roughness parameters—mean arithmetic deviation of profile (R_a), mean peak-to-valley height (R_z), root mean square roughness (R_q), and maximum roughness (R_y)—obtained from the wood surface were used to evaluate the effect of heat treatment on the surface smoothness of the specimens. Significant differences were observed ($p = 0.05$) for the dimensional stability and surface roughness parameters under the different heat-treatment variables used. The values of density, swelling, and surface roughness decreased with increasing temperature treatment and treatment times. Therefore, heat treatment allows rubberwood to be successfully utilized for value-added products manufacture, where dimensional stability and surface smoothness are important, such as for window frames.

Antibacterial property of China fir/TiO_2 composite. Suyong, H. (*Southwest Forestry University, China; lillahuangsuyong@sina.com*), Kaifu, L. (*South China Agricultural University, China; kfli@scau.edu.cn*).

Small samples (20 × 20 × 0.2 mm) of China fir/TiO2 composite were made by sol-gel method and MWLPD (microwave assistant liquid phase deposition) method for the first time (the size of TiO_2 crystals are 16.4 nm and 28.3 nm respectively). Part of the antibacterial property has been verified. The results are as follow: (1) *Escherichia coli*, *Salmonella typhimurium*, *Staphylococcus aureus*, and *Bacillus subtilis* were regarded as testing targets in the antibacterial testing. The antibacterial rates of China fir/TiO_2 composite were over 90%, meaning the antibacterial function is broad-spectrum and prominent. (2) When China fir/TiO_2 composite samples were put in air for different times after being made (1 month, 6 months, and 1 year), there was almost no change in antibacterial rates. (3) Antibacterial property is influenced by light supply (UV light, mercury lamp, natural light, fluorescence lamp, and dim light), because TiO_2 is a photocatalysis antibacterial agent. The least antibacterial rate of samples (dim light supply) is still over 80%. Testing temperature (10 °C, 20 °C, 30 °C, 37 °C) really does something to the antibacterial property, because bacterial activity is influenced by temperature. The least antibacterial rate of samples (testing temperature is 10 °C) is still over 85%.

Effect of weathering on the properties of plybamboo after 1 year exposure. Uyup, M., Husain, H., Mohmod, A. (*Forest Research Institute Malaysia, Malaysia; mkanwar@frim.gov.my; hamdan@frim.gov.my; latif@frim.gov.my*), Md. Tahir, P. (*Universiti Putra Malaysia, Malaysia; parida_introb@yahoo.com*), Mahmud, S. (*Forest Research Institute Malaysia, Malaysia; rafidah@frim.gov.my*).

The objective of this study is to determine the effect of weathering on the properties of plybamboo after 1 year exposure. The dimensional stability of plybamboo is relatively poor as compared to that of plywood. Thus, the impregnation modification method using phenolic resin was used to improve the dimensional stability of the plybamboo. The resin was impregnated into bamboo strips before plybamboo is produced. The MOR, MOE, and compression parallel to grain of the phenolic-treated plybamboo (PTP) were significantly higher compared to those of untreated plybamboo. After 1 year exposure to weathering conditions, the study showed that the strength properties of treated plybamboo decreased by about 35%, while the untreated plybamboo failed after 5 months of exposure. From the observations, the colour of untreated plybamboo has changed to dark whilst the treated remained unchanged. Generally, the treatment of bamboo strips with phenolic resins was found to significantly improve the properties of plybamboo and the surface of the products.

Theoretical discussion on water movement and force during wood vacuum drying. Zhengbin, H., Xueli, Y., Liqiong, C., Songlin, Y. (*Beijing Forestry University, China; gagongjoy@163.com; yaoxueli0304@163.com; fujianclq@126.com; ysonglin@163.com*).

Most of parameters in conventional drying cannot explain a lot of phenomena that appear in a vacuum condition, so it is necessary to further explore the internal water movement in wood under vacuum conditions. Because the water movement channel in wood is very narrow, the characteristics of heat and mass transfer in wood is the same as that found in microscale. This article applies the theory of liquid boiling nucleation in microscale combined with wood structure; and deduces the vessel's critical radius of wood if the water in wood could boil under 60 °C-100 °C and 0.01 Mpa, 0.02 Mpa respectively. We conclude that: (1) water in wood moves in the form of fictitious boiling but not bubbles boiling during the drying process; (2) there will also be a certain degree of pressure pulse during the process of water nucleation throughout drying, which drives the moisture inside to move out; (3) because the pressure is low in vacuum drying, which leads water coming out in the bubble form, the water potential is higher than that of conventional drying, which results in the vacuum drying rate becoming much faster.

Posters

Application of technologies for the production of furniture from tropical veneer pieces. Alvarez, D., Rodríguez, A., Castañeda, O. (*Universidad de Pinar del Río, Cuba; daniel@af.upr.edu.cu; mail.upr.edu.cu; oscar@ecomail.upr.edu.cu*).

The project aimed to examine the production of furniture of veneer pieces in order to satisfy the growing needs of people by means of advanced technology. Experiments carried out in the laboratories of the Study Centre for Integrated Use of Plant Biomass of the University of Pinar del Río, showed that the durability of furniture processed with the suggested technology exceeded 15 years of service life. The goods produced are characterized by the fact that raw materials have been used that are available in the country but are not applied for this purpose. The technological process permits the production of profiles with 1.5 times less wood and a double increase in real productivity throughout the whole process. As a result, furniture of high comfort and great artistic beauty are obtained, as has been certified by the renowned IKEA company based in Sweden. The use of veneer pieces for the production of furniture allows the creation of new articles that are characterized by simplicity, plasticity, a high degree of compositional mobility, and mechanical resistance, resulting from the optimized technological process.

Studies on potential lightening of glue line colour in exterior plywood resinated with PF resin. Dukarska, D., Łęcka J. (*University of Life Sciences, Poland*; *ddukar@up.poznan.pl; jlecka@up.poznan.pl*).

PF resin is a bonding agent providing wood-based materials with high water resistance and strength. However, the dark colour of glue lines is a defect of this resin. It has a particularly adverse effect on decorative value of plywood with increased water resistance and for esthetic reasons its further applications are limited. This study was an attempt to lighten glue line colour by adding titanium (IV) oxide (TiO_2) as pigment to PF resin and different inorganic fillers with a high degree of whiteness, e.g., barite, chalk, and talcum. Moreover, fumed nanosilica was used in liquid PF resin as an auxiliary pigment-stabilizing agent and viscosity regulator. The study included the determination of the effect of applied additives on properties of glue mixture, i.e., reactivity defined by its gel time at 130 °C, viscosity at 20 °C, colour of cured resin, and plywood properties (bond quality according to EN 314-1, bending strength, and modulus of elasticity according to EN-310). Analyses showed that it is possible to produce exterior plywood with considerably lightened PF glue line, plus water resistance and high strength required for bond quality class 3.

Effect of chemical modification of fillers on mechanical properties of polypropylene-based composites. Gwon, J.G. (*University of Seoul, Republic of Korea; titania1@paran.com*), Lee, S.Y., Chun, S.J., Doh, G.H. (*Korea Forest Research Institute, Republic of Korea; nararawood@forest.go.kr; sangjinchun@hanmail.net; ghdoh@forest.go.kr*), Kim, J.H. (*University of Seoul, Republic of Korea; jhkimad@uos.ac.kr*).

Because of the limitations of fossil fuel, renewable and low cost materials are gaining popularity. Bio-composites reinforced with wood fibers and mineral fillers attract great attention in regions of alternative materials. In this study, we investigated the effects of chemical modifications (alkali and silane) of wood fibers and mineral fillers on tensile strength of mineral-filled, wood fiber-reinforced, polypropylene-based composites. A silane (triethoxyvinylsilane) treatment was used to modify the wood fiber and talc in order to improve in adhesion between matrix polymer and fillers. Experimental ranges of silane concentrations were varied from 0.5 wt% to 3.0 wt% to obtain the optimal value for tensile strength. Tensile strengths of composites were significantly influenced by alkali treated wood fiber and also mineral filler (talc) depending on the silane concentrations. The optimum concentrations of silane for treating wood fiber and mineral talc to achieving the highest strength were about 2.5 wt% and 2 wt%, respectively. This effect of silane treatment on improving the tensile strength could be attributed to the compatibilization between matrix polymer and chemically treated fillers (wood fiber and talc).

Effect of heating on aldehydes emissions from solid wood. Ishikawa, A., Miyamoto, K., Tohmura, S., Inoue, A. (*Forestry and Forest Products Research Institute, Japan; aishi@ffpri.affrc.go.jp; mkohta@ffpri.affrc.go.jp; tomura@ffpri.affrc.go.jp; ainoue@ffpri.affrc.go.jp*).

Aldehydes released from wood and wood products have become a public concern in Japan. Acetaldehyde is known to be a probable carcinogen and is sometimes found in indoor air in concentrations exceeding the safety guidelines. We have found that acetaldehyde is produced from wood by heating or reaction with ethanol, but the mechanism remains unclear. In this study, the effects of heating and adding ethanol on acetaldehyde emissions from solid wood were investigated. Sugi (*Cryptomeria japonica*) green wood was used. Specimens of heartwood and sapwood with dimensions of 20 × 20 × 10 mm were prepared, and then heated at 28-180 degrees Celsius for different treatment times. Ethanol was dropped onto half of the specimens. Each specimen was kept in a syringe for 24 hrs, then the air in the syringe was sampled and analyzed by high-performance liquid chromatography. Significant acetaldehyde production was observed only when ethanol was dropped onto wood specimens that had been heated for a short time or at lower temperature. These results indicated that heating of wood can inhibit the emission of acetaldehyde from solid wood through the reaction with ethanol.

Morphological characteristics of carbonized wood-based materials at different temperatures. Jang, J.H., Kim, N.H. (*Kangwon National University, Republic of Korea; jhtojh@kangwon.ac.kr; kimnh@kangwon.ac.kr*), Park, S.B., Lee, S.H. (*Korea Forest Research Institute, Republic of Korea; parksb@forest.go.kr; kori0909@kanwon.ac.kr*).

Wood-based material boards are usually made with formaldehyde adhesives, and the formaldehydes can be removed by the carbonization process. Carbonization of boards requires, therefore, a potential source to obtain high functional carbon materials having various allotropic structures. The structural changes of the control wood (*Fraxinus rhynchophylla*), plywood, particleboard, and MDF carbonized at several temperatures ranging from 300 to 2,000 °C have been investigated to identify the carbonization characteristics. SEM and X-ray diffraction methods were used in the study. Energy dispersive X-ray operating with an accelerating voltage of 20 kV was used simultaneously. The cone or needle-shaped carbon structure was found from the SEM observations on all the carbonized boards at temperatures up to 1,800 °C. Especially a distinct needle-shaped carbon was found in the cell lumen of plywood at 1,800 °C. There was no change in peak position in the X-ray diffraction result between 300 °C and 1,500 °C, although there is a shift to a wider angle for the samples treated above 1,600 °C. A sharp peak appeared from the sample carbonized at 1,600 °C. From the EDX-ray analysis, it was found that the plywood carbonized at 1,800 °C was composed mainly of carbon and small amounts of silicon (Si).

Chemical treatment of oil palm lumber, an emerging non-timber forest product in the West African sub-region. Okai, R., Mensah P. (*University of Education, Ghana; reynoldsokai@yahoo.co.uk; prospermensah@gmail.com*).

Until recently, oil palm trunks were left to rot or burnt in the forest to pave the way for farming activities. Lumber produced from oil palm trunk has been found to be suitable for the production of light-load-bearing products such as coffee tables and centre tables. However, a major characteristic of the oil palm lumber that is making the industry shun its use is the surface discoloration associated with it. This study examined the factors influencing discoloration of oil palm lumber with the objective of recommending to the industry appropriate preservatives for the treatment of oil palm lumber. Wood samples of palm lumber of thickness 4 cm were conditioned in a kiln to a moisture content of 20%, 30%, 40%, and 50% after immersion in sea water for 48 hours, fresh water for 48 hours, and dursban 4E for 48 hours, and the surfaces monitored for 18 weeks. No discoloration was found on the surfaces of the oil palm lumber only when it was immersed in fresh water for 48 hours and thereafter immersed in dursban for another 48 hours before kiln drying.

Effects of carbonization temperatures on thermal properties and combustibility of MDF-carbonized boards. Park, S.B., Kim, J.J., Lee, S.M., Park, J.Y., Park, J.S., Kim, D.H. (*Korea Forest Research Institute, Republic of Korea; parksb@forest.go.kr; jikim99@forest.go.kr; sml5@forest.go.kr; jypark@forest.go.kr; jusang@forest.go.kr; k3d2h1@forest.go.kr*).

Wood charcoal has a good adsorptivity as a porous carbon material and has a good resistance against heat and decay. In Korea, wood charcoal with the high adsorptivity and heat resistance has been manufactured to be utilized in panels for beds, walls, and ceilings. In order to form board-type building materials, charcoal powder is commonly applied with organic or inorganic binders under high pressure and temperature conditions. However, in the forming process it loses some of its adsorptivity and produces some harmful gases during combustion. To use intrinsic characteristics of charcoal in board-type building materials, recently, we developed a new carbonization method using wood-based panels such as medium density fiberboard (MDF). The carbonized boards showed the same properties as wood charcoal, and they did not show any cracks or deformation after carbonization. In this study, we investigated the effects of carbonization temperatures on the thermal properties and the combustibility of carbonized boards to find possibilities as building materials. The thermal properties of carbonized boards were checked by DSC, and the combustibility was tested by KS F ISO 5660-1 with a dual cone calorimeter.

Manufacturing techniques of calligraphy-carving products using carbonized MDF boards. Park, S.B. (*Korea Forest Research Institute, Republic of Korea; parksb@forest.go.kr*), Ryu, H.S. (*2Mok Min Gallery, Republic of Korea; ryusoo8359@hanmail.net*), Lim, K.H. (*3Dai Yang Industrial Co, Republic of Korea; ceo@sic-carbon.com*).

We manufactured carbonized boards using medium density fiberboard (MDF) and investigated various properties of the carbonized boards. The carbonized porous boards show high volatile organic compound (VOC) adsorptivity, dimensional stability, and electromagnetic wave shielding effectiveness. In this study, we developed techniques to make calligraphy-carving products using carbonized boards. The calligraphy-carving products are new visual artworks having functionalities of wood charcoal. The calligraphy-carving products can be made by a sculptor's hand for individual artworks or a sand blaster machine for commercial artworks. In case of the calligraphy-carving products by a sculptor's hand, letters, figures and patterns were embossed on the surface of the fancy veneer overlaid MDF, and then carbonized in kiln by the pressure carbonization method at 850 °C. Embossed parts of the carbonized products were colored. On the other hand, the calligraphy-carving products by a sand blaster machine were made directly on the carbonized board, and then embossed parts of the carbonized products were colored. The ratios of shrinkage of length, width, and thickness of MDF after carbonization were investigated. In addition, weight loss and density change after carbonization were also determined.

Insecticidal activity of *Thuja occidentalis* essential oil and monoterpenoids against *Myzus persicae*. Song, H.J., Min, J.Y., Jeong, M.J., Heo, C.M., Kim, H.G., Sim, S.J., Yang, J.K., Choi, M.S. (*Gyeongsang National University, Republic of Korea; hyunjin617@hanmail.net; j-yoon0830@hanmail.net; jmivy121@naver.com; miya0726@nate.com; king3108@naver.com; tla23@nate.com; jkyang@gnu.ac.kr; mschoi@gnu.ac.kr*).

This study was determined insecticidal activity of *Thuja occidentalis* essential oil and monoterpenoids with surfactants against *Myzus persicae.* Insecticidal activity of *T. occidentalis* essential oil and monoterpenoids were tested through fumigant. Insecticide activity by spraying was determined to concentration (1%, 5%, 10%, and 15%) of *T. occidentalis* essential oil, terpinyl acetate, and bornyl acetate. In fumigant test, *T. occidentalis* essential oil showed insecticidal activity 60% for 12 hours and 100% for 24 hours at doses of 2 μℓ after treatment. In spraying test, *T. occidentali* essential oil at doses of 15% led to 100% death and terpinyl acetate at doses of 10% led to 100% death at 30 hours; bornyl acetae at doses of 15% showed 82% death at 30 hours. Effects of surfactants in this insecticide were determined. Formulation (*T. occidentalis* essential oil at 15% with nonyl phenol-10

mole-phosphate at 8% and terpinyl acetate at 10% with Tween #20 at 8%) showed 100% insecticidal activity at 30 min. This result was indicated that formulation with *T. occidentali* leaf essential oil might be useful bioinsecticide.

Multilayer hot-press drying and chemical modifying of poplar wood with urea-formaldehyde prepolymer. Wu, G., Jiang, Y., Yao, S., Qu, P., Chen, H., Pu, J. (*Beijing Forestry University, China; wu_guofeng@yahoo.cn; 30073609@163.com; yao.sh@163.com; qupinghappy@163.com; hillyo@126.com; jwpu@bjfu.edu.cn*).

The objective of this study was to determine the technology for chemical modifying and multilayer hot-press drying on poplar wood. The chemicals can be impregnated into cell lumen spaces by pulse-dipping machine to improve dimension stability and mechanical properties of timber. Timbers were compressed and dried by multilayer hot-press drying to increase the timber density. Results indicate that the physical and mechanical properties were comparable between modified timber and natural timber. Results demonstrated that the density of modified wood improves 58.1%, the hardness of the end profile surface improves 66.6%, while at tangential direction 210% and radial 160%, the bending strength improves 77.8% and the bend elastic modulus improves 66.3%. The improvements of mechanical property were due to the reinforcement of chemicals on the cell wall and lumen spaces of wood. Characteristics for modifying were studied using Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD). The intensity of hydroxyl absorption peak in the infrared absorption spectrogram decreased significantly, and that of carbonyl decreased lightly. The crystallinity of wood increased lightly. Four morphologic models of chemicals within wood were discovered by SEM.

E-09 Enhancement of service life of wood in an environmentally conscious global society

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Posters

Determination of equilibrium moisture content (EMC) of wood in the neighboring countries of Iran. Enayati, A., Zare Hosseinabadi, H.Z. (*University of Tehran, Iran, aenayati@ut.ac.ir; hfzare@ut.ac.ir*).

The mean values of annual temperature and relative humidity of 33 cities in Azerbaijan, Armenia, Turkmenistan, Afghanistan, Pakistan, Oman, United Arab Emirates, Bahrain, Qatar, Kuwait, Iraq and Turkey were determined using climatic data of the past 11 years. The EMC values were calculated using the Hailwood-Horrobin sorption model and its annual fluctuation, together with Temperature and relative humidity, were determined. The results indicated that EMC Values in the cities were ranged from 5.6% to 15.6%. Comparing annual temperature, relative humidity and EMC curves of these cities and conducting statistical analyses, the cities were classified into five groups with mean EMC values of 6.6, 8.6, 10.6, 12.6 and 14.6 percent. Thus, the results showed that EMC of the cities were below or equal to the allowable moisture content of wood and, wood products and the other hygroscopic materials (leather, textile and related products) in service except in Baku in Azerbaijan (EMC = 15.6%). Therefore, if wood and wood products and related hygroscopic materials are processed within the range of the respective moisture content and exported to the neighboring countries of Iran, their quality and durability could be guarantied.

Effect of addition of nanosize copper oxide particles on some properties of flakeboard. Gao, W. (*Beijing Forestry University, China; gaowei21230@163.com*), Kamdem, D. (*Michigan State University, USA; kamdem@msu.edu*), Cao, J. (*Beijing Forestry University, China; caoj@bjfu.edu.cn*).

The effects of nanosize copper oxide and basic copper carbonate on physical and mechanical properties of flakeboards prepared with mixed wood species were investigated. Flexural properties, internal bond strength, water absorption and thickness swelling were determined according to ASTM Standard D-1037, and the curing process of phenol formaldehyde (PF) resin containing nanosize copper oxide and basic copper carbonate was investigated by using dynamic differential scanning calorimetry (DSC). Nanosize copper oxide showed an optimistic effect on the internal bond strength (IB), modulus of rapture (MOR), and modulus of elasticity (MOE) and dimensional stability (thickness swelling at edge (TS) and water absorption (WA)) of flakeboard. While basic copper carbonate increased thickness swelling and water absorption to some extent, but the difference was not statistically significant. The DSC results indicated that the activation energy and the reaction enthalpy of PF resin decreased significantly with addition of 0.68% basic copper carbonate, which resulted in the relatively lower bond strength. However, comparable activation energy and reaction enthalpy, obtained from nanosize copper oxide treated samples, contributed to the higher degree of conversion of PF resin and better bond strength.

Distributions of metal components leached from CCA treated wood in soils: potential impacts of CCA-treated wood on environments. Kang, S.M., Kang, D.Y., Kang, S.K., Koo, W.M., Kim, K.M. (*Korea Forest Research Institute, Republic of Korea; kangsm@forest.go.kr; yeop82@gmail.com; richard514@korea.ac.kr; dnjsah85@naver.com; schizo09@naver.com*).

Chromated copper arsenate (CCA) had been the most widely used wood preservative in Korea until it was banned in 2007. However about 1 million m^3 of CCA treated wood are still in service in Korea. The toxicity of chromium and arsenic in this preservative has raised environmental concerns for the metal leaching from CCA-treated wood. The total concentrations and their speciation of copper, chromium, and arsenic in soil surrounding CCA-treated wood was investigated at several test sites in Seoul, Republic of Korea, to determine the horizontal and vertical distribution and accumulation of the metals. The physicochemical properties of the tested soils were investigated to understand the effect of soil properties on the CCA mobility. The results indicated that the mobility of metal components was very limited to the surface area adjacent to CCA-treated wood. Arsenate and trivalent chromium existed mainly in the environment and the treated wood. Although soil contamination due to the presence of

CCA-treated wood might be minimal, the metal components would be persistent and accumulate in the soil, resulting in high chemical concentration within the service area of treated wood.

Development of ecological river technology using brushwood mattresses. Lee, D.H., Hwang, W.J., Yoo, K.J., Kim, W.J. (*Korea Forest Research Institute, Republic of Korea; heub@korea.kr; wonjoung@korea.kr; petera@forest.go.kr; waejn@korea.kr*).

Recently the environment near the river is noticeably changing due to social-economic turnover. The river is not simply playing a role as a flood control and water flow, but also is connected to the reproduction, living environment, and "waterfront" for every living organism requiring water. Therefore, there is a need to develop and maintain nature-friendly waterfronts based on environmental considerations. Brushwood mattresses can be used as river materials, made of stones and hardwood branches, which are very strong and stiff, and so very efficient in preventing scouring of the river. Particularly, the material is effective in fixing the bottom part of the base river to protect from dike breaks. Also, various spaces within the mattresses facilitate useful environments for aquatic organisms. Due to anaerobic conditions, submerged brushwood mattresses do biodegrade easily, hence they retain stored carbon longer and prevent release of greenhouse gases compared to other forest products that biodegrade relatively easily. Creating environmentally friendly rivers for living organisms with brushwood mattresses, instead of concrete covers, would provide precious inheritance that eases environmental pressures for next generation. This study reports the on-site delivery process of this ecological river technology.

Utilization technology of forest by-products as environmentally friendly construction materials. Lee, D.H., Hwang, W.J., Yoo, K.J., Kim, W.J. (*Korea Forest Research Institute, Republic of Korea; heub@korea.kr; wonjoung@korea.kr; petera@forest.go.kr; waejn@korea.kr*).

Recently the government called for constructive technical development of low-carbon green growth, yet our circles of concrete structures and asphalt created by urban development are still increasing, life functions are damaged, and the heat island effect in cities does not improve. Quality of life and habitats for living creatures are decreasing. To solve such problems, we must have improved landscape architecture and buildings that mimic natural functions, such as emissions, drainage and storage of water, soils, and animal and plant habitats. For landscaping and engineering, ferroconcrete is mediocre because it takes a large amount of manufacturing energy, and stone as infrastructure would increase environmental costs. We need infrastructure that is simple, does not have strength problems, and is biodegradable—such as lumber. Despite such needs, in about the past 50 years, the domestic construction market has focused on ferroconcrete construction. So using timber as a material of construction has been devalued by consumers and the field of timber as an engineering material is wholly lacking. In this study, the goal is to renew interest in species of trees in order to develop the technology for manufacture and use of pitch pine (*Pinus rigida*).

Chemical composition and essential oil yield as environmental factors in *Chamaecyparis obtusa* leaves. Min, J.Y., Heo, C.M., Jeong, M.J., Song, H.J., Kim, H.G., Sim, S.J., Lee, J.Y., Yang, J.K., Choi, M.S. (*Gyeongsang National University, Republic of Korea; j-yoon0830@hanmail.net; miya0726@nate.com; jmivy121@naver.com; hyunjin617@hanmail.net; king3108@naver.com; tla23@nate.com; yyamy2me@nate.com; jkyang@gnu.ac.kr; mschoi@gnu.ac.kr*).

Essential oil is a volatile fragrance compound produced from plants as secondary metabolites, and essential oil from *Chamaecyparis obtusa* leaves was found to possess strong antimicrobial activity against microorganisms. We investigated several environmental factors affecting essential oil yield: regional disparity, moisture content, temperature, and soil chemical characteristics. *C. obtusa* leaf samples were collected from five different regions (Jangseong, Gokseong, Suncheon, Jinju, and Namhae) and essential oil extracted following methods: a round flask (2 L) containing the sample leaves (50 g) and water (500 mL) was placed in the machine, and distilled using an electric heater for 5 hours. Then extracted essential oils were analyzed by GC-MS for metabolite profiling. Also, soil chemistry (pH, total nitrogen, organic matter, available P_2O_2 and exchangeable cation) was investigated from five regions. To account for seasonal factors for essential oil production, temperature and moisture content were investigated at 1-month intervals. Yield of essential oil was observed November and March, and maximum yield (4.8%) was obtained from Gokseong and minimum (4.0%) at Jinju. Further, selection of high-oil-producing trees may be used as fundamental information on study of terpenoids as biosynthetic mechanisms.

Comparison and analysis on international standards determining formaldehyde and VOC emissions with environmental chambers. Zhang, S.B. (*Beijing Forestry University, China; shuangbaozhang@tom.com*), Kong, Q.Y. (*Beijing Products Quality Supervision and Inspection Institute, China; gloriakqy@163.com*), Li, H. (*Beijing Forestry University, China; lihuibjfu@163.com*), Yu, B. (*Beijing Products Quality Supervision and Inspection Institute, China; watercat520@163.com*).

Formaldehyde and hazardous VOC emissions from wood-based products are important environmental issues all over the world. Therefore, development of methods to test these substances has been given considerable attention. This paper emphasizes an environmental, non-destructive, chamber-testing method, to test samples between high-simulation and real circumstances. The purpose of this research is to analyze and summarize related standards applied throughout the world, including ASTM D6670-01, BIFMA M 7.1, ISO 16000-9, EN 717-1: 2004, ASTM E1333-96, and JIS A1901: 2001. The procedures were: (1) collect as many related standards as possible; (2) extract key details from every standard, such as requirements on chambers, testing conditions and parameters, treatment of samples, sampling, and calculation; and (3) thorough comparison and analysis propose proper testing conditions and methods as consideration of the establishment of the future standards. Thus the study aims to contribute to improving the indoor air environment.

General Posters: Forest Products and Production Processes for a Greener Future

Bending strength and fracture morphology of beting bamboo (*Dendrocalamus asper*). Ahmad, M., Osman, S. (*Universiti Teknologi MARA, Malaysia; mansur628@salam.uitm.edu.my; pools_msc780@msn.com*).

The aim of this work was to analyze the bending strength of beting bamboo (*Dendrocalamus asper*) and characterize the fracture morphology. In this study, bending samples was produced from bamboo slabs and tested in the laboratory according to international standards. Ultimate stress, stress at proportional limit, and modulus of elasticity of beting bamboo were determined, and the

fracture morphology was observed under the scanning electron microscopy (SEM). In this paper, bending strengths were considered for their variability with respect to location along the length of the bamboo culms and between nodes and internodes sections. The characteristics studied were found to have some variability at different locations and sections. The failure modes in bending were simple tension, splintering tension, and compression. When observed for failure morphology using scanning electron microscopy at the internodes, the failure occurred primarily at the parenchyma region. However, failure at nodes occurred in both vascular bundles and the parenchyma region. These characteristics are important to determine the suitability of this bamboo species as a raw material for composite products.

Estimation of forest biomass generated by forest management. Ahn, B.I. (*Korea University, Republic of Korea; ahn08@korea.ac.kr*), Lee, K.S., Kim, C.H., Kim, E.G. (*Gyeongsang National University, Republic of Korea; crystal1027@nate.com; jameskim@gnu.ac.kr; egkim@gnu.kr*).

In order to estimate the forest biomass generated by forest management, this paper projects the area of the forest that is the target of thinning. Two approaches are applied to the projections. First, various scenarios regarding timing and object of thinning are applied from 2009 to 2018. Second, for the same period, the target forests of thinning are estimated by several types of trend equations. Using results from prior studies, the amount of biomass accrued by thinning per 1 ha of forest is multiplied to the projected areas of forest. The probability distributions of estimated forest biomass in each year are presented. By adding the standard deviation to the mean, the upper bounds of the estimated forest biomass are constructed. The lower bounds of the estimated forest biomass are constructed by subtracting the standard deviation from the mean. The upper bound of forest biomass accrued by forest management is estimated to be 8,120,100 m^3 in 2009 and 8,115,858 m^3 in 2018. The lower bound of forest biomass is estimated to be 5,314,589 m^3 in 2009 and 4,013,540 m^3 in 2018.

Improvement of lumber recovery factory with low environmental impact in Pinar del Río, Cuba. Alvarez Lazo, D.A., Estévez, I., González Cruz, I., Domínguez Goizueta, A., González Hernández, O. (*Universidad de Pinar del Río, Cuba; daniel@af.upr.edu.cu; iesteves@mat.upr.edu.cu;*), Alaejos Gutiérrez, J. (*Universidad de Huelva, España; jalaejos@uhu.es*), Alvarez Godoy, E. (*Universidad de Huelva, Cuba; esther@af.upr.edu.cu*), Alves, A., Rodrigues, J.C. (*Universidad Técnica de Lisboa, Portugal; ana@isa.utl.pt; jocarod@isa.utl.pt*).

With the aim of reducing the negative impacts of activities related to the supply of wood to sawmills, an analysis of the utilization of animals for wood extraction was carried out, and it delivered more favourable results than the use of mechanized equipment. Secondly, by means of using near infrared spectroscopy, variations in the properties of wood in the direction from core to bark are predicted, and, with the construction of mathematical models based on the use of linear programming, the selection of sawing schemes that allow the reduction of wood deformation is optimized, which leads to an increase in the sawing process of 5.2%, that is, a gain of more than $300,000 for the sawmills of the province of Pinar del Río. All this is supported by the application of statistical process control by using the adequate production software called "Control". The implementation of the results obtained would reduce the necessity of using more than 100 ha of forest, which certainly would have a positive effect on the conservation of the environment.

Growth of small-scale sawmills in Finland. Backman, R. (*TTS Research, Finland; riitta.backman@tts.fi*).

The aim of this study was to investigate the characteristics of growing small-scale sawmills in Finland. By selecting nine leading growth enterprises from postal questionnaire (100 enterprises) for an open interview, we looked for factors that were related to the growth of the enterprise. Using analysis of financial statements and an interview, growing enterprises were identified on the basis of their growth strategy, competitive advantage, and profitability. Growing sawmills were keen on seeking slow and sustainable growth in the long term. The main target of their business was to improve profitability and return on capital. Satisfied customers and reasonable livelihood of the owner and employees were also important goals. On scale 1–5, the owners' estimates of both their innovativeness and risk-taking willingness averaged 3.8. High quality, upgraded products and flexibility in customer service and delivery were listed most commonly as the main competitive advantage of the enterprise. The financial position was stable in all enterprises in 2002–2007. The results indicate that reasonable rate of growth, sustainable economy, flexible customer service, and high quality products are the most common characteristics of growing small-scale sawmills.

Timber marketing in Kawempe Division: a case study of Bwaise industrial area, Uganda. Bakiika, R., Seremba, O. (*Makerere University, Uganda; rbakiika@forest.mak.ac.ug; oseremba@forest.mak.ac.ug*), Naigaga, S. (*EMLI, Uganda; naigaga@bwaisefacility.org*).

In Uganda, marketing function is minimal since it is charaterised by small primary and secondary producers trading in local markets characterised by illegal timber—unregulated and at very low prices. According to FAO, Ndeeba, Bwaise, and Kireka are the main three timber markets, representing about 50 percent of the total timber consumption in Uganda. A study was conducted in Bwaise Industrial area to document factors and prospects influencing the supply and demand of sawn timber. A total of 40 timber traders were interviewed and provided information on the species, quantity, provenance, price, and size of the marketed timbers. Data were collected, coded, tabulated, and entered in a statistical package for social scientists (SPSS) and Microsoft excel programme. The study showed that *Pinus patula*, *Albizia coriaria*, and *Antiaris toxicaria* were the most traded timber species with 15 percent response; and *Cypressus lusitanica*, *Markhamia platycalyx*, and *Prunus africana* were the least traded with a 2 percent response. Taxation, with a response of 27, was the major factor affecting timber marketing, whereas market information, raw material shortage, and poor storage facilities had a 12 percent response. Consumer tastes and preferences were the least factor affecting timber marketing, with a response of 2.

Valuation of long-term timber contracts in Germany. Brodrechtova, Y. (*Technical University in Zvolen, Slovakia; brodrechtova@vsld.tuzvo.sk*).

Securing resources is a challenging task for the forest products industries. In the past 10 years it was observed that the cooperation among actors within this industry sector was explicitly based on contracts, particularly long-term contracts. However,

increasing the length of contracts increases the risk associated with the uncertainty of future developments. The assumptions of transaction theory state that uncertainty causes problems, in part because of bounded rationality of actors and in part because of the danger of opportunism. How efficient then, are long-term contracts in achieving objectives such as the efficient allocation of natural resources, risk-bearing, or the minimization of transactions cost? The present study fills the gap in the limited knowledge concerning valuation of long-term timber contracts. A market approach was applied within a case study of the forest products industries in Germany. First, a document analysis of existent long-term timber contracts was carried out. Subsequently, based on 30 phone and 50 in-person interviews, the individual decision makers (the market) valued the long-term timber contracts. Preliminary results showed that 1-year contracts are valued as efficient, minimizing risk and cost. Furthermore, since various contract clauses and their arrangements could not achieve these objectives simultaneously, flexibility was preferred.

Assessment of the effectiveness of potassium polyacrylate as a method to optimize the use of irrigation water in sustainable urban reforestation projects. Chacalo Grabinsky, J., Aldama, A., Chacalo, A. (*Universidad Autonoma Metropolitana, Mexico; jags@correo.uam.mx; alao@correo.azc.uam.mx; lchacalo@yahoo.com.mx*).

An investigation was conducted to test potassium polyacrylate, a water super absorbent, recommended to irrigate soils during dry seasons. The study was based on a 2x 2 factorial experiment with 10 replicates. The experiment was installed in a protected area in the Azcapotzalco Campus. The soil selected was suitable for growing plants as it contained a high quantity of nutrients. The factors were: species with layers, oak (*Quercus rugosa*) and privet (*Ligustrum lucidum* Ait); and water regime, with levels of potassium polyacrylate and water only. Response variables were considered to control the survival of the trees and the efficiency of the super absorbent. To evaluate the biomass generation, the response variables were: differences in diameter and height at beginning and end of a 3-month period of observation; and for the control of characteristics of the soil, humidity level and temperature were recorded. For each response variable we did an analysis of variance.

Mechanical properties of shuttle-shaped columns used in historic buildings. Cho, C.L., Huang Y.H. (*National ILan University, China-Taipei, rockcho@seed.net.tw; momocaty2002@gmail.com*), Kuo, C.C. (*Kunn Yih Wood Corporation, China-Taipei; davidkune@yahoo.com.tw*).

Wood post-and-lintel construction is one of the typical historic buildings in Taiwan. Beams and columns are main members bearing vertical and horizontal loads. The mechanical properties of beams and columns of historical buildings have to be known to promote accuracy in construction safety evaluation. Many studies were primarily focused on the mechanical performance of dou-gong and mortise-tenon joints. However, further research rarely referred to the mechanical properties of shuttle-shaped columns with non-uniform sections, which have more complex behaviors than uniform ones. In this study, the natural frequencies and compression strength parallel to grain of the shuttle-shaped columns with five kinds of slenderness were presented. Results show that the values of compressive strength decreased when the slenderness ratio increased. The values of compressive strength parallel to grain and critical stress of shuttle-shaped columns are lower than those of round columns, but the relative strength between critical and the compressive strength in the shortest slenderness is better than that of round columns under the equivalent moment of inertia and area of cross-section. The fundamental frequencies of shuttle-shaped columns under axial loads show a significant 50% lower in frequencies than those under free of load.

Structural comparison of different pits between Eunsashi poplar and Konara oak. Chong, S.H. (*Korea Forest Research Institute, Republic of Korea; nayte@korea.kr*), Ali Ahmed, S., Kim, A.J. (*Kangwon National University, Republic of Korea; khokonbd@gmail.com; ajkimknu@kangwon.ac.kr*), Park, B.S. (*Korea Forest Research Institute, Republic of Korea; bspark@korea.kr*), Chun, S.K. (*Kangwon National University, Republic of Korea; chun@kangwon.ac.kr*).

The aim of this study to know the structural differences of endwall (tangential) pits in ray parenchyma, intervessel pits, and fiber pits in Eunsashi poplar (*Populus tomentiglandulosa* T. Lee) and Konara oak (*Quercus serrata* Thunb.). As pits play an important role in liquid penetration, the outcome of this experiment will help us to understand the permeability variation of the two above-mentioned hardwood species. Because of the elliptical shape of intervessel and fiber pit apertures, perimeters of pit aperture were calculated. It was found that the perimeter of the intervessel pit aperture in poplar was 1.1 times larger than that in oak; however, the perimeter in fiber pit aperture in poplar was 1.4 times smaller than that in oak. Average endwall pits in ray parenchyma of both species were the same. Furthermore, the endwall pit diameter of ray parenchyma in oak was 1.3 times wider than that in poplar. We also examined the thickness of pit membranes. It was found that the thickness of endwall pit membrane in ray parenchyma was 220.11 nm for poplar and 312.48 nm for oak. Furthermore, the thicknesses of intervessel pit membranes were found to be 111.47 nm in poplar and 163.79 nm in oak.

Assessment of sawmill waste generated at two mills: a concession FSC-certified forest in the region of Madre de Dios, Peru. Espíritu Tello, M. (*World Wildlife Fund (WWF), Perú; espiritu_marjorie@yahoo.com*), Yabar Meoño, D. (*Universidad Nacional Agraria La Molina-Perú; daym13@hotmail.com*).

Timber harvesting from tropical forests in Latin America may still be considered an emerging industry, because there is no adequate control for monitoring, the chain continues when it comes to yard collection for processing, and low yields mean a great deal of waste is often thrown on the banks of rivers or simply stored in the same mill, causing environmental pollution. Very rarely this waste is reused. In Madre de Dios, we carried out an assessment of sawmill waste generated in two mills of a concession FSC-certified forest. In order to produce wood fuel pellets and briquettes, waste generated was calculated using production records and identified by species declining volumes; volumes were compared with ideals. The results show a yield well below the theoretical standards, although certified to be a concession. Efforts to reduce waste are still not adequate and only commercially valuable species such as *Swietenia macrophylla* and *Cedrela odorata* reach 50% efficiency. This study attempts to go beyond the above, to get an idea of how they operate when concessions are not under a certification standard.

Nail joint performance of several wood-based panels during 5-year outdoor exposure. Fujimoto, Y. (*Miyazaki Prefectural Wood Utilization Research Center, Japan; fujimoto-yoshiyasu@pref.miyazaki.lg.jp*), Sekino, N. (*Iwate University, Japan: sekino@iwate-u.ac.jp*), Korai, H. (*Forestry and Forest Products Research Institute, Japan; korai@affrc.go.jp*), Nogami, H.

(*Okayama Wood Technology Institute, Japan; nogami@pref.okayama.lg.jp*), Ohashi, K. (*Iwate Prefectural Forestry Technology Center, Japan; k-ohashi@pref.iwate.jp*).

The durability of nail joint performance for several wood-based panels was examined by a group of researchers from the Japan Wood Research Society. Four kinds of commercial wood panels for construction use, such as 5-ply plywood, OSB made of aspen, particleboard using phenol adhesives, and MDF for construction use, were used for this examination. Outdoor exposure tests of nailed panel specimens were conducted at four places, Morioka, Tsukuba, Okayama, and Miyakonojo. Lateral nail resistance test, nail-head pull-through test, and shear-in-one-plane test were conducted annually to investigate the nail joint performance during a 5-year outdoor exposure. The results are as follows. The shear strength and other nail-joint performance depended largely on panel types and test places. The reduction of nail joint performance was small for plywood and MDF, while that for OSB and particleboard was remarkable. The affection of the exposure test site was extremely large, and the reduction of OSB was large at Okayama and Miyakonojo, where temperature was relatively high. It was thought that the large reduction of nail joint performance at Okayama and Miyakonojo was related to the weight loss caused by biological deterioration.

Pest identification from damaged preservative-treated wood. Hwang, W.J., Kim, J.K., Park, Y.R., Lee, D.H. (*Korea Forest Research Institute, Republic of Korea; wonjoung@forest.go.kr; jgk1010@hanmail.net; dalalo700@naver.com; dhlee99@forest.go.kr*).

The reasons for wood deterioration and degradation include wood fungi, termites, insects, and other factors. Because wood serves as a food or nutrition for the propagation and conservation of these deterioration agents, it can have a negative effect on the safety of exterior wood structures. The preservative-treatment has been done with aim of protecting wood from deterioration factors, ensuring the safety of wood structures, providing protection of the Earth's environment, and continuation and extension of carbon fixation over time. In fact, damage of preservative-treated wood from pests in Korea started on the outdoor wood structures in 2004. Recently, the damage also has increased gradually. Therefore, our study was carried out to identify pests on wood from Gumdan Mountain damaged by insects. We found that the identified pests were *Xylosandrus crasiussculus*, commonly known as the Asian ambrosia beetle. The male *X. crasiussculus* (about 1.4 mm long) were much smaller than female (2.5–2.9 mm long) and showed a different shape. Female *X. crasiussculus* has a dull rear end surface when dry.

Reinforcement of shear walls using post-and-beam and light-frame structures. Hwang, K.H., Park, M.J., Shim, K.B., Park, J.S. (*Korea Forest Research Institute, Republic of Korea; m54290@hotmail.com; mjpark@forest.go.kr; kbshim@forest.go.kr; jusang@forest.go.kr*).

Remarkable demands for timber structure have been increasing in Korea with environmental concerns. The Korean traditional residential house, hanok, is spotlighted as an environmentally friendly wooden house, typically a post-and-beam timber structure. Post-and-beam members support the whole weight of a house and they should endure horizontal (lateral) forces as well. Machine pre-cut post-and-beam structural members were prepared and jointed with appropriate connectors for column-base and column-beam joints. All the tested shear walls have the same span of 3.6 meters. Horizontal shear tests for a post-and-beam frame (PB), a light-frame structure (LF), and the combination of both structures (PB-LF), were conducted. LF and PB-LF shear walls were jointed by 75 mm helically threaded nails that were galvanized, and a light frame wall was infilled into a post and beam frame to build up the PB-LF shear wall. The shear strength of PB-LF at a certain deformation, P50, was 6 times and 1.3 times of PB and LF shear walls. Also, the strength is much higher than the sum of each structure, which means the combined structure is reinforced effectively as a shear wall system.

The effects and and utilization potential of logging residues in Nigerian forests. Ige, P., Oyeleye, B., Akinyemi, G. (*Forestry Research Institute of Nigeria, Nigeria; igeup@yahoo.com; gbemioyebolarinwa@gmail.com; akinyemigab@yahoo.com*).

Nigeria's tropical forests contain a large number of tree species that are extracted and used in diverse ways by individuals and industries. The quantity of forest residues has been observed to be enormous in tropical forests during forest operations. These constitute a great loss both in terms of revenue and forest regeneration. Such residues include small-diameter logs, stumps, branches, shavings, etc. The reduced impact logging (RIL) method was identified as a major technique for reducing these residues, capable of reducing up to 50% of the residues generated conventionally. Since this technique (RIL) cannot effectively eliminate all residues, different uses into which the residues can be put into are therefore enumerated. These include use of wood chips for panel and paper industries; production of charcoal and briquettes as alternative source of fuel; and production of small wooden and panel products such as carvings, wall clocks, particle boards, floor and wall tiles, etc. Therefore, to enhance sustainable forest management and for the forest to continue to provide relevant services for domestic and industrial sectors and other environmental and social services, appropriate harvesting techniques such as reduced impact logging (RIL) are recommended.

The annual harvesting plan to minimize harvesting cost for small area forest stands. Isikawa, T., Itaya, A., Nakanishi, M. (*Mie University, Japan; tomo@bio.mie-u.ac.jp; itaya@bio.mie-u.ac.jp; 506365@m.mie-u.ac.jp*).

In order to reduce harvesting cost, a harvesting system that consists of felling by manual work with a chainsaw, bucking by a processor, and yarding by a forwader is generally performed in Japan. In a previous study, for this harvesting system, we clarified relationships between an area of harvesting stand and a distance to next harvesting stand to minimize harvesting cost including a transportation cost of machines. Using that result, in this study we examined the development method of the annual harvesting plan to bring harvesting cost close to the minimum. This method consisted of the following procedures: decide the first harvesting stand; calculate distances from current harvesting stand to candidate harvesting stands; decide the next harvesting stand, minimizing harvesting cost from candidate stands; repeat this procedure. The annual harvesting plan in artificial stands in Japan was made, and the effectiveness of it was verified. As a result, the plan precisely chose the next harvesting stand whose distance to the current stand was appropriate to bring the harvesting cost close to the minimum. For this reason, it is suggested that this annual harvesting plan was useful.

Development of a retaining wall structure of forest road slope using logs. Ji, B.Y., Oh, J.H., Jung, D.H. (*Korea Forest Research Institute, Republic of Korea; by83700@forest.go.kr; jhoh@forest.go.kr; froad@forest.go.kr*), Lee, J.W. (*Chungnam National University, Republic of Korea; jwlee@cnu.ac.kr*), Cha, D.S. (*Kangwon National University, Republic of Korea; dscha@kangwon.ac.kr*).

Forest road slopes have been damaged by a downpour of rain every year; accordingly, the Korea Forest Service has being carrying out structure improvement plans that could reform and complement the structure of existing forest roads since 2000. This study was carried out to develop a retaining wall structure for stabilization of forest road slopes using logs. Planning for maximum earth pressure up to 5 ton, a steel-made structure frame was designed for vertical height of 8 m and a 45° road slope condition. The retaining wall structure is composed of four parts: front plate, back plate, base, and supporter. It could be used by putting logs of diameter from 10 cm to 15 cm between the front plate and back plate. To investigate the strength of the designed structure, we made experimental equipment that would be able to be pressured up to 5 ton. The strength of structure frames showed fairly good results on the condition of the 100 mm wide, 9 mm thick connecting plate and 100 mm wide, 6 mm thick supporter. The developed retaining wall structure will be helpful for environmentally friendly forest road slope stability by using logs collected from forest tending works.

Estimating wood biomass supply using spatial circumstances and transportation costs. Kamimura, K., Kuboyama, H., Yamamoto, K. (*Forestry and Forest Products Research Institute, Japan; kamimura@fr.a.u-tokyo.ac.jp; kuboyama@ffpri.affrc.go.jp; koichi@ffpri.affrc.go.jp*).

Using wood biomass for fuel has been proposed as a key to attaining sustainable energy without contributing to global warming. However, there are several difficulties in satisfying the economic requirements of energy plants using wood biomass in Japan. Because forests and timber industries are widely distributed, logging and transport costs are generally high or unstable. Thus, to sufficiently use wood debris for energy plants, we estimate wood biomass supply using spatial and economic circumstances such as load network, wood resource locations, and transport costs. First, normalized transport costs for wood biomass were calculated using transport and market costs actually used for large- and middle-sized timber industries. Second, wood biomass was spatially estimated using forest and timber statistics and digital data including road network and forest resource maps. Third, wood biomass supply was calculated for nearly all towns in Japan. Consequently, seven regions with high potential for wood biomass supply were found to have a maximum transportation cost of 7,000 yen/t-50%.o.b. (wet). Developing technologies and machineries for logging and chipping would also drastically increase wood biomass supply in Japan.

The development of a half crawler type mini-forwarder. Kim, J.H., Park, S.J., Kim, M.K., Kwon, H.J. (*Kyungpook National University, Republic of Korea; zizi0821@hanmail.net; sjupark@knu.ac.kr; pierre777@hanmail.net; bestibelli5@nate.com*).

This study was conducted to develop a half crawler type mini-forwarder that is an efficient forwarder in the steep terrain and small-scale logging operations of Korea. It is also used at a variety of operations such as log transportation, the work of erosion control, and forest roads. The half crawler type mini-forwarder was designed and manufactured as the front tire wheel, which is controlled by power steering and the rear rubber crawler. And it consists of the several parts: power, driving, body, loading, and controller. The power engine used in this study is maximum power 96 ps in 3,600 rpm and 3,568 cc. Hydraulic pumps consist of two main pumps and two charge pumps. Main hydraulic pumps are utilized for the running motor of the front wheel and rear crawler. Charge pumps are utilized for the attachment parts such as steering cylinder, crane, out rigger, and dump cylinder. Transmission was applied to hydro static transmission (HST) type. The total length and loading volume is 5,750 mm and 3 ton. Driving control parts consist of the power steering handle, lever that can move forward and backward, and accelerating pedal. As a result of the driving test, maximum speed was 8.5 km/hr.

Trends and prospects for wood industries in the Republic of Korea. Kim, J.S., Lee, S.Y. (*Korea Forest Research Institute, Republic of Korea; jskim99@forest.go.kr; leeferas@forest.go.kr*).

Wood product markets have rapidly expanded in South Korea since 2000, while the amount of imported wood products has also much increased as the economy has been booming. Now domestic wood industries in South Korea are highly competitive over the foreign industries in terms of price as well as product quality. Since only a limited amount of timber is available and much of it is small-diameter trees harvested from thinning, wood industries in South Korea have difficulties in securing sufficient timber supplies for their business, in spite of the high consumption of domestic timbers in wood industries. It is clear why wood industries in Korea have been struggling with such unstable timber supplies. Global wood product markets have been continuously expanded by removal of trade barriers over the world. Also, demands of high quality products are increasing in the market. Wood industries in South Korea now have to deal with these internal or external issues for their survival. They have to find more stable sources for timber supply, and to innovate in their manufacturing system to reduce production costs. In addition, it is essential to strength their competitive power by improving the quality of their products.

Bending performance of preservative-treated pitch pine stress-laminated beams. Kim, K.M., Shim, K.B., Kim, B.N., Kim, W.S. (*Korea Forest Research Institute, Republic of Korea; lovewood@forest.go.kr; kbshim@forest.go.kr; dolgari@forest.go.kr; kimws@forest.go.kr*).

Stress-laminated beams are manufactured by bolting laminar with threaded rods perpendicular to grain direction without any adhesives. Due to the ease of manufacturing large-dimension members with small-dimension laminar in the field, stress-laminated beams have been considered effective construction members for timber bridges, especially in areas that are difficult to access. The structural performance of stress-laminated beams is highly dependent on the friction between laminars induced by bolting. Therefore, it is difficult to analyze or predict structural load capacity. In addition, structural load capacity would be decreased abruptly by loosening the bolt pressure. Before applying the stress-laminated beams in the field, basic data for structural analysis should be obtained to determine optimizing manufacturing procedures, such as conditions of laminar, bolt intervals and torques, etc. Pitch pine lumber was selected for the laminar, and treated by Cuaz-2 preservative to increase the durability. Under 280 kPa bolting pressure, the stress-laminated beams showed relatively stable bending performance, and the stiffness of it was about 80%

of numerical summation of laminar stiffness. Additionally, it could be concluded that the re-bolting process just after installation prevented long-term loosening of bolt pressure.

Examination of the structures of timber bridges in Korea. Kim, K.M., Shim, K.B., Shim, S.R. (*Korea Forest Research Institute, Republic of Korea; lovewood@forest.go.kr; kbshim@forest.go.kr; srshim@forest.go.kr*).

In Korea, more than 1,000 bridges for transportation are built every year. These bridges are usually constructed with steel or reinforced concrete, although wood has been used as a construction material for a very long time, Timber bridges are difficult to find in Korea. Because of the rapid economical growth of Korea, usual construction materials are chosen for cost-effectiveness and ease of structural design. Recently, prosperity in Korea and global environmental issues on climate change generated an increase in interest in environmentally friendly construction materials such as wood. In this trend, timber bridges for pedestrians recently started to be built in parks. However, doubts about the safety and durability of wooden structures still limits demand for expansion of timber bridges in Korea. This research was planned to investigate a few representative timber bridges in Korea, in order to examine their structures and provide some basic data for timber bridges existing in Korea. Up to now, six bridges in total were investigated, and the characteristics of structures and details of connections were recorded for the public.

Removal of 2-chlorophenol from contaminated wastewater using low-cost corncob waste modified with NaOH, and/or H_2SO_4. Kurniawan, T.A., Sillanpää, M.E.T. (*University of Eastern Finland Finland; tonni696390@gmail.com; mika.sillanpa@uef.fi*), Lo, H.M. (*Chaoyang University of Technology, China-Taipei; hmlo@cyut.edu.tw*).

Chlorinated compounds such as 2-chlorophenol (2-CP) are frequently applied in timber industries for wood preservation. Due to its toxicity and recalcitrance, 2-CP is classified as a priority pollutant. Ozonation has been tested to degrade 2-CP, but it generates toxic by-products such as catechol. Due to its capabilities, corncob has been developed as an adsorbent for water purification. Corncob, which presents disposal problems for the environment, is a low-cost agricultural waste. Conversion of the waste into activated carbon, which could be applied as an adsorbent, would increase its economic value, help reduce the cost of waste disposal, and provide an inexpensive option to commercial activated carbon. This study investigated the performances of corncob in removing 2-CP from synthetic wastewater. To improve its removal for 2-CP, surface modification of corncob with H_2SO_4 and/or HNO_3 was undertaken. Our findings demonstrated that under optimized conditions of dose and pH at the same initial concentration of 20 mg/L, corncob treated with HNO_3 had a higher removal (75%) than that modified with H_2SO_4 (55%) or as-received (15%). Since the treated effluents still could not meet the discharge limit of lower than 1 mg/L, subsequent biological treatments are required to complement 2-CP biodegradation before its discharge.

Transition characteristics of wood cell walls during carbonization. Kwon, S.M., Kim, N.H. (*Kangwon National University, Republic of Korea; ksm7689@kangwon.ac.kr; kimnh@kangwon.ac.kr*).

Recently, utilization of charcoal has increased in various fields such as soil modification, water purification, carbon industry, etc. Many studies have been carried out to examine charcoal characteristics. The research area of transition from wood to charcoal, however, has yet to be fully understood. The objective of this study was to investigate transformation mechanisms of wood cell walls. Wood blocks were carbonized in an electric furnace under nitrogen gas atmosphere (1kg cm^{-2}) at 200–700 °C. The carbonization was carried out by heating wood samples from room temperature to the final carbonization temperature with a heating rate of 5 °C min^{-1}. After reaching the final carbonization temperature, samples were kept for 10 minutes at constant temperature and then rapidly soaked into sand for cooling. SEM observation indicated that the layering structure of the walls in wood was presented at 340 °C. However, the cell wall layering structures disappeared at 350 °C and changed into an amorphous-like structure. X-ray diffraction showed that the cellulose crystalline substance still remained at 340 °C, but it was not detected at 350 °C. From FT-IR spectroscopy, the intensities of absorption bands resulting from cellulose, hemicellulose, and lignin in FT-IR analyses were almost absent at 350 °C.

Soda pulping kinetics of hemp at low and high temperatures. Lee, M.K., Cho, B.U. (*Kangwon National University, Republic of Korea; mklee@kangwon.ac.kr; byounguk.cho@gmail.com*), Yoon, S.L. (*Jinju National University, Republic of Korea; slyoon@jinju.ac.kr*).

In recent years, hemp (*Cannabis Sativa*) has received great attention around the world as a substitute for wood pulp. The kinetics of alkaline delignification of hemp have been described and modeled by several researchers. Most of the researchers have studied the alkaline delignification of hemp only in high temperature (160–180 °C). However, mulberry bast fiber pulp, a typical non-wood pulp and a raw material for Korean traditional paper (Hanji), has been traditionally produced by soda pulping at an atmospheric pressure (i.e., 100 °C), which means that pulp can be produced with bast fiber even at lower temperatures. This research was carried out in order to check the possibility of producing hemp bast pulp at an atmospheric condition and to elucidate the effect of pulping conditions (cooking temperature, chemical concentration, and cooking time) on the kinetics of soda pulping (delignification and degradation of carbohydrates). It was found that hemp bast pulp can be produced at a low cooking temperature (100 °C) with a longer cooking time. Cooking temperature and chemical concentration have shown a strong influence on the kinetics of the soda pulping process.

Adsorption properties of charcoal against aqueous mixture of heavy metals. Lee, O.K., Ahn, B.J., Cho, S.T., Lee, S.M. (*Korea Forest Research Institute, Republic of Korea; oklee@forest.go.kr; bjahn@forest.go.kr; chost@forest.go.kr; lesoomin@forest.go.kr*).

Adsorption properties of charcoal were evaluated using aqueous heavy metal ions. For wood charcoal preparation, bark of *Larix Kaempferi* and wood of *Quercus mongolica* were carbonized at 600 °C and 900 °C. Adsorption ability of the charcoal against aqueous mixture of copper, zinc, lead, and cadmium in equal amounts in three batches of concentration, 80, 120, and 160 ppm, was determined at four different levels of charcoal amount, 0.5, 1.0, 1.5, and 2.0 g. The concentration of residual heavy metal was determined using ICP after the adsorption treatment. As a result, charcoal made from wood showed better adsorption ability than that made from the bark. Also, charcoal carbonized at 900 °C showed higher adsorption ability than charcoal carbonized at

600 °C. Especially, over 90% of heavy metals were removed when 1.0 g or higher amounts of charcoal carbonized at 900 °C was used. In all cases, it is revealed that adsorption rates of copper and lead were higher than those of cadmium and zinc. Therefore, it is considered that more removal of cadmium and zinc requires charcoal prepared at higher temperature and higher amounts.

Analysis of terpenoids released during the drying process of *Cryptomeria japonica*. Lee, S.Y., Choi, I.G., Gwak, K.S., Kim, S. H., Lee, J.J., Yeo, H.Y. (*Seoul National University, Republic of Korea; goodday8508@snu.ac.kr; cingyu@snu.ac.kr; blind@snu.ac.kr; sh98sh08@snu.ac.kr; junjae@snu.ac.kr; hyeo@snu.ac.kr*).

Cryptomeria japonica is a widely distributed conifer in Jeju Island of Korea, and it is a popular material for structural housing. For use as structural material, a drying process must be performed. The steam drying process is commonly used for the drying of *C. japonica*, and the control of its temperature and humidity is very important to minimize shrinkage, distortion, and degradation of timber during the drying process. During steam drying, many organic compounds are released from timbers such as hazardous compounds (e.g., formaldehyde), volatile organic compounds (VOCs), and odorous substances. They mostly included the hydrocarbons as the predominant group, and especially terpenoids as the primary hydrocarbon. The current steam drying process that is used for *C. japonica* typically discharged without collection of these compounds. Therefore, this study will collect the terpenoids that are released during the drying process to allow investigation of their utilization. The laboratory-scaled thermal extractor analysis will be substituted for the steam drying process because of its huge scale. The analysis of the terpenoids collected will be carried out depending on the drying temperature and it will offer the preliminary data for its utilization.

An estimation of wood dynamic viscoelastic properties using time-temperature superposition principle. Lu, J., Jiang, J. (*Chinese Academy of Forestry, China; jianxiong@caf.ac.cn; jialiwood@caf.ac.cn*).

Time-temperature superposition principle (TTSP) was used to examine dynamic viscoelastic properties of Chinese fir (*Cunninghamia lanceolata* [Lamb.] Hook.) wood at an extremely low moisture content (0.6%) over a wide range of frequencies. Storage modulus and loss factor data were obtained at different constant temperatures ranging from 25 °C to 150 °C in frequency multiplexing experiments (0.1 Hz to 20 Hz). All viscoelastic curves at other temperatures were shifted along the log-frequency axis to superimpose them on a reference temperature (i.e., 135 °C in this study) curve. The extended storage modulus and loss factor isothermal master curves were over frequency range of 10^{16} Hz and 10^{5} Hz, respectively. The shift factors were determined to be a function of temperature and fitted into the William-Landel-Ferry (WLF) equation or the Arrhenius model with the least square method. The results showed that the storage modulus data were excellently fitted into the WLF model, indicating the validity of the model to characterize the dynamic stiffness behavior of dry wood in the range of 25 °C–150 °C using the TTSP. However, the time-temperature equivalence was not able to predict the damping properties over a wide range of frequencies.

Development of a thinning system using an excavator with a long-reach grapple. Nakazawa, M. (*Forestry and Forest Products Research Institute, Japan; naka1978@ffpri.affrc.go.jp*).

This study aimed to develop a thinning system using an excavator with long-reach grapple for prehauling operations. We examined the effects of thinning method, prehauling direction, terrain, and road condition on productivity. The maximum productivity of labor was 9.0 m^3/man-hour under the conditions of line thinning, down-hill prehauling, slope of 23°, short prehauling distance of up to 33 m, road width of 3.5 m and timber volume of 0.32 m^3/tree, which was about 1.5 times higher than ordinary thinning at 5.9 m^3/man-hour under similar conditions. Using a small winch on the top of the arm, the maximum slope prehauling distance from thinning trees to roads exceeded 70 m, and the productivity decreased only 10%. The productivity for downhill prehauling was about 1.6 times higher than for uphill, and the maximum prehauling distance for downhill was 6 m longer than for uphill. The productivity for the road width of 3.5 m was about 1.6 times higher than for 3.0 m. On the other hand, the terrain had little effect on productivity. Consequently, this machine offers high productivity for both ordinary and line thinning, although a road structure that can support the heavy weight of this machine is needed.

Development of a vibratory walnut harvester. Oh, J.H., Kim, J.W. (*Korea Forest Research Institute, Republic of Korea; jhoh@forest.go.kr; jaewkim@forest.go.kr*).

Harvest costs have typically been about half of the total production cost for green walnut and even more for small-scale growers with low volume. Mechanical harvesting systems for green walnut should allow the grower to take advantage of new technology and reduce personnel requirements. An inertia type slider crank limb shaker mounted on the arm of an excavator was designed and developed for effective harvesting green walnut. The limb shaker harvesting unit has motion of three degrees of freedom like tilting, gripping, and shaking. All shaker controls are positioned for the excavator operator's convenience, and the mounting of the shaker on the excavator is accomplished with minimum time and effort. Shaking frequency is also easily controlled by hydraulic flow valve and rpm indicator. To minimize tree damage, the clamp for holding the tree limb had a multi-layered rubber pad with shock absorbing characteristics. Shaking rates, including move time, varied from 226 to 631 sec/tree, 360–420 sec/tree being considered the normal shaking time through field test. Removal of over 90% of green walnut could be expected.

Can the pressures on tropical forests be reduced through industrial utilization of oil palm lumber, a non-timber forest product? Okai, R. (*University of Education, Ghana; reynoldsokai@yahoo.co.uk*).

In spite of the numerous uses of the oil palm tree (*Elais guineensis*), its trunks are sometimes left to rot or burnt in the forest to pave the way for farming activities. Thus, enormous quantities of palm trees are discarded, while destruction of the rain forest has been expanding in the same tropical areas by excessive cutting of trees. In this study, discarded oil palm trunks were extracted from the forest, converted into boards, and kiln dried to a moisture content of 8–10%. Compression parallel to grain tests and three point static bending tests were conducted to clarify the suitability of the oil palm trunk for furniture production. A compression parallel to grain of 13 N/mm^2, a modulus of elasticity of 2,924 N/mm^2, and a modulus of rupture of 25 N/mm^2 at 12% moisture content were obtained. Planning and sanding operations of oil palm lumber produced rough surfaces with raised grains sharp in nature. However, application of sanding sealer followed by sanding operations removed all the sharp raised grains, and smooth surfaces were produced. Light load bearing products such as coffee tables and center tables were successfully manufactured from oil palm lumber.

Fire resistance of timber wall systems with portal frame reinforcement. Park, J.S., Shim, K.B., Hwang, K.H. (*Korea Forest Research Institute, Republic of Korea; Jusang@forest.go.kr; kbshim@forest.go.kr; m54290@hotmail.com*).

New hybrid timber framed wall systems—to substitute for the current typical light timber framed wall system and to improve fire resistance—have been developed. Basically, these wall systems are composed of two major structural parts; one is a portal frame part designed to take the whole vertical load using heavy timber post-andabeam, and the other is an infill-wall structure designed to take the whole horizontal load and to provide an established level of fire resistance. Portal frames are constructed with Japanese larch solid timber posts (180 mm × 180 mm) and beams (180 mm × 240 mm), which are connected by Korean traditional jointing methods without any steel or metal connectors. As infill wall systems, typical light timber framed walls with solid blockings and structural insulated panel walls are applied. For all tested walls, two layers of 12.5-mm thick type-X gypsum boards are used on fire-exposed sides. Prior to tests for hybrid walls, two types of infill walls were tested without the timber portal frame. Fire resistance tests were carried out in accordance with KS F 2257 (based on ISO 834). All hybrid walls tested in this study showed improved fire resistance by portal-frame reinforcement.

3-Dimension skidding distance calculation in a mountain area. Park, S.K. (*Yeungnam University, Republic of Korea; pskyoo@hotmail.com*).

This paper describes a calculation method of mean skidding distance in a mountain area. The road length in the investigation site amounted to 8,656 m in a plane of projection and 8,732 m in 3-dimension with GIS software. The study is for a calculation method of 3-dimension skidding distance. The skidding distance is calculated with a combination method that is the buffering method in combination with point grid method. The 2-D mean shortest skidding distance amounted to 149.6 m with point grid method and 139.7 m with buffering method. The 2-dimension mean actual skidding distance was 251.5 m. The 3-D mean shortest skidding distance amounted to 144.9 m with point grid method and 138.5 m with the combination method. The 3-dimension mean actual skidding distance was 255.5 m. The buffering method can save the time compared to the point grid method, but the method calculates only the skidding distance of a plane of projection. The new improved combination method is calculated faster than the point grid method and has accurate correction in average corridor distances. Also, the combination method can calculate the 3-dimension skidding distance.

A case study on the estimation of the risk of forest-road collapse and forest road evaluation. Saito, A., Tanaka, K. (*Kyoto Prefectural University, Japan; aisaito25@gmail.com; tanakazu@kpu.ac.jp*).

A forest-road network is an essential infrastructure for modern and sustainable forest management. However, simply constructed forest roads have a high risk of collapse, and expensive running costs and road repairs often strain forest management. Consequently, when constructing forest roads, selecting a safe slope with a low risk of collapse is key. In this study, we tried to estimate the risk of forest-road collapse, and evaluate topographic characteristics of existing forest-roads in Ujitawara, Kyoto Prefecture, Japan. First, we analyzed the local topography with GIS using a 10-m digital elevation model and estimated the risk of forest-road collapse. Next, we classified existing forest-roads according topographic characteristics by cluster analysis. Forest-roads were classified into the following three types: type A roads are in a valley with gentle slopes; type B roads are on ridges with gentle slopes, and type C roads have a high proportion of steep slopes. The mean values of forest-road collapse risk were highest in type A and lowest in type B. Existing forest-roads in Ujitawara were mainly constructed on sites where the risk of forest-road collapse was lower. As these results show, forest-road collapse risk is useful as an indicator when planning forest roads.

Construction of a forest road network planning system considering reachability. Sakurai, R., Son, J.Y., Nitami, T., Sakai, H. (*University of Tokyo, Japan; sakurai@fr.a.u-tokyo.ac.jp; jiyoung@fr.a.u-tokyo.ac.jp; nitami@fr.a.u-tokyo.ac.jp; sakaih@fr.a.u-tokyo.ac.jp*).

A forest road network planning system was constructed, in which the algorithm considers the possibility of reaching from the forest road to each tree in a site within a given distance by the cable of mobile-yarder. A mobile-yarder has poor ability to get over a ridge or obstacle by terrain. On this system, the end point of a new road is first found by considering the distance from an existing road and yarding-able area. As the next step, the route from the existing road to the found point is determined by dijkstra's algorithm within the terrain. In this step, the suggested road is determined with consideration of longitudinal slope of the road, gradient of surface, radius of curve, and other factors. As the third step, the suggested road is added to existing road network. And the three steps are repeated until whole planning sites are previously set distant from the existing or suggested roads. The constructed system is used for a 114-ha forest site of south Japan; the site should be under 120 m distant from road; a 6398 m road network was suggested.

Lateral load resistance of structural insulated panels and post-and-beam hybrid structures. Shim, K.B., Hwang, K.H., Park, J.S., Park, M.J. (*Korea Forest Research Institute, Republic of Korea; kbshim@forest.go.kr; m54290@hotmail.com; jusang@forest.go.kr; mjpark@forest.go.kr*).

Traditional Korean timber constructions are mainly post-and-beam structures with a heavy curved roof. Without any metal connectors, traditional Korean buildings can resist vertical and lateral loads due to the pressure from the heavy roof weight. Traditional Korean buildings have many advantages such as aesthetic and environmental friendly construction, but they have a lot of disadvantages such as high cost construction and uncertain structural safety. Their quality mainly depends on skills and experiences of laborers. To increase timber demand in Korea, the Korea Forest Research Institute developed a model that takes advantages from both traditional and modern timber constructions. The model was designed to use pre-cut engineered wood for posts and beams to resist vertical load, and structural insulated panels (SIPs) for shear walls to resist lateral loads. This study was carried out to analyze lateral load capacity and characteristics of the hybrid structure with openings. The tested wall length was 3.6 m and height was 2.4 m. A quasi-static reversed-cyclic test was implemented. The result showed that the size of openings affect the stiffness and maximum lateral load capacity.

Historical changes in market segmentation of Japan's sawmill industry from the 1960s to 2000s. Shimase, T. (*Forestry and Forest Products Research Institute, Japan; shimase@affrc.go.jp*).

This study examines historical changes in the industrial organization of Japan's sawmill industry from the 1960s to 2000s, by reviewing earlier studies and statistics. In Japan, the domestic lumber market is clearly segmented into two types of sawmilling: wholesale and retail. Wholesale sawmilling specializes in certain items, and can be further subdivided by items produced: commodity mills and specialty mills, with the former being larger than the latter. Retail sawmills receive orders directly from small builders for complete sets of housing members, which are handled by smaller mills. Wholesale sawmills do not have regular customers and so require a well-formed distribution system. Therefore, their market is limited to urban areas such as Tokyo, Osaka, and Nagoya, where the wood market is well-developed. Retail sawmills, on the other hand, which function as commercial capitals, are suitable for areas where the distribution system is poor, so the market has typically been in rural areas. From the 1990s, however, large builders and precut plants have moved into rural areas, creating new distribution systems and stimulating the entry of wholesale sawmilling, thus reducing the retail sawmillers' niche there. Thus, smaller sawmills are declining in number and their retailing character is weakening.

Drying profiles of rubberwood at high temperature. Sik, H.S., Choo, K.T. (*Forest Research Institute of Malaysia, Malaysia; sik@frim.gov.my; chookt@frim.gov.my*), Sarani, Z., Sahrim, A. (*Universiti Kebangsaan Malaysia, Malaysia; sarani@ukm.my; sahrim@ukm.my*).

The aim of this study is to develop a two-in-one technique, encompasses both the accelerated drying process and heat fumigation treatment of rubberwood, operating at temperature above 100 °C in a single operational process. This study established the temperature-moisture profiles of 60 × 100 × 30 mm sawn rubberwood obtained during drying at 60 °C (as control) and high temperatures at 100, 120, 130, 140, and 150 °C conducted in separate experiments using a laboratory experimental kiln. Drying profiles indicated that the initial high dry bulb temperature used in the study is not a detrimental factor to effective moisture movement from the core towards the surface of rubberwood during drying. Overall, respective drying periods were reduced down to or at least 25% of the control conventional drying time. Results showed that the drying rates of rubberwood increased in an exponential manner with increased drying temperatures up to 150 °C. Additionally, the quality of timber is generally good for downstream processing. More essentially, all drying runs were conducted without the used of chemical preservatives. Hence, the potential use of this green processing technique for commercial production of rubberwood furniture dimensional stocks is currently being explored by the researchers and industry partners.

Pareto-optimality between road construction costs, forest harvesting costs, and negative ecological impacts. Stückelberger, J. (*EcoEng GmbH, Switzerland; juerg.stueckelberger@ecoeng.ch*), Heinimann, H. (*ETH Zurich, Switzerland; hans.heinimann@env.ethz.ch*), Chung. W. (*University of Montana, USA; woodam.chung@umontana.edu*).

Economical objectives are mostly controversial to ecological objectives. There are solutions that can be improved for one objective only by worsening another objective. Such solutions are called Pareto-optimal. We aim to present a forest road network design model that is able to find the set of Pareto-optimal solutions between forest harvesting costs and negative ecological impacts caused by the road construction and timber harvest. The model considers four objectives: (1) minimizing road construction and maintenance costs, (2) increasing attractiveness for cable yarding, (3) reducing negative impact on marshland, and (4) minimizing disturbances for endangered birds (such as *Tetrao urogallus*). The road network problem was mapped on a mathematical graph and solved as a Steiner-Tree-Problem. This problem is NP-hard, and the solution space is too huge to be optimally solved by complete enumeration. However, we developed an algorithm that can find a near-optimal solution very fast. The model has been applied in several mountainous areas in Europe. These tests led to three major findings: (1) the model representation is crucial for accurate and practical solutions, (2) there are only few Pareto-optimal solutions, and (3) small changes in the preferences of the stakeholders may influence the solution greatly.

Bending properties of wedged through oval-end mortise and tenon joints. Wang, Y., Chen, Y., Su, W. (*National Chiayi University, China; woody@mail.ncyu.edu.tw; s0901531@mail.ncyu.edu.tw; wencsu@mail.ncyu.edu.tw*).

The oval-end mortise and tenon joint has shown higher pull-out strength with wedges. This study investigates the effect of wedges on the bending moments and rigidity efficiencies (bending behaviors) of maple through oval-end mortise and tenon joints by varying groove widths, wedge slopes, and number and spacing of wedges. Finite element method was used to predict the bending moments and stress distributions. Maximum bending moments of the oval-end mortise and tenon joint with wedges were greater than those without wedge. The bending moments with a single wedge were increased with the increase of wedge slopes and with the decrease of groove width. However, for the same groove widths and wedge slopes, the bending moments with 1 or 2 wedges and without wedges have no significant differences. The differences between the measured and predicted bending moments were between –5.00 and 6.21%. The compressive stress concentration was found on the apex of the lower shoulder of the tenon and was increased with the increase of the displacement loading. The finite element analysis shows the bending moments increased with the increase of wedge spacing. Rigidity efficiencies of the wedged oval-end mortise and tenon joint had no significant differences among various combinations.

Withdrawal loads of wedged through oval-end mortise and tenon joints. Wang, Y., Chen, Y., Su, W. (*National Chiayi University, China; woody@mail.ncyu.edu.tw; s0901531@mail.ncyu.edu.tw; wencsu@mail.ncyuedu.tw*).

The wedged square-end mortise and tenon joint was believed to be a stronger joint compared to the regular square-end mortise and tenon joint. However, oval-end mortise and tenon joints have been more popular in furniture making due to excellent joint strength and ability to be processed rapidly and precisely. This study investigated the effect of wedge on pull-out loads of maple through oval-end mortise and tenon joints by changing groove widths (3, 4, and 5 mm) and wedge slopes (1:7, 1:8, and 1:9) for single wedge; and wedge spacings (12 and 19 mm) for double wedges. Finite element method was used to predict pull-out loads and stress field. The pull-out loads with either single or double wedges were greater than those without wedge. The joints with double wedges had higher loads but were affected by the spacing. Both the tested and predicted pull-out loads with single wedges

were increased with the increase of wedge slopes and with the decrease of groove widths. The difference between the measured and predicted pull-out loads are between -2.10 and 7.47%. The highest compressive stress and displacement were found at the uppers corners of the groove when wedge was in the groove.

Overview of renewable phenolic resins by fast pyrolysis of biomass. Xu, S., Chang, J., Gou, J., Han, Y., Zhang, L., Xia, B., Huang, Y. (*Beijing Forestry University, China; supershewa@163.com; cjianmin@bjfu.edu.cn; jinsheng.gou@gmail.com; hyx.m.s@163.com; zhanglita@gmail.com; xiabihua12@163.com; annabelleyu@163.com*).

Fast pyrolysis of biomass is one of the most recent renewable energy processes to have been introduced. This review covers the production and utilization of bio-oil from the fast pyrolysis of biomass and related materials to substitute for synthetic phenol and formaldehyde in phenol formaldehyde resins. These resins are primarily employed in the manufacture of wood panels such as plywood, MDF, particle-board, and OSB. Many feedstocks have been tested for their suitability as sources of phenolics including hard and softwoods, bark, paper waste, and agricultural waste. Resins have been prepared using either the whole liquid product, or a phenolics-enriched fraction obtained after fractional condensation or further processing, such as solvent extraction. This survey shows that considerable progress has been made towards reaching the goal of a price-competitive renewable resin, but that further research is required to meet the twin challenges of low renewable resin cost and satisfactory quality requirements. For example, bio-oils lack reactive sites compared to phenol, unstable renewable resin properties, and poor image. Therefore, so far, high-value applications of this fraction have not been widely commercialized.

Research on proper estimation of access time in forests by walking time analysis. Yamada, Y., Yamamoto, K., Kondo, M. (*Nagoya University, Japan; yozo@agr.nagoya-u.ac.jp; kazukiyo@agr.nagoya-u.ac.jp; mkondo@agr.nagoya-u.ac.jp*), Matsumoto, T. (*Gifu Academy of Forest Science and Culture, Japan; tmatsu@forest.ac.jp*).

The access time in forests is usually calculated as an isochrone buffer of walking time from roads. However the walking time is not correct in Japan because forest workers cannot walk at a constant speed due to steep terrain and thick vegetation. Moreover, approach points from roads to forest are limited owing to less parking area, steep slopes, and structures beside roads. Thus the conventional isochrone buffer is apt to give lower estimation than the actual access time. So we developed a novel method to improve more precisely the access time. The method is composed of a search algorithm of walking routes with GIS and an estimated walking speed under various conditions with walking speed formulas and walking friction index. The search algorithm can show the most effortless walking route. The walking speed formula can calculate the fastest walking speed on each walking gradient, and the walking friction index can represent the influence of the under vegetation conditions. According to using our developed method, the isochrone buffer was metamorphosed into complicated and chaotic isochrone distribution.

Influence of steam heating on the properties and surface performance of moso bamboo (*Phyllostachys pubescens*). Zhao, R. (*Chinese Academy of Forestry, China; rongjun@caf.ac.cn*), Hou, L. (*Inner Mongolia Agricultural University, China; nmghly168@yahoo.com.cn*), Fei, B., Ren, H. (*Chinese Academy of Forestry, China; fbh@caf.ac.cn; renhq@caf.ac.cn*).

Moso bamboo was processed by steam heat treatment in this study. Mechanical and chemical properties and surface performance of moso bamboo were tested with Chinese national standard methods. The results showed that the modulus of rupture (MOR) and modulus of elasticity (MOE) of the outer culm zone-layer of bamboo were at least 2.4 to 2.2 times greater than that of inner culm zone-layer. The steam treatment temperature and time had no effect on bending properties of the outer and inner culm zone-layers. A significant decrease in MOR occurred after the specimens were subjected to 200 °C. Of the three major chemical compositions of moso bamboo, alpha-cellulose was very stable to the steam treatment temperature and time, but hemicellulose decreased substantially when temperature was increased to 200 °C. Compared with untreated bamboo, the lightness (L*) of treated bamboo surface reduced while chromaticity parameters a* and b* remained plus. With higher treatment temperature and longer treatment time, Value a* and the overall color change (Δ E*) increased; on the contrary, b* decreased. Contact angles of a water drops were in all cases higher for heat-treated bamboo than that of untreated bamboo.

Theme F: Emerging Technologies in the Forest Sector

F-01 Detecting, monitoring and modeling forest fire and carbon emission using remote sensing and GIS

Organizer: Yousif A. Hussin, *University of Twente Netherlands, hussin@itc.nl.*

Optimizing tree-removal to efficiently minimize crown fire hazard. Contreras, M., Chung, W.D. (*University of Montana, USA; marco.contrerassalgado@umontana.edu; woodam.chung@umontana.edu*).

High intensity wildfires have resulted in large financial, social, and environmental costs around the world. Thinning is a common silvicultural treatment used to reduce potential fire intensity and severity by decreasing fuel load and breaking vertical and horizontal fuel continuity. Typically, thinning is applied at the stand-level using prescriptions designed to reduce crown fire initiation by increasing canopy base height (CBH), and to reduce crown fire propagation by decreasing canopy bulk density (CBD). In this study, we present a model for optimizing removal of individual trees to improve efficiency of thinning treatments for reducing crown fire potential. Light detection and ranging (LiDAR) data were used to obtain detailed terrain information and tree locations and attributes. The model includes three functional modules: (*i*) quantify fuel connectivity of individual trees in a stand, (*ii*) estimate location-specific costs of timber harvesting, and (*iii*) optimize location of cut-trees to maximize discontinuities in fuel connectivity, while ensuring cost efficiency and applicability of system results. The model was applied to a 4.6-ha forest stand selected for thinning with a target tree density of 300 trees per ha. Model results, data requirements for implementation, and model potential as a generalized tool are presented.

Modelling fire-induced carbon emissions in tropical forests of Ghana. Dowmoh, F.K. (*Kwame Nkruma University Science and Technology, Ghana; dowmoh17943@alumni.itc.nl*), Hussin, Y.A. (*International Institute for Geoinformation Science and Earth Observation; the Netherlands; hussin@itc.nl*), Oppong, K. (*Kwame Nkruma University Science and Technology, Ghana; kobbyoppong@yahoo.com*).

Tropical forests are a major reservoir of global terrestrial carbon, and thus play an essential role in the carbon cycle. Large amounts of carbon held in forest biomass are released into the atmosphere when trees are burned. Controlling or preventing tropical forest fires will significantly reduce global carbon emissions. Unfortunately, Ghana's tropical forest is not spared from this phenomenon. The high forest zone of Ghana experienced no fire until the early 1980s, when wildfire swept through most of the nation's forest. Since then wildfire has become an annual phenomenon. Quantifying gaseous emissions from fires constitutes a significant concern, both environmentally and politically, within the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Estimation of fire-induced carbon emission from Ghana's tropical forest will make an essential contribution in addressing Ghana's commitment to the UNFCCC. Modeling fire behavior accurately can give a good estimation of carbon emissions. This study integrates state-of-the-art fire behavior modeling in a GIS environment for the estimation of carbon emissions. The main focus of this research is to model tropical forest fire behavior and study the influence of forest condition, topography, and weather on severity of fire and consequently on carbon emission.

Mapping burn severity by using spaceborne high resolution MS data. Kim, C. (*Kookmin University, Republic of Korea; choenkim@kookmin.ac.kr*), Hong, S.H. (Space Environment Laboratory, *Republic of Korea; shhong@selab.co.kr*), Cho, H.K. (*Korea Forest Research Institute, Republic of Korea; hccho@forest.go.kr*).

Burn severity is an important role for rehabilitation of burned forest area. This factor led to the pilot study to determine if high-resolution multispectral (MS) images could be used to classify and delineate the burn severity over burned areas in Korea. This paper presents also the capability to use the images for effect of forest disturbance after the wildfire. The result of this study can be summarized as follows. (1) The modified normalized burn ratio (NBR) for both IKONOS and QuickBird images can be evaluated using burn severity mapping. (2) Both IKONOS-derived and QuickBird-derived NBR images could provide fire scar and detail mapping of the burned areas. (3) The mapping of QuickBird imagery can locate reliable rehabilitation (namely, secondary succession) over post-fire surface. (4) Comparisons of mapped forest disturbance derived from QuickBird NBR data and the mapped burn severity derived from Landsat delta NBR data show substantial agreement (KHAT value = 0.7886). (5) The method calculated from the correlation between tasseled cap wetness of both images and Landsat ETM+ band7 may also have application to forest harvest disturbance.

A comparison of precipitation and drought index related to forest fire occurrence in Korea. Kwak, H., Lee, W.K. (*Korea University, Republic of Korea; nextsunday@korea.ac.kr; leewk@korea.ac.kr*), Lee, S.Y. (*Kangwon University, Republic of Korea; lsy925@kangwon.ac.kr*), Won, M.S., Koo, K.S., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; mswon@forest.go.kr; kyosang@forest.go.kr; mblee@forest.go.kr*).

In this study, we compared the relationship between climate indices and forest fire occurrence. From previous studies, it is well-known that fuel moisture is very significant to forest fire occurrence. We chose two indices to compare forest fire occurrence with fuel moisture. Because precipitation affects fuel moisture, which is related with fire ignition and spread, standardized precipitation index (SPI) is a very useful index to determine the risk of forest fire. Drought index is also a convenient method to express the degree of fuel dryness, which is the opposite concept of fuel moisture. In this study, we used Palmer Drought Severity Indices (PDSI) for measuring the drought. To compute these two indices, we used the climate data that was collected on 76 stations by Korea Meteorological Administration. To cover all of Korea, precipitation station data were interpolated to raster. Forest fire occurrence history was provided by the Korea Forest Research Institute from 1991 to 2008. These fire point data contain the spatial-temporal information. As a result, the significant correlations were found between these indices and forest fire occurrence in Korea.

Optimization for the forest fire management program of the Bío-Bío region in Chile. Real, P., Riquelme, R. (*Universidad de Concepción, Chile; preal@udec.cl; rriquelm@ing-mat.udec.cl*), Rodriguez, R. (*Corporación Nacional Forestal, Chile; rolando.rodriguez@conaf.cl*).

In Chile, 35.6% of forest fires are concentrated in the Bío Bío region, affecting 14,036 ha. These fires are man-made, either by negligence or intention. From the point of view of environmental damage, mean MP3 emissions during the past 25 years have amounted to an average of 10,249 tons per year. In firefighting, the success of the initial attack depends on the control efforts of those who get to the fire first. The arrival must take place in a minimum time to carry out resolute, efficient, and safe first actions so that the fire can be controlled from the very beginning. Resources earmarked for the first attack need to be stored in strategic places, which is the result of an optimization process that considers in its analysis the relationship between the factors that define risk and danger of occurrence. From this starting point, a mathematical optimization model was developed to localize the "stand by" position of the fire brigade; a computer platform facilitates via the Internet the exchange of digital geographic information between the actors of the presuppression program and offers a program of capacity-building and introduction to the GPS and GIS information technologies.

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Mapping the forest fire occurrence risk using the conditional probability. Hong, Y.J., Kim, D.Y., Im, S.J. (*Seoul National University; Republic of Korea; lights03@snu.ac.kr; hendrix7@snu.ac.kr; junie@snu.ac.kr*).

Forest fire can be recognized as an ecological disaster, regardless of whether they are induced by natural causes or human activities. The occurrence of forest fire can be directly or indirectly related tohuman acts, surface fuel type, topographic characteristics, as well as meteorological conditions. In this study, a raster-based GIS was applied in order to map forest fire occurrence risk of Gwangnung city, located in Jeollanam-do, Korea, with eight thematic layers: tree species related to fuel condition, elevation, slope, aspect, and distance to facilities such as forest road, orchard/farm, governmental office, and shrine. Combining each thematic layer with surveyed fire occurrence sites during 1997–2004 was carried out in order to calculate conditional probability of fire occurrence, and each thematic layer was weighted by conditional probability calculated. The forest fire occurrence risk map was produced by combining all the weighted thematic layers. The resulting map was verified by the fire occurrence sites for 2004–2007 and showed that it contained 92% of the fire event points cumulatively at the middle of the fire risk.

Development of computational wind field model and applicability assessment for forest fire. Kim, D.H., Lee, M.B. (*Korea Forest Research Institute, Republic of Korea; k3d2h1@forest.go.kr*; *mblee@forest.go.kr*), Kim, B.Y. (*NEXT ENS Co., Republic of Korea; bykim@nens.co.kr*).

To predict the behavior of fire spreading in mountain terrain, knowing the accurate surface wind pattern is essential. The most powerful method of predicting wind pattern is computational fluid dynamics (CFD) simulation. But CFD simulation has several defects: it needs a long time compared to other methods, and the pre-processing job (making 3-dimensional geometry from the computational domain and making the computational grid) is tedious and time consuming. To remove this annoying job, we integrated the CFD program with a GIS program. The digital elevation map (DEM) data of the GIS program is directly pushed to the CFD program, and a 3-dimensional structured type grid is automatically generated. For the CFD solver, we used a pressure-based solving method using SIMPLE algorithm and the turbulence k-omega model. The result was compared with a commercial CFD program, FLUENT, and showed good agreement. The results can be used directly in a fire-spreading simulation program. With this program, the time-consuming and annoying CFD simulation process can be finished with several inputs such as GIS file, wind direction, wind speed, and grid resolution. So it became possible to more accurately and quickly predict fire spread in the forest.

Fire spread modelling for fire management in the montane forest of Majella National Park, Italy. Nyatondo, U.N., Leeuwen, L.V., Hussin, Y.A. (*International Institute for Geoinformation Science and Earth Observation; the Netherlands; nyatondo22136@itc.nl; Leeuwen@itc.nl; hussin@itc.nl*).

Although fires are responsible for shaping most ecosystems, they can be destructive both to vegetation and human life. Fires have a major role in the global carbon cycle and a primary disturbance in most forest ecosystems. Global climate change is influenced by these fire-induced gases, especially carbon dioxide and methane. It is therefore important in fire management to predict the potential behavior of wildland fires and assist in fire management. Fire Area Simulator (FARSITE) is a fire growth simulation model that describes the spatial and temporal spread of fire in forests and rangelands using spatial information on weather conditions, fuel type, and topography. In 2007, the fires in southeast Europe were the worst recorded in history. Majella National Park in south Italy was affected and the area burnt was the largest recorded in the history of the park. The objectives of this work were to identify fire-sensitive areas, estimate the spatial distribution of fire intensity, evaluate the potential of fire spread modelling for the identification of ignition points, and evaluate the effect of incorporating spatial variation in wind speed and direction on the accuracy of fire area simulation.

F-02 Contemporary frontiers in forest inventory and assessment using successive remotely sensed data

Organizer: Temesgen Hailemariam, *Oregon State University, USA, hailemariam.temesgen@oregonstate.edu;* Cris Brack, *Australian National University, Australia, cris.brack@anu.edu.au.*

Using multi-temporal airborne laser scanning data to monitor changes in forest structure on the Kenai Peninsula of Alaska over a 5-year period (2004–2009). Andersen, H.E., Winterberger, K. (*U.S. Forest Service, Anchorage, Alaska, USA; handersen@fs.fed.us; kwinterberger@fs.fed.us*), Strunk, J., Temesgen, H. (*Oregon State University, College of Forestry, Corvallis, Oregon, USA; jacob.strunk@oregonstate.edu; hailemariam.temesgen@oregonstate.edu*).

Wildfires are a dominant factor in determining carbon dynamics within the boreal forests of Alaska. While fire perimeters can be monitored and mapped using optical satellite imagery, these technologies do not provide a direct measurement of three-dimensional structural changes occurring in these forests due to fires. In contrast, airborne laser scanning is an active remote sensing technology that, if acquired on multiple occasions, can be used to directly measure changes in forest structure due to disturbances such as fire and insect infestations. In this study, we analyzed the capability of airborne laser scanning data to monitor changes in forest structure and above-ground carbon/biomass on the Kenai Peninsula due to fires occurring between 2004 and 2009. High density LiDAR was acquired in a strip sampling mode on the Kenai Peninsula in May, 2004 and these same flight lines were reflown in October, 2009. Approximately 10 large fires occurred on the western Kenai between 2004 and 2009, which burned approximately 49,000 ha. Changes in forest structure and above-ground carbon due to these fires was quantified through an analysis of structural metrics developed from the multi-temporal LiDAR data sets and field measurements collected within burned areas on the Kenai Peninsula.

Improving vegetation classification from Landsat and IRS image: evaluation of unsupervised and supervised classification through band ratios and DEM in a mountainous landscape in Nepal. Bahadur KC, K. (*University of Hohenheim, Germany; Krishna@uni-hohenheim.de*).

Modification of the original bands and integration of ancillary data in digital image classification has been shown to improve land use land cover classification accuracy. There are not many studies demonstrating such techniques in the context of the mountains of Nepal. The objective of this study was to explore and evaluate the use of modified band and ancillary data in Landsat and IRS image classification, and to produce a land use land cover map specifically of types of forestry land uses of the Galaudu watershed of Nepal. Classification of land uses was explored using supervised and unsupervised classification for 12 feature sets containing the Landsat MSS, TM, and IRS original bands; ratios; normalized difference vegetation index; principal components; and a digital elevation model. Overall, the supervised classification method produced higher accuracy than the unsupervised approach. The result from the combination of bands ration 4/3, 5/4, and 5/7 ranked the highest in terms of accuracy (82.86%), while the combination of bands 2, 3, and 4 ranked the lowest (45.29%). Inclusion of DEM as a component band shows promising results.

Integration of Landsat time series and LiDAR to understand trajectories of forest change. Cohen, W. B. (*U.S. Forest Service, USA; wcohen@fs.fed.us*), Pflugmacher, D., Kennedy, R., Yang, Z. (*Oregon State University, USA; dirk.pflugmacher@oregonstate.edu*; *robert.kennedy@oregonstate.edu; zhiqiang.yang@oregonstate.edu*).

LiDAR data provide high-quality forest structure descriptions at landscape scales, but do not contain information about disturbance histories that led to current conditions. Presently diverse forest stands may have been quite similar decades ago, even without active forest management. Forest stands that have similar forest structures now might have originated at different times or experienced different disturbance histories. Knowledge of the linkage between forest history and current condition is critical for predicting forest response in projections of future forest conditions associated with a host of management- and climate change-induced disturbances. We will present results from an integrated Landsat time series and LiDAR dataset to demonstrate the importance of considering this linkage between current forest condition and disturbance. Field data will inform LiDAR descriptions of current conditions. Stand histories will be informed by new time series analysis tools: LandTrendr, an automated time series segmentation and labeling algorithm; and TimeSync, a human time series visualization and data collection tool for LandTrendr validation. Our results are expected to present compelling evidence that the integration of LiDAR and Landsat data is imperative for understanding forest resiliency in projections of future forest conditions to meet management and policy goals.

Challenges and opportunities in estimating biomass change using successive remotely sensed and ground data in coastal Alaska forests. Hailemariam, T., Strunk, J. (*Oregon State University, USA; hailemariam.temesgen@oregonstate.edu; jacob.strunk@oregonstate.edu*), Andersen, H.E. (*U.S. Forest Service, USA; handersen@fs.fed.us*).

National and regional estimates of biomass change are required to estimate carbon stock change, monitor CO2 mitigation projects, characterize forest productivity and processes, and evaluate the feasibility of bioenergy projects. Yet, estimating biomass change is a very difficult task. Emerging technologies such as LiDAR (light detection and ranging) offer unprecedented opportunities to quantify status and change of forest attributes. Using successive remote sensed and ground data collected from across a range of major forest types in coastal Alaska, we demonstrate selected approaches that integrate different data sources and estimate biomass change. Differences over successive measurement periods provided estimates of biomass change, which varied widely by forest types and productivity classes. In this presentation, we discuss (1) suitability and predictive abilities of selected estimators to quantify and analyze biomass change in the coastal Alaska forest types, (2) impacts of climate variables in estimating biomass change, and (3) challenges and opportunities in using successive remotely sensed and ground data. Finally, we demonstrate how repeatedly measured data can be used as decision support tools in forest monitoring and assessment.

The analysis of vegetation restoration after natural disturbance with multi-temporal remote sensing images and field survey data. Tsai, J.I., Feng, F.L. (*National Chung Hsing University, China-Taipei; d9833003@mail.nchu.edu.tw*; *flfeng@nchu.edu.tw*).

The disastrous "9/21" earthquake, Richter magnitude 7.3, in September 1999, caused substantial land-cover/land-use (LC/LU) change in central Taiwan. Jiou-Jiou Peaks Natural Reserve was established in May, 2000, to protect the specific topography and complex diversity, so human disturbances were prohibited. Typhoons tore into and influenced this place in 2001, 2004, 2005, and 2008. The aim of this study is to investigate vegetation restoration after a series of natural disturbances. Multi-temporal SPOT images (1999, 2000, 2001, 2003, 2006, and 2008); ortho-aerial photos; and digital terrain models (DTM) were applied to investigate the status, function and change of LC/LU. Supervised classification, an image differencing algorithm, and field survey data were used to obtain the landscape change. The results showed that natural vegetation could restore by itself after natural disturbances, including the 9/21 earthquake and continuous typhoons, but vegetation types were different. We also discovered that the LC/LU had almost no change in the basin region, and vegetation restoration processing is proceeding from the foot to top of each peaks after combining with DTM. Vegetation restoration areas in each year were 23.37%, 28.80%, 61.51%, 64.64%, 64.54% and 91.28%, respectively. The patches of succession period could be detected also.

Automatic stem location mapping using several single-scan TLS for plot-wise forest inventory. Liang, X., Litkey, P., Hyyppa, J., Kaartinen, H. (*Finnish Geodetic Institute, Finland; xinlian.liang@fgi.fi*; *paula.litkey@fgi.fi*; *juha.hyyppa@fgi.fi*; *harri.kaartinen@fgi.fi*), Holopainen, M. (*University of Helsinki, Finland; markus.holopainen@helsinki.fi*).

The application of terrestrial laser scanning (TLS) for accurate forest inventory has received increasing attention and interests in the past decade. Research studies have been carried out mainly on parameter estimation, such as stem location, diameter profile, and projection area, from one single-scan or merged multi-scan TLS data. In general, merged multi-scan data provide the full point cloud coverage of targets and potentially lead to the high estimation accuracy, but the automatic registration of point clouds is still a research topic at this stage. One single-scan data can provide the point cloud coverage on one side of the object and offers simple scan geometry and fast data processing, but the recognition of objects in the shadow area is impossible. However, for stem location mapping, the accuracy of the position estimation from one single-scan data can be improved using several single-scan data without merging. In this paper, an automatic algorithm is reported on this topic. Trunk points are identified by points spatial distribution and the individual map is estimated by trunk models. The final stem map is produced by combining ones from single scans. The automatic method provides a generic solution for the stem map production.

Utilization of non-parametric methods to map forest attributes using airborne laser scanning data. Maltamo, M., Packalén, P. (*University of Eastern Finland, Finland; matti.maltamo@uef.fi*; *petteri.packalen@uef.fi*), Breidenbach, J. (*Norwegian University of Life Sciences, Norway; johannes.breidenbach@umb.no*), Vauhkonen, J. (*University of Eastern Finland, Finland; jari.vauhkonen@uef.fi*).

Non-parametric methods have been used to map forest attributes with remote sensing data since the 1980s. However, the development of airborne laser scanning (ALS) technology has offered many new possibilities to combine remote sensing and field data. In terms of forest assessment and monitoring the information, the content of ALS data is superior compared to many other remote sensing data sources. Several metrics that form highly informative predictor variables can be derived from ALS data at the stand, plot, or tree level. Non-parametric methods allow modeling a multivariate response and maintain the covariance structure of the data. This presentation summarizes studies on non-parametric methods and ALS data. The earliest attempts focused on forest inventory applications with the area based approach, but recently the single tree level has been studied as well. Especially, in the case of species-specific forest inventory applications, the use of ALS data in combination with aerial images has become essential. Additionally, ALS data have been used to characterize other forest attributes such as forest site types, timber sortiments, and dead wood content by means of non-parametric methods. Nearest neighbor methods (k-most similar neighbor inference) and classification trees (e.g., random forest) have frequently been applied.

Spatial monitoring of late-successional forest habitat over large regions with nearest neighbor imputation. Ohmann, J.L. (*U.S. Forest Service, USA; johmann@fs.fed.us*), Gregory, M.J., May, H.K.; Kennedy, R. (*Oregon State University*, USA; *matt.gregory@oregonstate.edu; heather.may@oregonstate.edu; robert.kennedy@oregonstate.edu*); Cohen, W. (*U.S. Forest Service, USA; wcohen@fs.fed.us*), Yang, Z., Pfaff, E. (*Oregon State University, USA; zhiqiang.yang@oregonstate.edu; eric.pfaff@oregonstate.edu*); Moeur, M. (*U.S. Forest Service, USA; mmoeur@fs.fed.us*).

The Northwest Forest Plan, which aims to preserve late-successional and old-growth forests (LSOG) and associated species, significantly reduced harvesting of older forests on U.S. federal land in the Pacific Northwest. To monitor plan effectiveness, we mapped detailed attributes of forest vegetation across 23 million ha, for 1996 and 2006, using gradient nearest neighbor (GNN) imputation. The feasibility of developing a time-series of GNN model-based maps that accurately portray forest change had not been tested. Reference data were from 17,000 forest inventory plots measured from 1993 to 2008. Spatial predictors were from Landsat imagery and GIS data on climate and topography. Landsat data were developed from a trajectory-based, pixel-level method for change detection, which detects subtle changes from growth and disturbance and reduces noise from sun angle and seasonality. Overall, LSOG was stable on non-federal lands and increased slightly on federal lands because of harvest reductions and growth. Wildfires and insects caused LSOG losses in drier forests and at higher elevations. Landscape trends from two GNN models were quite reasonable at the scale of small landscapes, but pixel-level change was often noisy and unreliable. A major challenge for assessing landscape change is identifying the appropriate geographic scale for analysis.

Using the SSEB-ET model to characterize the seasonal and spatial dynamics of forested regions in the Greater Horn of Africa. Senay, G. (*U.S. Geological Survey Earth Resources Observation and Science (EROS), USA; senay@usgs.gov*), Bohms, S. (*SGT, USA; sbohms@usgs.gov*), Verdin, J. (*U.S. Geological Survey Earth Resources Observation and Science (EROS), USA; verdin@usgs.gov*).

Evapotranspiration (ET) is a key component of the hydrologic budget of a forested watershed and is directly related to plant biomass accumulation. Consistent ET estimates can be used to study the spatial and temporal dynamics of forest biomass change. We implemented the simplified surface energy balance (SSEB) to generate 10 years' (2000–2009) monthly and seasonal ET estimates in the Greater Horn of Africa at 1-km resolution. The SSEB model integrates weather data sets from the Global Data Assimilation System with remotely-sensed thermal and optical data from the MODerate resolution Imaging Spectroradiometer (MODIS). ET estimates were summarized by forest cover types for different parts of the region. Generalized temporal ET patterns highlight spatial differences in the growing season. The year-to-year ET magnitudes demonstrated the impact of known drought and excess rainfall years. The consistency of satellite-based ET estimates allows a precise estimation of water balance components of remote watersheds without stream gauge instrumentations. Future research will focus on the estimation of basin water budgets of forested catchments. An operational implementation of the SEEB model is planned for the general landscape to monitor the impact of drought and assess crop and vegetation performance for early warning applications.

Posters

Land cover change and classification using ISOCLUST method. Combalicer, E.A. (*Nueva Vizcaya State University, Philippines; eacombalicer@yahoo.com*), Kim, D., Im, S. (*Seoul National University, Republic of Korea; oioino@hotmail.com; junie@snu.ac.kr*), Cruz, R.V.O. (*University of the Philippines Los Banos, Philippines; rexcruz@yahoo.com*).

The study presents various land cover types, which were classified using ISOCLUST method from Landsat ETM+ (1992 and 2002) and ASTER imageries (2008). Applying NDVI in the segmentation process during the image classification proved to be an effective approach for classifying land cover types at the Mt. Makiling Forest Reserve, Philippines. The classification explicitly figured out whether the forest areas are persistent or still intact while spatially expanding the coverage from the area. The change analysis revealed that the spatial distribution of various land cover categories were subjected to gain and loss based on the present and previous imageries. High gains for forest areas and many losses on agroforestry areas were established at a certain time span. The land cover by category denotes a decrease of forest areas between 1993 and 2002, and eventually increases in line with the latest period. The increase in agroforestry areas was merely detected between 1993 and 2002 and subsequently reduced the possible expansion of its area coverage. A great land cover can be perceived from the restoration efforts made in the study area.

Relying on fuzzy set theory for landscape multi-temporal analysis: a test in a mountainous area. Geri, F., Amici, V. (*University of Siena, Italy; francesco.geri@unisi.it; valerio.amici@unisi*), Rocchini, D., Neteler, M., La Porta, N. (*FEM-IASMA, Italy; duccio.rocchini@iasma.it; markus.neteler@iasma.it; nicola.laporta@iasma.it*).

Remote sensing represents a powerful tool for investigating landscape change over time, since it allows for a synoptic view of areas reached in a limited time span. This is particularly true when considering extreme habitats like mountainous areas. Further, the analysis of land cover maps and their change over time is important for more efficient landscape monitoring and management. To date, most studies have relied on a crisp view of the landscape, identifying crisp boundaries among different patches. Nevertheless, this attempts to divide the gradual variability of the Earth's surface into a finite number of non-overlapping classes. In other words, classes are considered exhaustive and mutually exclusive. On the contrary, landscapes are expected to be spatially continuous. Thus, no matter how accurately map classes are defined, the uncertainty associated with class mixtures will be never completely eliminated. Fuzzy-based methods allow us to account for uncertainty, attributing to each spatial entity (polygon or pixel) the degree of membership to each land cover class. The aim of this study is to apply fuzzy sets for evaluating multitemporal changes of a mountainous area (Trento Province, northern Italy) and to disentangle advantages and disadvantages of fuzzy set theory for landscape change monitoring.

Estimating site index of sugi (*Cryptomeria japonica*) and hinoki (*Chamaecyparis obtusa*) man-made coniferous stands using low-density airborne LiDAR. Kodani E., Tarumi A. (*Forestry and Forest Products Research Institute, Japan; kodani@ffpri.affrc.go.jp; tarumi@ffpri.affrc.go.jp*), Awaya, Y. (*Gifu University, Japan; awaya@green.gifu-u.ac.jp*).

Site indices were estimated in man-made coniferous forest stands of sugi (*Cryptomeria japonica*) and hinoki (*Chamaecyparis obtusa*) using low-density airborne LiDAR. LiDAR data were acquired along a 20-km long × 100-m wide transect in eastern part of Shikoku Island with low-density (1 pulse per square meter) and small footprint (20 cm). First pulses and last pulses were recorded. We set 24 plots—including non-forest, small forest, and large forest areas—in the transect, and measured DBH and height. Laser pulses of digital canopy height model were extracted in each plot and the following LiDAR indexes were calculated: the average, maximum, minimum; 90, 75, 50, 25 percentiles; standard deviation; and coefficient of variation. A linear regression analysis was performed between the LiDAR indices and stand height. Stand height had the strongest relationship with the LiDAR index of first pulse 80 percentile ($R^2 = 0.91$). We could estimate the site index in a large area, using the stand height of the LiDAR data, the stand age in forest GIS, and the site index equation.

LiDAR-based estimation of leaf area index and canopy openness in broad-leaved forest. Sasaki, T., Imanishi, J., Ioki, K., Morimoto, Y. (*Kyoto University, Japan; sasakita@kais.kyoto-u.ac.jp; imanishi@kais.kyoto-u.ac.jp; ioki@kais.kyoto-u.ac.jp; ymo@kais.kyoto-u.ac.jp*), Kitada, K. (*Nakanihon Air Service Co. Ltd., Japan; kkitada@nnk.co.jp*).

We estimated leaf area index (LAI) and canopy openness of temperate broad-leaved forest using discrete return and small footprint LiDAR data. We tested four LiDAR-based variables, including two newly proposed ones; three echo types (first, last, and only); and three classes (ground, vegetation, and upper vegetation). We compared the accuracy by means of correlation and regression analyses with several conventional vegetation indices derived from simultaneously acquired high-resolution near-infrared digital photographs. Among the LiDAR-based variables, the ratio of "only and ground" pulse to "only" pulse ("only and ground" fraction, OGF) was the best estimator of both LAI and canopy openness, followed by the ratio of the pulses that reached ground to projected lasers (ground fraction, GF). Among the vegetation indices, the normalized differential vegetation index (NDVI) was the best estimator of both LAI and canopy openness. The LiDAR-based variables proposed in the present study, GF and OGF, seemed to have great potential to estimate LAI and canopy openness of broad-leaved forests, and they were better than or comparable to the vegetation indices derived from high-resolution near-infrared digital imagery.

Environmental impacts of the shelter forests in Horqin Sandy Land, China. Yan, Q.L., Zhu, J.J., Jin, C.J. (*Institute of Applied Ecology, Chinese Academy of Sciences, China; yqliae@yahoo.com.cn; jiaojunzhu@iae.ac.cn; yqliae@yahoo.com.cn*).

Aiming to control blown sand and wind erosion and to prevent soil and water losses, the Three-North Shelter Forest Program (TNSFP) in China (the largest ecological reforestation/afforestation program in the world) was initiated in 1978. Horqin Sandy Land (HSL), the largest sandy land in China, is the key area for the TNSFP construction. Thirty years of the construction has passed, but there is little information on the environmental impacts of the shelter forests. Based on four periods of Landsat MSS/TM/ETM images in HSL, the effects of variations in area/spatial distribution patterns of shelter forests (including broadleaved forests and shrubs) on area of sandy land were explored. Results showed that for the past 30 years, areas of sandy land gradually decreased by 6.5% with increasing area of broadleaved forests and decreasing area of shrubs. Using the Gray correlation analysis method, the most correlative factors to the variation of sand areas were both resolution index of shrubs and landscape diversity index, with correlation coefficients of 0.78 and 0.71 respectively. It can be concluded that during TNSFP construction, the increases of shrub resolution and landscape diversity would contribute greatly to controlling blown sand and wind erosion in HSL.

F-03 Biotechnology applications in forest breeding and plantation management

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Conservation of critically endangered tree species based on information obtained by ubiquitous genotyping. Isagi, Y., Kaneko S. (*Kyoto University, Japan; isagiy@kais.kyoto-u.ac.jp; skane@kais.kyoto-u.ac.jp*).

Conservation of biodiversity requires genetic information of endangered species, such as clonal structure, genetic structure, genetic diversity, genetic differentiation, gene flow, inbreeding coefficient, and relatedness. However, many problematical activities for biological conservation without genetic information have been made for a variety of endangered plant species so far. They are, for example, propagation and plantation of a few lineages of a species, transplantation without consideration of intraspecific genetic differentiations, breeding without consideration of relatedness, hybridizing with related species that causes genetic pollution, etc. We have attempted to conserve several critically endangered tree species with remnant individuals (fewer than 100s). For all trees of these target species growing in the wild, we measured the position in their habitat and collected leaf samples for DNA analysis. Microsatellite markers were developed for each species and genotypes were determined for all individuals of the species. We call this research approach *ubiquitous genotyping*. We found the information from the ubiquitous genotyping was quite useful to uncover genetic traits of critically endangered plant species surviving in the wild and to evaluate sustainability of wild populations.

Role of brassinosteroids in lignin biosynthesis and secondary xylem formation of yellow poplar. Jin, H.J. (*Kookmin University, Republic of Korea; hjung0716@naver.com*), Kwon, M. (*Korea University, Republic of Korea; mikwon@korea.ac.kr*).

Brassinosteroids (BRs), plant steroidal hormones, have various physiological roles such as promotion of cell elongation, regulation of seed germination, induction of rhizogenesis, and protection against various abiotic stresses during plant growth and development. Brassinosteroids have been recently implicated for their roles during secondary xylem formation in plants. However, this role as regulator for secondary xylem formation has not been analyzed in tree species. Thus, this study was attempted to elucidate the role of brassinosteroids in secondary xylem formation. Brassinolide, the most active brassinosteroid in plants, was exogenously applied to the vascular cambium of 2-year-old yellow poplar stems, and its effects on cell wall assembly and lignin biosynthesis at cellular and sub-cellular levels were analyzed. Anatomical analysis clearly demonstrated that the length of both types of cells, fiber and vessels, significantly increased upon BL treatment. Interestingly, the occurrence and size of cell vessel types greatly increased upon BL treatment, implying a cell-type-specific role of brassinosteroid during secondary xylem formation. Since histochemical analysis detects the changes in lignin content upon BL application, the expression level of lignin biosynthetic genes was analyzed at the transcriptional level via quantitative real-time reverse transcription polymerase chain reaction (RT-PCR).

Characterization of transgenic poplar plants expressing AtNDPK2 gene. Kwak, S.S., Kim, Y.H. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; sskwak@kribb.re.kr; cefle@kribb.re.kr*), Choi, I.M. (*Korea Forest Research Institute, Republic of Korea; yichoi99@forest.go.kr*), Kim, M.D., Lee, H.S. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; dorrf@kribb.re.kr; hslee@kribb.re.kr*), Yun, D.J. (*Gyeongsang National University, Republic of Korea; djyun@gnu.ac.kr*), Noh, E.W. (*Korea Forest Research Institute, Republic of Korea, ewnoh@forest.go.kr*).

Desertification is one of the most serious global problems caused by rapid industrialization in developing countries. To cope with global energy and environmental problems, it is urgently required to develop new environmentally friendly industrial plants to be grown on marginal lands including desertification areas for sustainable development. Oxidative stress derived from reactive oxygen species (ROS) is one of the major factors causing injury to plants exposed to environmental stress. To develop transgenic plants with an enhanced tolerance to multiple environmental stresses, we are focusing on the manipulation of antioxidant genes in plant cells. In this study, transgenic poplars (*Populus alba* × *P. tremula* var. *grandulosa*) expressing the AtNDPK2 (Arabidopsis NDP kinase 2) gene under the control of oxidative stress-inducible SWPA2 promoter were generated and characterized. Transgenic poplars showed reduced oxidative stress derived from by methyl viologen (MV), a ROS-generating non-selective herbicide. Transgenic poplars showed increased activities of various antioxidant enzymes as well as NDPK activity after MV treatment. Transgenic poplars also showed increased growth under field conditions compared to non-transgenic plants. The overall growth characters of transgenic plants and the quantitative expressions of auxin-response genes in transgenic plants under field conditions will also introduced.

Development of microsatellite markers for the mangrove tree *Avicennia schaueriana* and analysis of natural populations from Brazil's northern coast. Maruyama Mori, G. (*State University of Campinas, Brazil, mori@unicamp.br*), Zucchi, M.I. (*Agronomic Institute of Campinas, Brazil, mizucchi@iac.sp.gov.br*), Sampaio, M.I.C. (*Federal University of Pará, Brazil, ira@ufpa.br*), Souza, A.P. (*State University of Campinas, Brazil, anete@unicamp.br*).

Mangrove forests are wetland ecosystems within the intertidal zone of tropical and subtropical coastlines whose services include extreme events mitigation, and provision of nursery and spawning areas for economically important fishes and shellfishes. The intense urban and industrial pressures along coastlines coupled with climate changes consequences, mainly sea-level rise, seriously threaten these forests, which are being lost by the rate of 1 to 2% per year. This scenario highlights the need for effective mangrove forest conservation, restoration, and management programs. Success can be achieved only when information about genetic variation is taken account in order to elucidate problems and guide decisions. Therefore, we developed 12 polymorphic microsatellites for the South American species of the pantropical mangrove genus *Avicennia*, *A. schaueriana*. These high-resolution molecular tools were used to study three populations from the north coast of Brazil. We found very low differentiation among these samples and high inbreeding coefficients (which has already been reported for other species of *Avicennia* in many other locations) and evidences for drastic population reduction in two of these samples. These results have important implications for mangrove conservation and management. Our future efforts will focus on analysis of populations sampled from the entire distribution of this species.

Influence of leaf litter of transgenic *Populus simonii* × *P. nigra* on soil ecosystems. Qiuyu, W. (*Northeast Forestry University, China; wqyll@sina.com*).

In this study, the leaves of transgenic *Populus simonii* × *P. nigra* with the Bt (spider insecticidal) peptide gene (target gene) and with the NPT gene (report gene) were buried in broad-leaved forest soil for 6 months, to study the horizontal transfer possibility of transgenic genes. Five kinds of soil microbes around buried leaves were counted in order to study the change of soil microbe community during leaf decomposition. From six observations during leaf decomposition, the number of bacteria was higher than other microbes. The result showed that the target and report genes left in the soil from the transgenic poplar existed more than 60 and 90 days, respectively; both of them were not detected after 120 days. After the transgenic leaves decomposed totally, the target and report genes in transgenic plants were detected using PCR technique, in which the positive result of NPT genes from soil bacteria was higher than control, from 12.5% to 58.46%, and of Bt-spider insecticidal peptide gene from 1.92% to 3.08%, respectively. The result was also proved by southern blotting detection, but with the lowest probability. Therefore, further study needs to be done.

Prospect of *in-vitro* technology for propagation, conservation, and sustainable use of recalcitrant tropical forest trees. Roy, S.K. (*Jahangirnagar University, Bangladesh; shkmroy@yahoo.com*).

In-vitro propagation technology has been utilized for mass propagation of recalcitrant tropical forest trees. From shoot tip and nodal explants of mature trees, protocols for some tropical trees—e.g., *Artocarpus heterophyllus, A. chaplasha, Azadirachta indica, Gmelina arborea*, and *Elaeocarpus robustus*—have been established. The techniques consisted of four major steps: (i) establishment of *in-vitro* cultures from rejuvenated tissues, (ii) induction of multiple shoots from individual explants, (iii) rooting, and (iv) acclimatization. For culture establishment, multiplication and rooting Murashige and Skoog's (MS) and woody plant medium (WPM) nutrient media were used. About 85% of cultures produced shoots. For shoot multiplication, newly formed shoots were subcultured to fresh medium designed for each plant species, and 20–45 shoots per culture were obtained through several subcultures. Well-developed shoots were rooted by implanting them on root induction medium. About 75% of the regenerated plants survived. The technique was found prospective as a viable alternative for the continuous supply of planting materials for recalcitrant tropical trees as well as for the conservation of forest gene resources.

Interactions between transgenic trees and herbivores. Vihervuori, L., Pasonen, H.L., Lyytikäinen-Saarenmaa, P. (*University of Helsinki, Finland; liisa.vihervuori@helsinki.fi; hanna.pasonen@helsinki.fi; paivi.lyytikainen-saarenmaa@helsinki*).

New technologies that produce transgenic trees expressing specific charasteristics may help to develop trees for different purposes. Introducing genes from other organisms in order to improve tree resistance has been increasingly studied, for example. Besides the targeted properties, transgenic technology may also have unexpected effects on the trees themselves and on co-organisms. We have studied ecological interactions of transgenic trees for almost 10 years. We have focused on birches (*Betula pendula*) expressing sugar beet chitinase, and aspens (*Populus tremula*, *P. tremula* × *tremuloides*) expressing pine pinosylvin synthase transgene. The trees were originally produced to study fungal interactions and fungal resistance. We presumed that the transgenic trees could have non-target impacts on tree properties and on insect community structure, for example on tree growth characteristics and herbivorous interactions. Our studies have shown that the growth charasteristics of the trees as well as their insect density and composition may be influenced by the chitinase transgene. Also, transgenic chitinase seems to affect feeding performance of herbivorous insects and transgenic pinosylvin on feeding choices of hares. The main focus will be in the key findings of herbivore-related interactions. Also plant properties important for herbivore-interactions will be discussed.

Rescue and maintenance of selected eucalypt ortets through rejuvenation by tissue culture. Yasodha, R., Subhashini, R., Shanthi, K. (*Institute of Forest Genetics and Tree Breeding, India; yasodha@icfre.org; subhashinibt@gmail.com; shanthik@icfre.org*).

Regeneration of highly productive *Eucalyptus* plantations is achieved through selection and propagation of high yielding ortets. Presently, in India the techniques used for establishment and management of clone banks does not support the long-term conservation of selected ortets, and many individuals face extinction due to poor rooting ability. The combination of tissue culture techniques and conventional propagation strategies yields quality planting stock with low prices. To increase genetic diversity of clonal plantations and productivity, it has become essential to gradually shift towards changes during the establishment of clonal systems. Efforts were made to use tissue culture options for maintenance of continuous *in-vitro* cultures of the best clones, rejuvenation of difficult-to-root clones, and rescue mature hybrid clones without coppicing. Five difficult-to-root clones of *E. camaldulensis* were rejuvenated with 70–90% rooting, and one best performing hybrid ortet *Corymbia torelliana* X *C. citriodora* was rescued through the tissue culture approach. The *in-vitro*-rejuvenated plantlets are used as responsive stock plants for mass production as rooted cuttings, which is a cheap technique for clonal propagation. The rejuvenated cultures of 30 clones are maintained *in-vitro* to continuously retrieve plants for disease/insect pest free stock plant establishment.

Posters

Cross-species transferability of SSR markers in *Pinus roxburghii.* Chauhan, P., Ginwal, H.S., Barthwal, S. (*Forest Research Institute, India; priti14@rediffmail.com; ginwalhs@rediffmail.com; barthwal.santan@gmail.com*).

Knowledge of genetic variability is an important tool in various steps of breeding programs, which can be assisted by use of molecular markers. Simple sequence repeats (SSRs) are highly informative DNA-based markers widely used in population genetics and linkage mapping studies. Developing microsatellites from the large, highly duplicated conifer genome requires special tools; and de novo development for each species is expensive, labor-intensive, time consuming, and demanding of skilled personnel. However, the evolutionary conservation of DNA sequences that flank SSR sites allows previously developed SSR primers to be used in various other related species. Here we report the transferability of microsatellite markers from *Pinus sylvestris, P. thunbergii, and P. resinosa to P. roxburghii.* Out of the 40 primer pairs tested, 29 primer pairs showed positive amplification and can be characterized as high quality for use in population genetic analysis, as they gave clean PCR amplification products of given product size and the remaining 11 either showed no amplification or showed non-specific amplification. These cross species transferable marker sets will be useful for more extensive population genetic studies.

Development of diagnostic markers in plantation species of casuarina and eucalypts: implications in quality control of clones and certification of controlled crosses. Dasgupta, M., Ramasamy, Y. (*Institute of Forest Genetics and Tree Breeding, India; modhumitaghosh@hotmail.com; yasodha@icfre.org*).

Tree clone identification is traditionally performed using morphological descriptors that are subjected to ambiguity due to habitat, age, and plasticity. Nevertheless, with increasing demand for accurate identification of clones for certification and hybrid authentication during breeding programs, a marker-based detection system becomes a critical need. DNA-based markers are used for marketing forest reproductive materials in poplars, curly birch, *Castanea* hybrids, and eucalypts. With a similar aim, we have developed DNA-based diagnostic markers for species, hybrids, and clones of two important plantation trees, *Eucalyptus* and *Casuarina*. Diagnostic inter simple sequence repeats (ISSR) and simple sequence repeat markers were developed for *E. camaldulensis, E. tereticornis, E. grandis, E. globulus, E. urophylla*, and *E. pellita*. The use of marker profiles to confirm hybridity was demonstrated in two clones propagated by the paper and pulp industry. Similarly, ISSR and fluorescent-ISSR (FISSR) markers were used to discriminate superior clones of *C. equisetifolia.* Highly stringent sequence characterized amplified region markers (SCAR) were developed for *C. equisetifolia* and *C. junghuhniana*. The markers were multiplexed into a single reaction and successfully amplified in their hybrids. The implications of these markers in clone certification, hybrid confirmation, and varietal protection will be discussed.

Selection of drought-resistant aspen clones using SNP marker system. Hong, K.N., Um, T.S., Park, Y.J., Hong, Y.P. (*Korea Forest Research Institute, Republic of Korea; honeutal@forest.go.kr; tuhm@cnu.ac.kr; fresheugene@naver.com; yphong@forest.go.kr*).

A total of 377 4-year-old individuals from 3 full-sib families of *Populus davidiana* were identified using 57 SNP markers from 7 gene regions known as drought-related genes. Seven polymorphic SNP markers were selected for testing drought-resistance of aspens. The markers were called as AAP1_L3-3, AOX_D11_5-1, dhn_C9, GS_G5-1, GS_G5-4, HPD_O5-1, and TF_G13_3-2. Thirty trees per family were randomly selected, and 90 cuttings of 60-cm length were obtained for the test. After drought-stress-induced 5% PEG treatment for 8 hours, leaf damage of the cuttings was optically evaluated at three levels. Correlation between the levels of leaf damage and the SNP genotypes was tested. Only one SNP marker (dhn_C9) of dehydrin was weakly correlated with the drought resistance (r = 0.261) at 5% significance level. Weight of cuttings and growth performance of donor trees had no relationship with the resistance or the dhn_9 SNP genotype, respectively. Drought resistance was linearly related to the base substitution (T to G) from Mantel-Haenszel Chi-square test. Sixty elite clones of the conservation stand of *P. davidiana* were classified into two groups based on their SNP genotypes of dhn_C9. The number of the lower and the higher resistant clones to drought stress was 28 and 32, respectively.

Development of agroforestry biotechnology to combat desertification. Kim, M.D., Kim, Y.H. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; dorrf@kribb.re.kr; cefle@kribb.re.kr*), Choi, Y.I. (*Korea Forest Research Institute, Republic of Korea; yichoi99@forest.go.kr*), Lee, H.S. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; hslee@kribb.re.kr*), Noh, E.W. (*Korea Forest Research Institute, Republic of Korea; ewnoh@forest.go.kr*), Kwak, S.S. (*Korea Research Institute of Bioscience and Biotechnology, Republic of Korea; sskwak@kribb.re.kr*).

Who will support the world population of more than 9 billion people in 2050? The dramatic increase in population accompanied by rapid industrialization in developing countries has caused imbalances in the supply of food and energy. Desertification is one of the most serious global problems. The cause of desertification primarily comes from human activities such as overgrazing, deforestation, the improper management of soil and water by local poor peoples at the desertification areas. To cope with these global crises over food and energy supplies as well as environmental problems, it is urgently required to develop new environmentally friendly industrial plants to be grown on marginal lands including desertification areas for sustainable development. In this respect, the agroforest biotechnology will be important to combat desertification to increase incomes for local farmers. In the presentation, the results and prospects of our studies on several industrial transgenic plants such as sweet potato (*Ipomoea batatas*) and poplar (*Populus alba* × *P. tremula* var. *grandulosa*) with enhanced tolerance to multiple environmental stresses will be introduced. In addition, the Korea-China Biotechnology Collaboration Research Center on Combating Desertification will be introduced for future collaboration.

Genetic diversity of *Ilex* × *wandoensis* based on ITS sequence. Oh, C.J., You, H.C. (*Jeonnam Forest Environment Research Institute, Republic of Korea; ohcj3441@korea.kr; hckor7810@korea.kr*), Lee, S., Han, S.S. (*Chonbuk National University, Republic of Korea; devillup@naver.com; sshan@chonbuk.ac.kr*).

The current investigation was carried out to understand the genetic diversity of *I.* × *wandoensis*, which was a putative natural hybrid between *Iiex cornuta* and *I. integra*. Genetic diversity analysis was conducted by sequence analysis of the ITS regions of the *I. integra*, *I. cornuta*, and *I.* × *wandoensis* (Aquifoliaceae). ITS sequence length was 254–256 bp; ITS-2 varied from 221 to 234 bp; and those of the 5.8SrDNA were 159 bp. Sequences were aligned using FASTA, and genetic similarities were confirmed. The genetic similarity of the sequences aligned between male and female populations of *I. integra* were 100%; that between male and female populations of *I. cornuta* showed above 99.8%. In case of *I.* × *wandoensis*, one female population showed very high similarity with *I. cornuta*, 98.9%, but the male population of this group showed 95.1% homology with *I. integra*. The other female and male populations of the present study revealed high homology with the *I. integra*. The results of the current research work indicates that the male and female populations of *I.* × *wandoensis* belong to genetically varied hybrid diversities, although natural hybridization would have occurred between *I. integra* and *I. cornuta* in Korea.

Nuclear microsatellites reveal possible cryptic species within *Livistona chinensis* var. *boninensis*, an endemic palm species in the oceanic Bonin Islands. Ohtani, M. (*Forestry and Forest Products Research Institute, Japan; motani@ffpri.affrc.go.jp*), Tani, N. (*Japan International Research Center for Agricultural Sciences, Japan; ntani@affrc.go.jp*), Yoshimaru, H. (*Forestry and Forest Products Research Institute, Japan; hyoshi@ffpri.affrc.go.jp*).

The Bonin Islands are isolated oceanic islands in the northwestern part of the Pacific Ocean. Restoration of native vegetation is one of the most urgent tasks in this endemic-rich archipelago. Transplantation of seedlings is a common approach in such cases;

however, it can result in problematic consequences such as outbreeding depression. To avoid this, information on genetic and ecological backgrounds should be collected for a wide range of species. In this session, we will report the case of *Livistona chinensis* var. *boninensis*, an endemic but locally common palm species dominant in thin-soiled dry habitat. Model-based Bayesian clustering based on 12 microsatellite loci revealed two distinct clusters, in both of which north-south genetic clines were separately observed. One cluster was dominant in each island of Chichijima group and Hahajima Island, while the other was mainly distributed in the northern and southern margin of the archipelago. Despite their frequent sympatricity, genetically admixed trees were rarely found. The preliminary survey indicated that leaf and stem morphology and flowering phenology were significantly different between the two clusters. We concluded that cryptic species with different evolutionary histories but sharing the geographic ranges are likely to be present within this palm tree species.

Chloroplast DNA (cpDNA) variation of *Shorea laevis* in the Indonesian part of Borneo assessed by microsatellite and PCR-RFLP. Siregar, I.Z., Siregar, U.J., Yunanto, T. (*Bogor Agricultural University, Indonesia; izsiregar@yahoo.com; ulfahjsiregar@yahoo.com; genom_tedi@yahoo.com*).

Shorea laevis (Dipterocarpaceae) is an economically important timber species commonly found in Borneo. Due to its depleting natural population, sound conservation is planned, which requires information on spatial distribution of genetic variation. An investigation was carried out using microsatellite and PCR-RFLP markers to observe cpDNA variation in natural populations. Leaf samples were collected from seven natural populations located across West, Central and East Borneo. In this study, five individuals per population were sampled and cpDNA polymorphisms were tested using six universal microsatellite primers and combination of five cpDNA gene specific primers and five enzyme restrictions. Only results on cpDNA variation assessed by microsatellite are reported in this paper. In general, low variation among cpDNA haplotypes (n_a = 1.0 - 1.29) in *S. laevis* were detected, where two microsatellite primers showed cpDNA polymorphisms, i.e., ccmp2 and ccmp10. Two cpDNA haplotypes amplified by primer ccmp2 were observed in population SBK (Central Borneo), while three haplotypes based on primer ccmp10 were revealed in population ITCIKU (East Borneo). Cluster analysis resulted in four groupings with no clear geographic separation. This genetic information may be of practical uses in terms of selection of genetic resources for conservation and seed sources.

Cross-amplification of *Shorea* microsatellites in Bangkirai (*Shorea laevis*) and its genetic variation in Indonesia. Siregar, I. Z., Siregar, U.J., and Yunanto, T. (*Bogor Agricultural University, Indonesia; izsiregar@yahoo.com; ulfahjsiregar@yahoo.com; genom_tedi@yahoo.com*).

Bangkirai (*Shorea laevis*) is a tree species with very good quality timber found only in Borneo. The timber is recorded from illegal shipping cases to be traded illegally across national borders. In addtion, due to over-exploitation, its genetic resources are highly depleted. Here we report the results of population genetic study based on cross-species amplification of microsatellite markers in seven populations sampled from the Indonesian part of Borneo, mainly from eastern and central regions of the island. The cross-species amplification 10 *Shorea* microsatellites was successful using DNA samples either from dried leaves or wood, and resulted in three of them harboring amplicons of expected sizes. All three microsatellites were found to be of moderate polymorphisms (N_a = 1.78–2.7). Expected heterozygosities ranged from 0.39 to 0.51. Cluster analysis based on UPGMA showed that there is no clear population separation following geographical distribution, i.e., from eastern and central regions. However, admixed populations from both regions were clearly observed, indicating random mating among populations during species re-colonization in the past. These microsatellites are useful for genetic studies in which the information can be considered for setting up the appropriate strategies of genetic resource conservation or other uses such as timber tracking verification.

Obtaining transgenic poplar (*Populus* × *euramericana* 'Guariento') with multiple stress tolerance traits by introduction of multiple genes. Su, X., Chu, Y., Zhang, B., Huang, Q., Hu, Z., Huang, R., Tian, Y. (*Chinese Academy of Sciences, China; suxh@caf.ac.cn; ygchu@126.com; byzhang@caf.ac.cn; huangqj@caf.ac.cn; zmhu@genetics.ac.cn; rfhuang@caas.net.cn; tianyc@sun.im.ac.cn*).

Environmental stresses are crucial constraints for the performances and production of plants. We describe how the expression of five stress-tolerance genes (*SacB*, *JERF36*, *vgb*, *BtCry3A*, and *OC-I*) significantly enhances drought, salt, and waterlogging tolerance and insect resistance in transgenic hybrid poplar, *Populus* × *euramericana* 'Guariento'. After half-growing-season experiments in the greenhouse, several multigene-transformed lines showed remarkable higher values of height growth, basal diameter growth, and biomass accumulations than control plants under stressed conditions. This can be largely attributed to elevated water-use efficiency (WUE), the indicator of plant yield potential. The transgenic lines had general higher chlorophyll content under drought or salt conditions but not under waterlogging stress. Compared with non-transgenic trees, multigene-transformed poplar exposed to drought accumulated more proline, but had less proline when waterlogging stress was present. Monitoring of insects populations in field trial across 2 years found that D5-26 is the most Chrysomelidae-resistant line. Analyses of growth performances of 2.5-year-old transgenic trees growing in another field trial revealed 1.25–6.10% higher height growth and 1.97–6.26% larger diameter growth in comparison with non-transgenic plants. Our data suggest that long-term tolerance to multiple stresses can be achieved simultaneously using multiple genes that are involved in distinct metabolic pathways in poplar.

Molecular phylogeny of *Lignosus* spp. (Tiger's milk mushroom): implications for taxonomy and utilization. Thi, B.K., Lee, S.S. (*Forest Research Institute of Malaysia, Malaysia; thibeekin@frim.gov.my; leess@frim.gov.my*).

Lignosus spp. or "Tiger's milk mushroom" is reported to provide some important nutritional and medicinal properties. However, there is some confusion about the identity of this fungus due to its highly variable morphology. Molecular phylogenetic studies aimed specifically at *Lignosus* spp. have not been conducted before. In this study, PCR amplification was used to identify and determine the differences in the genetic variation of this fungus. DNA was successfully extracted from dried fruiting bodies and mycelial cultures of 10 isolates for the molecular studies. A preliminary phylogenetic relationship of the 10 isolates obtained from various locations in Peninsular Malaysia was inferred based on sequence data from the nuclear small subunit ribosomal DNA (rDNA) and 5.8S rDNA and their internal transcribed spacers (ITSs). Comparison of the nuclear rDNA ITS region sequences

showed that the 10 isolates of *Lignosus* obtained from the states of Perak, Selangor, Terengganu, and Pahang were monophyletic, forming a distinct clade within the family Polyporaceae. However, this may be a complex of species. This study, which is the first to focus on the phylogenetic relationship of "Tiger's milk mushroom," provides preliminary information on the phylogeny of the genus *Lignosus*.

***Aquilaria mallacensis* and *A. macrocarpa*: a study of their genetic relationship, genetic diversity, and genetic identification for a genetic conservation program.** Widyatmoko, A., Rimbawanto, A. (*Centre for Forest Biotechnology and Tree Improvement, Indonesia; aviwicaksono@yahoo.com; rimba@indo.net.id*).

Aquilaria mallacensis and *A. microcarpa* are two important agarwood species. Identification of these species based on morphological characters is difficult, except by their flower or fruit characteristics. The natural population is diminishing because of excessive logging. Therefore, an effective conservation strategy should be developed for the species. In this study, several DNA markers were used to clarify genetic relationship, genetic diversity, and genetic identification in order to develop a conservation program for the species. Leaf samples of both species have been collected from several populations in Sumatera and Kalimantan. RAPD markers were used to elucidate genetic relationship and genetic diversity between the two species and to detect species-specific markers of the species. In order to obtain species-specific markers, 200 RAPD primers were screened. Sequence of ITS-4 has also been used to identify variation between species. Based on these markers, both species have a very close genetic relationship. Both species were clustered together in the same area/province rather than the same species in different provinces. No variation of ITS-4 sequence between the two species was found. However, only 1 putative marker was detected. Genetic conservation strategy of the species is discussed.

Genetic variation and structure of the relict populations of Korean arborvitae (*Thuja koraiensis* Nakai) in South Korea, using I-SSR markers. Yang, B.H., Song, J.H., Hur, S.D., Hong, Y.P. (*Korea Forest Research Institute, Republic of Korea; time1124@forest.go.kr; sjh8312@forest.go.kr; protenaf@forest.go.kr; yphong@forest.go.kr*).

Knowledge of the genetic diversity and distribution pattern of a tree species is crucial to the effective *in-situ* conservation of genetic resources because current genetic status may not only tell us about the past history of foundation but also the likelihood of sustainability of populations in future environmental changes. We investigated the genetic variation and structure in Korean arborvitae (*Thuja koraiensis* Nakai), by examining 29 I-SSR polymorphic loci in 84 individuals distributed among four natural populations in Korea. The level of population genetic diversity (A_e = 1.44, P = 72.42, H_e = 0.258, *S.I.* = 0.385) was similar to or slightly higher than that of plants with similar ecological traits and life history (Cupressaceae). Most genetic diversity was allocated among individuals within populations (Φ_{ST} = 0.13). The UPGMA dendrogram based on genetic distance failed to show decisive geographic relationships. The Mt. Bangtae population had the lowest level of genetic diversity and was the most distinctive from the other populations. The Mt. Jang population, which possessed the highest level of genetic variation, and the Mt. Bangtae population, which was heterogeneous, were considered to be prime candidates for the conservation studies.

Genes expressed in the transition zone of *Cryptomeria japonica* in the dormant season when heartwood is formed. Yoshida, K., Nishiguchi, M., Futamura, N. (*Forestry and Forest Products Research Institute, Japan; ykazu@ffpri.affrc.go.jp; nishi3@ffpri.affrc.go.jp; futa@ffpri.affrc.go.jp*).

Heartwood is thought to have functions such as optimization of sapwood volumes and mechanical support with durability. However, how heartwood is formed is largely unknown. To obtain clues to understanding the mechanism of heartwood formation at a molecular level, we collected expressed sequence tags (ESTs) from the transition zone (TZ) of sugi (*Cryptomeria japonica* D. Don) in November, in which heartwood formation is considered to proceed. DNA sequences of 1029 ESTs were determined, and they were clustered into 676 unique nuclear-encoded sequences. Sequence similarity analysis was performed with public protein databases using the BLASTX program. The most abundant ESTs encoded dehydrins, followed by those encoding oleosin. A total of 291 (43%) annotated sequences were categorized according to the eukaryotic orthologous groups (KOG) functional classes. As a result, they were grouped into 21 categories. "Posttranslational modification, protein turnover, chaperones" was the largest category. Expression of several genes in the TZ was higher in November than in June. The genes encoded enzymes involved in glycolysis and sucrose catalysis (invertase), dehydrin, and *S*-adenosylmethionine transferase. These genes may play a role in heartwood formation.

F-04 Achievements in seed orchards, somatic embryogenesis and seed science for forest productivity and conservation

Organizers: Kyu-Suk Kang, *Korea Forest Research Institute, Republic of Korea, kangks@forest.go.kr;* Yill-Sung Park, *Natural Resources Canada, Canada; Yillsung.Park@nrcan.gc.ca.*

Forest tree improvement for *Eucalyptus pellita*: investigation on the results of first-generation genetic improvement across two generations of breeding with seedling seed orchards in Indonesia. Leksono, B. (*Centre for Biotechnology and Forest Tree Improvement Research, Indonesia; boedyleksono@yahoo.com*), Kurinobu, S. (*Forestry and Forest Products Research Institute, Japan; kurinobu@affrc.go.jp*), Ide, Y. (*University of Tokyo, Japan; ide@es.a.u-tokyo.ac.jp*).

The investigations involved analyzing data collected in first (F-1) and second (F-2) generation seedling seed orchards (SSO) of *E. pellita* at four locations in Indonesia. The F-1 orchards were established in 1994–1996, and the F-2 orchards in 2003. Studies focused on the following five issues: (1) trends of within family-plot selection, (2) optimum age for selection, (3) genotype-environment interactions (GEI), (4) design of the SSO, and (5) realized genetic gains. The results show that: (1) mean realized gains in the F-2 SSO were around 16%, 19%, 13% for height, diameter, and stem form, respectively; (2) the overall process of selection in the F-1 SSO favored the improvement of growth rather than stem form; (3) one generation of breeding cycle of

E. pellita should be achieved in a 5-year period with 8-year rotations; (4) the design of SSO should also use ca. 40 to 50 families with six to eight trees per plot; and (5) the GEI in SSO of *E. pellita* will have significant adverse effects if the seeds from F-1 orchards are supplied to other islands. The results also indicate that a breeding strategy plays a key role in ensuring the success of tree improvement programs.

Relatives in seed orchards and clone mixtures. Lindgren, D. (*Swedish University of Agricultural Sciences, Sweden; Dag.Lindgren@genfys.slu.se*), Danusevicius, D. (*Lithuanian Forest Research Institute, Lithuania; darius.danusevicius@takas.lt*), Högberg, K-A. (*Forestry Research Institute of Sweden, Sweden; karl-anders.hogberg@skogforsk.se*), Weng, Y. (*New Brunswick Department of Natural Resources, Canada; Yuhui.Weng@gnb.ca*), Hallingbäck, H. (*Swedish University of Agricultural Sciences, Sweden; Henrik.Hallingback@vbsg.slu.se*).

A clone deployment and selective harvest model and algorithms for seed orchards and clonal mixtures where candidates are related have been developed and applied. Candidates have known breeding values (different characters can be weighted) and relatedness (coancestry). The algorithms consider and are able to optimize average breeding value, loss by inbreeding depression, and gene diversity (status number). Typically, and surprisingly, loss of gene diversity was a more important consideration than inbreeding depression loss. Some related clones in advanced generation seed orchards are often advantageous. The algorithms permit optimization of selective harvest in seed orchards where the clone representation is heterogeneous. Before applying the algorithms it is recommended to short-list candidates. If the desired status number is considerably lower than that of candidates, linear deployment of a short-list is near enough to optimal and further optimization not needed. For establishing a Norway spruce seed orchard in Sweden, both growth and wood density could be considerably improved by the algorithms. Based on volume in a black spruce clonal trial series in Canada, deployment by those algorithms raised 7–25% gain (different scenarios) compared to truncation.

Achievements in somatic embryogenesis of conifers and its implementation in the management of future forests and plantations. Park, Y.S. (*Natural Resources Canada, Canada; Yillsung.Park@nrcan.gc.ca*).

The global forestry sector, managing both natural forests and commercial plantations, is faced with many future challenges, including adaption to climate change, forest protection, conservation and restoration, and changing forest product goals. To meet these challenges, a forest management system should be sufficiently flexible, and such flexibility may be obtained though the use of emerging technology. One such biotechnology is somatic embryogenesis (SE), whereby genetically identical trees can be mass produced. The use of SE technology offers exciting new opportunities in research to elucidate genetic response to environmental factors, diseases, and insects, providing an additional dimension for species conservation and restoration, and for the implementation of high-value plantation forestry. SE technology is available for many commercially and ecologically important conifers; however, presently, its most important application is for commercial multi-varietal forestry (MVF), which is defined as the deployment of tested tree varieties in plantations. MVF offers many advantages, including: (1) much greater and accelerated genetic gain than from seed orchards; (2) flexibility to rapidly deploy suitable tree varieties with changing breeding goals and environments; and (3) ability to design and balance genetic gain and diversity in plantations. Various applications of SE in forestry are discussed.

Characteristics of *Chamaecyparis obtusa* seeds development. Son, S.G., Kim, H.J., Kang, Y.J., Kim, C.S., Kim, C.S., Byun, K. O. (Korea Forest Research Institute, Republic of Korea; *sonsak@korea.kr; mueriel@jeju.go.kr; yjkang@forest.go.kr; jskim20@forest.go.kr; daram@forest.go.kr; bn1212@forest.go.kr*).

Chamaecyparis obtusa has been cultivated in China, Japan, Taiwan, and Korea as one of the most important tree species for wood and landscaping. Because of global warming, growing and replanting areas of this tree have been enlarged, and more seeds have been needed. We analyzed aspects of *C. obtusa* seeds and embryo development depending on cone harvest time to increase quantity of sound seeds. *C. obtusa* trees with average seed productivity were chosen, and 20 cones from each tree were picked. The picking time of cones was designed to be picked every 10 days from July 20–31 to October. The number of embryos was normally two in one seed coat. From these two, only one embryo was normally developed. At the beginning, a germ-like shape of embryo was taken from the seed picked at July 30. Around 1 month later, the size of 1-mm long embryo was observed, with somewhat hard shape. Another 1 month later, a normal-like embryo was appeared. The perfect embryos were from the seeds picked at October 15. After microscopic analysis of the embryos, several other types of embryos were observed depending on the picking time.

Development of cork oak varieties for high quality and productivity cork production by cloning selected trees through somatic embryogenesis. Toribio, M., Hernández, I. (*IMIDRA, Spain; mariano.toribio@madrid.org*), Cuenca, B. (*TRAGSA, Spain; bcuenca@tragsa.es*), Carneros, E., Alonso-Blázquez, N., Ruiz, M., Celestino, C. (*IMIDRA, Spain; mariano.toribio@madrid.org*), Ocaña, L. (*TRAGSA, Spain; locana@tragsa.es*), Alegre, J. (*IMIDRA, Spain; mariano.toribio@madrid.org*).

The implementation of multivarietal forestry as part of breeding strategies is expected to provide more productive forest plantations. To achieve this, a reliable and profitable method of mass production of clonal plants is required. Somatic embryogenesis is considered the suitable way of cloning for this purpose. We developed a protocol that allows cloning of adult cork oak trees by somatic embryogenesis. The cork oak is one of the most significant tree species of the Mediterranean ecosystem. These trees produce cork, a renewable natural material that is usually harvested every 9 years and used for diverse industrial applications; also, acorns produced by this species are used in feeding pigs. Therefore its economic importance justifies the development of varieties for high-value plantations. We describe a protocol to regenerate plants from leaves of adult trees, developed by a public research institution, and its application by a public company for developing varieties from trees selected on the basis of their high quality and productivity of cork in Southwest Spain. Somatic embryos were induced in most of the selected genotypes at the first attempt; they were amplified by recurrent embryogenesis; and plants required to establish clonal tests were produced. Field trials are in progress.

Posters

Somatic embryo germination of *Liriodendron tulipifera* L. by immersion time in bioreactor. An, C.H. (*Kangwon National University, Republic of Korea; soaurora@naver.com*), Kim, Y.W., Moon, H.K. (*Korea Forest Research Institute, Republic of Korea; dragonkim@forest.go.kr; hkmoon@forest.go.kr*), Choi, Y.E., Yi, J.S. (*Kangwon National University, Republic of Korea; yechoi@kangwon.ac.kr; jasonyi@kangwon.ac.kr*).

To determine physical and physiological factors for *Liriodendron tulipifera* L. somatic embryo germination, a temporary immersion bioreactor (TIB) system was investigated. Immersion of 60 minutes every 4 hours was found to be effective in germination (85.67%), with low abnormal plantlet production. In hyperhydricted leaf, mesophyll and intercellular space was loosely aggregrated. In abscisic acid (ABA), short immersion time of 15 minutes every 6 hours showed the highest amount of ABA 7.70 $pmolml^{-1}$; with longer immersion time and shorter frequency, ABA generally decreased. Antioxidant activities were different depending on enzyme types. Superoxidant dismutase (SOD) activities were lower with 60-minute immersions every 4 hours and 120 minutes every 4 hours. Catalase activities were lower in 60-minute immersions every 4 hours and 120 minutes every 4 hours, while higher in 120 minutes every 4 hours to 30 minutes every 6 hours. Glutathion peroxidase(GPx) was higher with 120 minutes immersion every 4 hours than in other treatments. Therefore, sensitive reaction enzyme was SOD by immersion time and it was in inverse proportion to germination. Among treatments no difference was found in carotenoid amount. Quantity of chlorophyll was similar to that of SOD in 60-minute immersion every 4 hours and 120-minute immersion every 4 hours.

Transcriptional profiles of cambial cell division in poplar (*Populus alba* × *P. tremula* var. *glandulosa*). Bae, E.K., Lee, H., Lee, J. S., Jo, A., Noh, E.W. (*Korea Forest Research Institute, Republic of Korea; betsy@hanmail.net; hslee@forest.go.kr; jasolee@forest.go.kr; aruna1212@gmail.com; ewnoh@forest.go.kr*).

Cambial activity is important in the process of the wood formation and perennial tree life. Particularly, the differentiation of cambial daughter cells is controlled by physiological and molecular mechanisms such as cell division, cell expansion, cell wall thickening, lignifications, and cell death. To understand the gene regulation involved in cambial activity, changes in the relative expression levels of the transcripts in cambial cell layers of 2-year-old poplar were analyzed by using cDNA microarray consisting of 6,837 unique ESTs from *Populus alba* × *P. tremula* var. *glandulosa*. We identified 722 genes up-regulated by at least 2-fold during cell division and cell expansion in the cambial cell layers. These genes—including transcriptional factor, phytohormone biosynthesis, stress response, and cell-cycle regulation—are differentially expressed before and after the cell division. In particular, the transcription factors, type A or type B cytokinin-responsive regulators, and Class III HD-ZIP, auxin-responsive regulators, were up- and down-regulated between cambial cell division and expansion. These results may help us to understand the specific functions of genes involved in the regulation of both the division and the expansion of the cambial cells.

Genetic improvement in seedling seed orchard of *Dalbergia sissoo* Roxb. Dobhal, S., Kumar, A. (*Forest Research Institute, India; shivanido@gmail.com; ak_meena@yahoo.com*), Luna, R.K. (*Punjab Forest Department, India, lunark@yahoo.com*).

The seedling seed orchard (SSO) of *Dalbergia sissoo* Roxb., consisting of 34 most promising progenies, was established in 1997–98 at Mattiwara, Punjab (India) in completely randomized block design with six replications and five plants in a row. Mid-term assessment of SSO was carried out during 2007–08 by developing a selection index using five traits—DBH, height, CBH, straightness, and health—for each progeny. Within-plot selection was conducted with 50% selection intensity, and selection differential was recorded as 2.25, 1.48, 0.51, 0.60, and 0.64 for DBH, height, CBH, straightness, and health, respectively. Two most promising traits of height and DBH were used for further analysis of different genetic parameters both in base population and retained population after culling of undesired individuals. The low narrow sense heritability was recorded for height (0.0525) and DBH (0.1186) in the base population, which was improved to 0.3008 and 0.3843, respectively in retained population. Genetic advance was improved from 2.43 to 5.14 and from 9.29 to 11.68 respectively for height and DBH, with net genetic gain of 10.20 and 13.47%. Thus, the seed collected from the rouged SSO is expected to produce quality seed to meet the demands of the growers.

Genotypic variability of acorn mineral concentration in *Quercus acutissima* and *Q. serrata.* Kim, C.S., Kim, D.H., Han, S.U., Woo, K.S., Kang, K.S. (*Korea Forest Research Institute, Republic of Korea; jskim20@forest.go.kr; dkim@korea.kr; sanguhan@forest.go.kr*; *woo9431@forest.go.kr*; *kangks@forest.go.kr*).

The objective of this study was to determine mineral element concentrations in *Quercus acutissima* and *Q. serrata* acorns and to estimate variability in different genotypes and species from clonal seed orchard. Acorns were collected during the 2008 harvest from 10 genotypes of each species. Investigation of the nutritional status of acorns revealed significant differences between the studied genotypes and species. Based on the data from all genotypes and species, the order of the mineral contents in the entire acorn was P>K>Na>Ca>Fe>Zn>Mn>Cu>Mg. Mineral concentrations (mg/100 g) in acorns of *Q. acutissima* and *Q. serrata* consisted of P (494 to 684 and 541 to 672), K (113 to 569 and 140 to 251), Na (57 to 121 and 49 to 85), Ca (10 to 53 and 26 to 68), Fe (0.71 to 1.14 and 0.77to 2.15), Zn (0.34 to 0.81 and 0.38 to 0.84), Mn (0.47 to 3.43 and 1.8 to 4.50), Cu (0.13 to 0.40 and 0.90 to 0.34) and Mg (0.1 to1.29 and 0.14 to 1.37), respectively. Concentrations of P, Fe, Ca, and Mn in acorn were significantly higher in *Q. serrata* than in *Q. acutissima* over all minerals examined.

Variations of physicochemical composition of acorns in two oak species from clonal seed orchard. Kim, C.S., Kim, D.H., Han, S.U., Woo, K.S., Oh, C.Y. (*Korea Forest Research Institute, Republic of Korea; jskim20@forest.go.kr; dkim@korea.kr; sanguhan@forest.go.kr; woo9431@forest.go.kr*; *chang05@forest.go.kr*).

This study investigated the physicochemical properties of acorns of *Quercus acutissima* and *Q. serrata*. The results showed that width, length, and weight of acorns were significantly ($p \leq 0.05$) larger in *Q. acutissima* than in *Q. serrata.* Chemical analysis of acorns showed that 10 genotypes of *Q. acutissima* and *Q. serrata* were rich in carbohydrates (45.7 to 50.2% and 51.3 to 55.6%), crude protein (3.3 to 4.8% and 2.9 to 4.4%), crude lipid (1.3 to 2.5% and 1.3 to 2.1%) and ash (0.9 to 1.4% and 0.9 to 1.3%), respectively. The contents of galactose and glucose in acorns were significantly higher in *Q. serrata* than in *Q. acutissima*. The

contents of unsaturated fatty acid, such as oleic, linoleic, and linolenic acids, were higher compared to those of saturated fatty acids. Saturated fatty acid (18.3 and 16.9%), oleic acid (44.4 and 45.5%) and palmitic acid (15.2 and 14.0%)—which were the highest components in unsaturated and saturated fatty acids—were measured in *Q. acutissima* and *Q. serrata*, respectively. This study showed the differences in the physicochemical compositions among genotypes and species, suggesting that acorns may be used as a breeding material for the production of functional food.

Rooting of *Astragalus membranaceus* var. *alpinus* in several auxin treatments. Kim, H.J., Son, S.G., Kang, Y.J., Kim, C.S., Byun, K.O. (*Korea Forest Research Institute, Republic of Korea; mueriel@jeju.go.kr; sonsak@korea.kr; yjkang@forest.go.kr; daram@forest.go.kr; bn1212@forest.go.kr*).

This study was performed to test *in-vitro* and *in-vivo* rooting characteristics of *Astragalus membranaceus* var. *alpinus* Nakai, which has been known as a rare and endangered species on Mt. Halla. *In-vivo* rooting tests were conducted on WPM medium supplemented with auxins. While the rooting ratio of was relatively good in the NAA treatments, most of the root formations were poor in *in-vitro* tests, especially in the 2.4-D treatments in which explants were nearly withered. Contrary to *in-vitro* results, overall rooting rate *in-vivo* tests was relatively high, except in the 2.4-D treatment. In the treatment of NAA, the number of roots developed and appearances of growth were much better than any other treatments. This result suggested that 2.4-D would not be a good promoting hormone for rooting of *A. membranaceus.* The results also implied that some auxins such as NAA could be helpful to promote root formation in not only *in-vitro* but also *in vivo* treatments. After acclimatization, all rooted *A. membranaceus* were transplanted to outdoors. In a nursery, all transplanted explants showed a high survival rate.

Initiation of embryogenic suspensor mass (ESM) and somatic embryogenesis in Japanese red pine (*Pinus densiflora* Zieb. et Zucc.). Kim, Y.W., Moon, H.K., Park, S.Y., Shin, H.N. (*Korea Forest Research Institute, Republic of Korea; dragonkim@forest.go.kr; hkmoon@forest.go.kr; soypark@forest.go.kr; hanashin@forest.go.kr*).

The best ESM initiation frequency was obtained from 0.88% (June 28, 2004, Suwon); 1.4% (July 1, 2005, Suwon); 2.31% (July 1, 2005, Anmyeon); and 0.91% (July 1, 2006, Suwon), respectively; and the all embryos in the seeds were at the proembryo stage regardless of seed collection year or location. Although it is well-known that seed development may vary in climate, from year to year by latitude and elevation, the initiation frequency of ESM in relation with histological result suggests that the optimum yearly collection time for seeds can be based on the collection dates (June 28, July 1, and July 5), at least for *Pinus densiflora*, in Korea. The highest proliferation rate (9.8-fold) of ESM was obtained from ½LM medium supplemented with 3.42 mM L-glutamine. For somatic embryo maturation with 0.05% activated charcoal (AC), the highest number (798/g^{-1} FW) of cotyledonary somatic embryos (line 06–29) was obtained. In germination of somatic embryos from ESM line 05–3 with light-emitting diodes (LED), the frequency was strongly inhibited by both fluorescent lamp and red+blue light (0%, respectively) for that. On the other hand, other lines (05–12, 05–29, and 05–37) showed similar germination patterns to five LED sources.

Component analysis of acorns of *Quercus mongolica* and *Q. variabilis* superior trees. Lee, H.S., An, C.H. (*Kangwon National University, Republic of Korea; lvangood@nate.com; soaurora@naver.com*), Kim, C.S., Han, S.U. (*Korea Forest Research Institute, Republic of Korea; jskim20@forest.go.kr; sanguhan@foa.go.kr*), Shim, T.H. (*Gangwon Research Institute of Health and Environment, Republic of Korea; thshim9194@korea.kr*), Yi, J.S. (*Kangwon National University, Republic of Korea; jasonyi@kangwon.ac.kr*).

To compare seed components with growth characteristics of superior trees, seed ingredients of *Quercus monglica* (QM) and *Q. variabilis*(QV) were analyzed. QM and QV are typical oak trees in Korea, but they have different physiological characteristics; QM is white oak, while QV red oak. We aimed to analyze and compare minerals, sugars, and fatty acids. The two species were similar to each other in water contents, crude ash, crude protein, and free-sugars, but crude fat contents in QV was 2.5times higher than in QM. Crude proteins of clone124 was 1.5times higher than of 75 in QM. Crude fat contents showed the highest in 0511 of QV, and phosphate and iron were more in QM than in QV. Glucose was above 90% of total sugars in both species, and galactose and arabinose were found. Unsaturated acids consisted of more than 80% of the total fatty acid contents. Oleic acid was higher in QV, while linoleic-acid was higher in QM. Depending on the clones, composition difference was not recognized between QM and QV. In conclusion, difference between two species was found in phosphate, iron, crude fat, and fatty acids composition, while difference among clones was found in several clones.

Regeneration of *Eleutherococcus seoulensis* using immature seeds via somatic embryogenesis. Lee, S.G., Lee, S.H., Kang, H.D. (*Dongguk University, Republic of Korea; i820316@dongguk.edu; nash7700@hanmail.net; hdk0225@dongguk.edu*).

High-frequency somatic embryogenesis was achieved from the zygote seeds of *Eleutherococcus seoulensis.* Callus were induced from the immature zygote embryo on a callus induction medium. Among the callus induction media, mixtures of 2,4-D and TDZ hormones on the medium are the most effective way to induce the callus. Opaque and friable embryogenic calli were formed on a medium without any hormones during about 2 weeks. Initiation of somatic embryogenesis and development up to the globular stage from embryogenic cell clumps occurred in callus materials. To find the best maturation condition on somatic embryos, several experiments were experimented. Concentrations of MS salt, sucrose, active charcoal, PEG, and density of embryogenic callus were manipulated. From that, the medium including 1/2MS 3% sucrose, ABA 0.1mg/L, A.C 0.02%, 0.5% gelrite was the best medium for the embryogenic callus to mature. The highest rate of germination was the medium with 0.2mg/L GA_3 hormone. Plantlets were transferred to 1/2 SH solid medium with 1.0 mg/L GA_3 and 0.2% activated charcoal for shoot and root elongation, and the elongated plantlets were further developed on 1/2 SH medium for 4 weeks. Plantlets produced somatic embryos, which were acclimatized in a greenhouse.

Regeneration of wild *Panax ginseng* via somatic embryos in root culture. Lee, S.G., Lee, S.H., Kang, H.D. (*Dongguk University, Republic of Korea; i820316@dongguk.edu; nash7700@hanmail.net; hdk0225@dongguk.edu*).

This study was conducted to establish the optimal condition for plant regeneration and acclimatization from somatic embryos of wild *Panax ginseng*. Cotyledon segments of wild *P. ginseng* produced primary and secondary somatic embryos when cultured on

MS and WPM media with supplement of 7% sucrose. To induce plantlet conversion, cotyledonary somatic embryos were cultured on WPM solid medium with GA_3 at various concentrations (1–30 mg/L) for 4 weeks. The highest rate of plantlet conversion was the medium with 3.0 mg/L GA_3. Plantlets were transferred to 1/2 WPM solid medium with GA_3 at various concentrations (0–5 mg/L) and 0.5% activated charcoal for shoot and root elongations. Elongated plantlets further developed into well-developed leaf and root system on 1/3 SH medium with 0.5% activated charcoal under ventilation condition for 5 months. The highest survival rate to soil was 75% when plantlets were regenerated on 1/3 SH medium without sucrose under ventilation condition. And *in-vitro* flowering occurred when 2–4 cm plantlets were cultured on 0.7, 0.9, and 1.1% Bacto-agar gelling 1/2 SH medium. Frequency of *in-vitro* flowering of plantlets is 12, 8, and 8%, respectively.

Somatic embryogenesis of *Hippophae rhamnoides* as an endemic species in Mongolia. Lee, S.H., Lee, S.G., Kang, H.D. (*Dongguk University, Republic of Korea; nash7700@hanmail.net; i820316@dongguk.edu; hdk0225@dongguk.edu*).

This study was conducted to establish the optimal condition for regeneration through somatic embryogenesis of *Hippophae rhamnoides* as an endemic species in Mongolia. The highest rate of mature seed germination was 47.5% on control medium without any plant growth regulators under *in-vitro* condition. The effects of carbon source for seed germination of *H. rhamnoides* were investigated on White media supplemented with 0.35% gelrite, with 3% of dextrose, glucose, sorbitol, sucrose, and sugar respectively. The addition of 3% glucose as a sugar source showed the highest rate (80%) of seed germination in *in-vitro* condition. Somatic embryos were induced directly from explant of cotyledons on SH media with 3% sucrose and 0.3% gelrite. Among the various treatments of PGRs, the combination of 2.0 mg/L BA and 1.0 mg/L IAA produced the highest rate (77.8%) of somatic embryo formation. *In-vitro* germination from somatic embryos was 8.8% at the combination of 2.0 mg/L Kinetin and 1.0 mg/L IAA. In consequence, the rates of somatic embryo formation were 21.8% at the addition of 3% dextrose from *in-vitro* cotyledons, and 28.1% at adding 3% sugar from *ex-vitro* cotyledons.

Somatic embryogenesis and plant regeneration from transverse thin cell layers (tTCLs) of *Oplopanax elatus,* a rare and endangered tree species. Moon, H.K., Park, S.Y., Kim, Y.W. (*Korea Forest Research Institute, Republic of Korea; hkmoon@forest.go.kr*; *soypark7@forest.go.kr; dragonkim@forest.go.kr*).

An effective protocol for plant generation via somatic embryogenesis was established by using transverse thin cell layers (tTCL) from a rare and endangered tree species, *Oplopanax elatus.* Cultures were maintained on MS medium supplemented with 2,4-D alone or in combination with TDZ in the dark. Explants were made two methods: 10 × 10 mm of explants as a conventional method and 10 × 1 mm of a tTCL culture system, respectively. The use of tTCL induced embryogenic callus (EC) at a higher rate compared to the conventional method, and its effect was more fortified by the combination treatment of 2,4-D and TDZ than by 2,4-D alone. Root-derived EC produced 6 times more somatic embryos than did leaf-derived EC. There were no significant differences in terms of endogenous levels of ABA and cytokinin in the explants. The best somatic embryo germination was obtained by using a half-strength MS medium containing 0.2mg/L GA_3. Approximately 85% of somatic embryos were converted to plantlets, which were then acclimated in artificial soil mixture in another two months. This study suggested that tTCL culture system may be a feasible approach for regenerating a rare and endangered tree species, *O. elatus.*

Somatic embryogenesis of *Kalopanax septemlobus* as a model system in Korea. Park, S.Y., Moon, H.K., Kim, Y.W., Lee, H.S., Bae, E.K. (*Korea Forest Research Institute, Republic of Korea; soypark7@forest.go.kr; hkmoon@forest.go.kr; dragonkim@forest.go.kr; hslee@forest.go.kr; betsy@hanmail.net*).

Kalopanax (*Kalopanax septemlobus*) is widely distributed in northeast Asia and has been traditionally used for medicinal purposes. In recent years, somatic embryogenesis (SE) of the species was achieved from zygotic embryos and mature trees by Korea Forest Research Institute. In Korea, this species was considered a reliable model tree for studies on SE from hardwoods due to its stable embryogenic capacity and genetic stability. The objective of this study was to investigate factors influencing embryogenic cell (EC) initiation from vegetative tissues of Kalopanax and to improve each step involved in SE. We also investigated the physiological changes during SE development. To this end, we assessed the influences of several factors, including osmoticums, and hormone precursors in SE cultures. The changes in endogenous hormone levels and gene expression patterns were analyzed from EC and SE. High levels of 2,4-D and pre-plasmolysis triggered somatic cell conversion to EC, and cytokinin precursors stimulated EC conversion to SE at the early stage of embryogenesis. We also found that 42 genes were differentially expressed during the conversion of EC to somatic embryo. This approach would allow mass propagation of elite trees via SE and provide better understanding of the SE process in hardwood trees.

Variation of outcrossing rates in *Pinus merkusii* seedling seed orchard assessed on single-cone basis. Siregar, I.Z. (*Bogor Agricultural University, Indonesia; izsiregar@yahoo.com*).

Seed produced in a seedling seed orchard is expected to come largely from outcrossing events, which are usually estimated on a single-tree basis. Estimation of ourcrossing rates based on the single cone is rarely done. In this study, isozyme gene markers were used to estimate outcrossing rates, based on a mixed mating model, on the single cone basis. Cones were collected from three respective mother trees: tree J-01, tree J-07 and tree J-26, from a seedling seed orchard of *P. merkusii*. The number of sound seeds from single cones varied (n = 9–25 seeds/cone) and were analysed electrophoretically by embryo and megagametophyte pairs at eight polymorphic loci (GOT-B, GOT-C, GOT-D, PGM-A, PGM-B, SKDH-A, NDH-AA, and FDH-A). Results showed that similar patterns of outcrossing rates were found between single cones and their respective trees. Low outcrossing rate in one mother tree (J-01) (t_m = 0.54 ± 0.13) was reflected also in each of its two single cones, i.e., 0.00 ± 0.00 and 0.15 ± 0.11, respectively. The same holds also for trees of high outcrossing rates, i.e., trees J-07 and J-26, and their respective single cones. This information is useful for effective management of pollen and supplemental pollination in the seed orchard.

***In-vitro* propagation of improved sengon trees (*Paraserianthes falcataria*) from Solomon Island to overcome its limited seed production.** Siregar, U.J., Wulandari, S.A. (*Bogor Agricultural University, Indonesia; siregaruj@gmail.com; rr_arum@yahoo.com*).

Sengon (*Paraserianthes falcataria*) is a native leguminous tree in the eastern part of the Indonesia archipelago. This species has long been domesticated and cultivated by local people as community forest. To improve forest productivity, sengon accession

from Solomon Island, which has better phenotypic performance, was introduced to Indonesia. The accession, however, rarely flowers and produces small number of seeds in Indonesia. To obtain larger number of seedlings from Solomon accession, *in-vitro* propagation method is necessary. Seeds of Solomon accession were sterilized and germinated aseptically in MS media. Highest germination percentage (90%) was obtained when seeds were treated with 5% detergent; 5 minutes in hot water, 96% alcohol, and chlorox (20%, 10%, and 5%); and finally washed with sterile water. From uncontaminated seedlings, cotyledons and hypocotyls were excised and used as explants in subsequent cultures. Highest shoot multiplication (52%) was obtained from hypocotyls in MS media containing 0.2 ppm Kinetin and 0.2 ppm BAP. Meanwhile cotyledons were produced from callus in MS media containing 0.1 ppm 2.4D. Root induction was done by spraying plantlets with 1 ppm IBA solution once a week, during acclimatization. About 50% of plantlets were rooted and developed into mature seedlings, ready to be transplanted into polybags.

Perspective of biotechnology of somatic embryogenesis of coniferous species for plantation forestry in Russia. Tretyakova, I., Barsukova, A., Sirenko, A., Noskova, N., Ivanizka, A., Shalaev, E. (*V.N. Sukachev Institute of Forests, Russian Federation; culture@ksc.krasn.ru; alendemyxa@mail.ru; andromeda123@mail.ru; larixforever@bk.ru*).

Advances in plant biotechnology offer new opportunities in the field of forest trees propagation. In conifers, somatic embryogenesis is an efficient tool for precise estimation of genetic value and for mass production of genetically improved seedling. An ultimate goal of these studies is the regeneration of high-quality and pathogen-stable plants in forest breeding and reforestation programs. Experiments of culturing immature isolated embryos of coniferous species were carried out with modified media MS, MSG, LV, DCR, and MA, and with different hormone concentrations and their different proportions. Under the action of hormones 2,4-D and BA somatic cells of immature zygotic embryos, morphogenic callus began, including formation of embryonal mass (EM). Active EM proliferation was observed on the medium with reduced concentration of cytokinins. On basal medium with ABA, somatic embryos matured. Growing of plantlets was conducted on basal hormone-free medium. However, not all donor-plants of coniferous species can form morphogenic callus and somatic embryos; as a rule, heterotic genotypes and hybrids form somatic embryos intensively. The success of somatic embryogenesis is due to hormonal regulation and tree genotypes.

Genetic diversity assessment using DNA markers in half-sib seed orchard of *Eucalyptus tereticornis*: implications for seed orchard performance. Yasodha, R., Dasgupta, M. (*Institute of Forest Genetics and Tree Breeding, India; yasodha@icfre.org; ghoshm@icfre.org*).

Eucalyptus tereticornis is an industrially important species in India because of its suitability for paper pulp and wider environmental adaptability. This species shows severe inbreeding depression. *Eucalyptus* improvement programs establish half-sib seed orchards by phenotypic thinning to meet large-scale plantings. However, optimal maintenance of seed orchards with balanced genetic gain requires information about within and among population genetic diversity. Cost-effective and reliable DNA markers are the best choice to estimate genetic diversity. In this study, a family-identified progeny trial cum seed orchard was selected for genetic diversity estimation. Twelve native Australian provenances, three native Papua New Guinea provenances, and one local land race were analyzed using inter simple sequence repeat PCR (ISSR-PCR) markers. Analysis of molecular variance partitioned the genetic variation into inter- and intra-provenance components. The inter-provenance component accounted for 55.0% of variation, and the intra-provenance component accounted for 45.0%. Existence of population structure was revealed in STRUCTURE analysis, but geographical region based clustering was not observed. The practical importance of genetic diversity estimates with molecular markers will be discussed in conjunction with the orchard design and selective thinning and its influence on seed orchard progeny performance in *Eucalyptus* improvement programs.

F-05 Advances in handling missing data in sustainable forest management

Organizers: Temesgen Hailemariam, *Oregon State University, USA, hailemariam.temesgen@oregonstate.edu*; Valerie LeMay, *University of British Columbia, Canada, ValerieLeMay@ubc.ca;* Göran Ståhl, *Swedish University of Agricultural Sciences, Sweden, Goran.Stahl@srh.slu.se.*

Design-based calibration of k-NN estimates by histogram matching. Baffetta, F. (*University of Siena, Italy; baffetta@unisi.it*), Corona, P. (*University of Tuscia, Italy; piermaria.corona@unitus.it*), Fattorini, L., Francesch, S. (*University of Siena, Italy; fattorini@unisi.it; franceschi2@unisi.it*).

Several techniques for assessing natural resources use information from remotely sensed imagery and ground data. Among them, k-nearest neighbours (k-NN) is becoming increasingly popular at the forest professional level. Most literature is model-based, and properties of resulting predictors depend on the validity of the adopted super-population model. Recently, statistical properties of the k-NN estimators were derived in a completely design-based framework, avoiding any assumption about populations. General results that hold for any sampling scheme were derived. The design-based performance of k-NN, evaluated by an extensive simulation study, demonstrates that k-NN estimates at the pixel level tend to average towards the population mean, underestimating large values and overestimating small values. This study proposes a histogram-matching procedure to calibrate k-NN estimates, coupling field forest inventory and satellite data. First, the cumulative frequency distribution of population values is estimated by means of the Hajék estimator from field data samples; subsequently, p-quantiles of the cumulative frequency distribution of k-NN estimates are transformed in the p-quantiles of the estimated population counterpart. The performance of the procedure at the pixel level is evaluated by a simulation study, while the statistical properties of resulting estimators for totals and averages of forest attributes are theoretically derived.

Using imputation for risk mapping of disease when climate changes: an example from the temperate rainforest of Alaska, USA. Barrett, T.M., Hennon, P.E. (*U.S. Forest Service, USA; tbarrett@fs.fed.us; phennon@fs.fed.us*), Eskelson, B.N.I., Temesgen, H., Latta, G. (*Oregon State University, USA; bianca.eskelson@oregonstate.edu; hailemariam.temesgen@oregonstate.edu; greg.latta@oregonstate.edu*).

Imputation methods have been increasingly used in forestry to fill in missing data across time and space. In this paper, we show how imputation can be used in risk mapping of disease when climate is changing. In the coastal temperate rainforest of Alaska, hemlock dwarf mistletoe (*Arceuthobium tsugense*), a parasitic plant, occupies a smaller range than its host tree species western hemlock (*Tsuga heterophylla*). Using 1,162 forest inventory plots systematically sampled from the 4.2-million-ha temperate rainforest ecoregion, we explored the respective climatic niches of mistletoe and its host. Using ancillary climate variables we imputed presence/absence of hemlock with and without mistletoe infestation using most similar neighbor (MSN) and random forest (RF) imputation. The methods were compared using leave-one-out cross-validation. MSN was almost unbiased, while RF over-predicted presence of hemlock without mistletoe by 11 percent and under-predicted mistletoe infestation by 59 percent. However, RF was more accurate at predicting presence/absence for individual plots (hemlock presence: Kappa 0.7351 for RF compared to 0.6942 for MSN; mistletoe presence: Kappa 0.1242 for RF compared to 0.1118 for MSN). By combining these models with climate projections from general circulation models, imputation can be used to model change in disease risk for different possible futures.

Missing observations in long-term monitoring data for parameterizing both empirical and process based forest growth models used for sustainable forest management. Gertner, G. (*University of Illinois, USA; gertner@illinois.edu*).

The focus of this paper is "missing observations" in long-term monitoring data for the calibration of parameters of two forest growth models used for assessing sustainable forest management practices. The two models considered were: (1) a Weibull-based model that is used for short- and long-term management planning for industrial woodlands; and (2) a complex physiologically based dynamic forest ecosystem process models used in assessing senescence of plantation monocultures. A variety of Markov chain Monte Carlo (MCMC) approaches were used to calibrate these models that explicitly do not account for the missing observations. To illustrate the overall importance of missing observations in long-term monitoring data for parameterization of each of these models, error/uncertainty budgets are used for the assessment of predictions made with these parameterized growth models. For each of the two growth models, the prediction uncertainties are partitioned according to the estimated parameter uncertainties based on the different MCMC approaches. The most effective ways for handling missing observations are accessed via the error/uncertainty budgets. Case-specific and general recommendations are made for handling missing observations.

Comparing k-NN and linear regression: is there reason to select one over the other? Kangas, A. (*University of Helsinki, Finland; annika.kangas@helsinki.fi*), Haara, A. (*Finnish Forest Research Institute, Finland; arto.haara@metla.fi*).

In this study, we compared the k-NN method and linear regression in three modelling problems with increasing curvature (mean height, height, and mortality models), and in both balanced and unbalanced datasets. The datasets used were simulated using either the k-NN method or linear regression model as a basis, using (mean) diameter as the sole independent variable. In many applications, it is assumed that k-NN results are averaged, especially in the edges of the datasets. The results show, however, that k-NN and linear regression give similar results with respect to averaging effect. The average RMSEs of the methods were also quite similar, and in both cases a balanced modelling dataset gave better results than an unbalanced dataset. When results were examined within diameter classes, k-NN results were less biased than regression model results, especially in the edges of the data; the differences increased with increasing curvature of the model and increasing unbalanced-ness of the data. This result, however, requires that modelling and test datasets have a similar distribution; if the distributions are different, the regression model is more robust. In such a case, using a combination of k-NN prediction and linear prediction produced the best results.

A comparison of spatial regression models in determining the influence of climate on productivity in coastal Alaska forests. Latta, G. (*Oregon State University, USA; greg.latta@oregonstate.edu*), Barrett, T.M. (*U.S. Forest Service, USA; tbarrett@fs.fed.us*), Temesgen, H. (*Oregon State University, USA; hailemariam.temesgen@oregonstate.edu*).

Statistical methods that have focused on determining the impact of climatic parameters on forest growth have largely avoided problems associated with spatial dependence of the error term and non-stationarity of coefficients. In recent years studies have used localized regression techniques such as geographically weighted regression (GWR) and simultaneous autoregressive (SAR) models to accommodate the spatial component of their models. In this analysis we use data of Sitka spruce (*Picea sitchensis*) and white spruce (*P. glauca*) site index along with geographic and climatic parameters in coastal Alaska to compare the two approaches to spatial problems. For GWR, maps of values and standard errors of coefficient estimates and r-squared of the model are mapped. For SAR, we map the predicted error term over the region. To further test the predictive ability of each model, we randomly divided into reference plots and target plots 30 times. Each spatial regression method was evaluated by calculating the coefficient of variation, bias, and root mean square error of both the target and reference data set and also tested for evidence of spatial autocorrelation.

Nearest-neighbour imputation for edge correction of sample plots. LeMay, V. (*University of British Columbia, Canada; Valerie.LeMay@ubc.ca*), Pommerening, A. (*Bangor University, UK; arne.pommerening@bangor.ac.uk*).

Fixed-area plots are often used in measuring trees over time. However, trees along the edges of these plots have neighbours outside the plot. As a result, an edge-correction method must be applied before calculating competition indices and other measures. One edge-correction method commonly applied involves establishing a buffer around each plot and measuring all trees within the buffer. This is a very expensive option, where many outside plot trees are measured. Another option uses replication of the plot measures around the plot (translation). A third approach is reflection, where the within-plot trees are "folded over" the plot edge. However, translation and reflection both assume that the spatial pattern is isotropic. In this paper, we examine an alternative method where the trees that are interior to the plot are used to impute trees outside the plot edges using nearest-neighbour (NN) imputation. A number of spatial stand structure metrics used in stand reconstruction are used as auxilliary variables for this imputation, including Hegyi's competition index; diameter differentiation index; species mingling index, diameter correlation index, and mean directional index. The results are compared to the commonly used methods.

Imputing branch volume or mass from changes in tree bole shape. MacFarlane, D.W. (*Michigan State University, USA; macfar24@msu.edu*).

Tree branch volume/mass is a major component of forests and is likely to figure prominently in any discussion regarding sustainable forest management, yet branches are often poorly quantified. A major reason for this persistent branch data gap is that branches are typically of low economic value and have a complex fractal geometry that complicates quantification, reducing incentives and increasing costs for developing accurate branch inventories. In contrast, the main stem or 'bole' of a tree contains most of the economic value and can be accurately quantified using simple geometric models of bole form. Here, a new method is presented for imputing branch volume or mass from predictable changes in the centroid of volume or center of gravity of tree boles. The method was applied to an extensive data set covering a range of tree sizes and species harvested from timberlands across Michigan, USA, and found to accurately predict branch volumes. A major benefit of the new method is that it allows for branch volume to be imputed from data generated under existing bole-based forest inventory methods. Imputing branch mass is complicated by a general lack of data describing tree branch specific gravity as it differs from the bole.

Kriging with external drift in model localization. Räty, M. (*University of Helsinki, Finland; minna.s.raty@helsinki.fi*), Heikkinen, J. (*Finnish Forest Research Institute, Finland; juha.heikkinen@metla.fi*), Kangas, A. (*University of Helsinki, Finland; annika.kangas@helsinki.fi*).

The aim was to (1) test if there is a spatial correlation in residuals of a global form-height model fitted over a large study area, and (2) use this correlation to predict the variables. The dataset consisted of 19,175 Scots pines (*Pinus sylvestris*) from the 9th national forest inventory of Finland. The spherical, circular, and exponential model variograms had the best fit to a sample variogram calculated from the residuals of the global model. The last two were selected to follow kriging calculations, in which we used a 10-fold cross-validation method. We limited the calculations to the local neighbourhood by setting the number of neighbours from 20 to 80, i.e. 8–16-km radius. On the global level, 35 neighbours were needed for stable estimates; with 60 neighbors, the RMSEs of kriging were lower than the globally fitted model. At the regional level, we got better estimates than with regionally re-fitted models, when the number of neighbours was 80 and 70 for the circular and exponential variogram models, respectively. Concluding, there was short-range (4-km) spatial correlation in residuals, which combined with kriging improved estimates. The size of the kriging neighbourhood required to improve prediction was large compared to the range.

Posters

Simultaneous fit of individual-tree growth and mortality equations from data with missing values: an example for *Pinus sylvestris* L. in northwestern Spain. Crecente-Campo, F., Gómez-García, E., Diéguez-Aranda, U. (*Universidad de Santiago de Compostela, Spain; felipe.crecente@usc.es; esteban.gomez@usc.es; ulises.dieguez@usc.es*).

Missing values are often problematic in compiling forest inventory data. Heights, and sometimes diameters, for cut and dead trees are usually not available. Sometimes errors in any of the measurements make it necessary to eliminate some data in the development of growth and mortality models. Weighted regression is proposed as a tool for fitting a simultaneous system of individual-tree growth (diameter and height) and mortality equations when heights are not measured in all the trees, allowing the use of all the information in model fitting, and not only the data with all the measurements. This system of equations could not be fitted simultaneously without using weighted regression because only the observations with non missing values could have been used, resulting in a wrong estimation of the mortality model. The same technique can be used when some trees have some missing observations. Weighted regression is also useful to account for heterocedasticity and non-normal errors, allowing the models to be fitted in conditions of independent and identically distributed residuals, and using all the available observations in the development of the model. An example for *Pinus sylvestris* L. in northwestern Spain is shown.

Estimation of forest statistics for small areas by proportional allocation method using the national forest inventory data in Korea. Han, W.S., Seo, S.A. (*Korea Forest Research Institute, Republic of Korea; wshan@kookmin.ac.kr; saseo@forest.go.kr*), Shin, M.Y., Yim, J.S. (*Kookmin University, Republic of Korea; yong@kookmin.ac.kr; jsyim@kookmin.ac.kr*).

Sampling design of Korea national forest inventory (NFI) traditionally used a stratified sampling, but ground plot shape had a single fixed-radius circular plot in the 1st and the 2nd NFI, and a cluster consisting of four subplots in the 3rd and 4th NFI. The NFI program has been enhanced, moving from periodic to annual system from the 5th NFI (2006–2010), in which sampling design was newly changed to a systematic sampling. The NFI is designed to provide forest statistics at the national level, but the number of available field plots within small areas were very few, which means that the field plots could not provide reliable information and could not estimate forest statistics such as forest areas and growing stock volumes for multi-stage stratification (for example, forest cover type, age class, etc.). This study was conducted to produce estimates of forest statistics for small areas by the proportional allocation method. To provide reliable information for small areas from the NFI data, a calibration technique was applied to small areas using stratifications of regional level (province) data. It was found that the forest statistics of small areas by proportional allocation method using stratifications of regional level data is statistically precise.

Estimation of forest statistics by moving average and stratification methods in Korea. Kim, C.C., Han, W.S., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; sok32cho@forest.go.kr; wshan@kookmin.ac.kr; shkimfri@forest.go.kr*), Shin, M.Y. (*Kookmin University, Republic of Korea; yong@kookmin.ac.kr*), Hwang, J.H. (*Taeeun Co., Republic of Korea; hwangjooho@naver.com*).

Previous national forest inventories (NFI) in Korea had been carried out four times on a regular base approximately at 10-year intervals. Since then, the 5th NFI (2006–2010) system has adopted a systematic cluster sampling and collects data on about 20% of a total sample plots per year over the entire country. This study was the first conducted to develop calculation algorithm of forest statistics using the data collected from the 5th NFI and then to estimate forest statistics based on the algorithm. A total of 8,926 field plots, which were collected for 3 years from 2006 to 2008 over the entire country, was used to estimate various forest statistics in this study. Since the NFI has been implemented annually, a moving average method was applied to allow for

weighting per annual data. A stratification method was also used to estimate the forest statistics. The stratification was conducted by forest conditions such as forest cover type, age class, forest origin, land class, and ownership. In this study, forest statistics for Daejeon and Chungcheonnam-do in Korea were estimated by the moving average and stratification of forest conditions.

Development of tree volume equations with geographically weighted regression. Yang, H., Kong, L., Zhao, J., Kang, X. (*Beijing Forestry University, China; huayang8747@163.com; 1234konglei4321@sina.com; Zhao.Junhui@hotmail.com; xingangk@163.com*).

Volume equations were developed for dominant tree species (spruce and fir) in boreal forests in northeast China. Data consisting of diameter and height for each section were collected for all trees after cutting. Volume was calculated by Huber's equation. Ordinary least squares (OLS) regression was used to construct the volume function at the beginning. Analytical results indicate that diameter and height are significant variables, but the residuals exhibit spatial autocorrelation. The geographically weighted regression (GWR) model was then applied to modify the traditional regression model to reduce the problem of spatial autocorrelation. The comparison of goodness-of-fit indicates the GWR has higher precision, and the spatial autocorrelation in the residuals was no longer evident. The parameter for DBH is between 2.0502 and 2.0664, while it is between 0.6802 and 0.7223 for height. Additionally, the volume increment was found correlated with the parameters for trees with the same DBH. A modified OLS model with a dummy variable to capture the spatial autocorrelation pattern was also proposed for future applications. In conclusion, the GWR model not only captures the spatial variations of the affecting factors, but also obtains an equation of a single tree's volume.

F-06 Remote sensing in carbon balance evaluation and monitoring

Organizers: Tomasz Zawila-Niedzwiecki, *Forest Research Institute, Poland, tzawila@ibles.waw.pl;* Mathias Schardt, *Joanneum Research Institute of Digital Image Processing, Austria, mathias.schardt@joanneum.at.*

An active remote sensing method for biomass assessment and its potential impact on the global forest resource assessment. Becek, K. (*Universiti Brunei Darussalam, Brunei Darussalam; kazimierz.becek@fass.ubd.edu.bn*).

Synthetic aperture radar interferometry (InSAR) allows the capture of both the horizontal and vertical extent of vegetation. Including an extra dimension in the forest modelling process makes the resulting model more accurate than passive remote sensing methods and free from human-induced errors. With its day-and-night and all-weather capabilities, and significantly less human participation required for data processing than passive remote sensing, InSAR has the necessary attributes to become an ultimate method for providing robust and accurate forest inventories anywhere in the world. The need for an independent way of validating national forest inventory data is quite apparent while studying, for example, the Global Forest Resource Assessment report. Yet, the lack of sufficient funds and the prohibitively high costs of deploying passive remote sensing methods to validate data, constrain the report's quality. Here, we argue that the InSAR-based biomass data validation method is a much more economically viable alternative than passive remote sensing. We also demonstrate the merit in the idea of an active remote sensing satellite's providing biomass inventory services on a global scale, which satellite would belong to an organisation representing all of us.

Using MODIS time series to characterize the annual dynamics of photosynthesis in tropical forests of Central Africa. Gond, V., Pennec, A., Fayolle, A., Gourlet-Fleury, S. (*CIRAD, France; valery.gond@cirad.fr; pennec@yahoo.fr; Adeline.fayolle@cirad.fr; sylvie.gourlet-fleury@cirad.fr*), Mayaux, P. (*JRC-GEM, Italy; philippe.mayaux@jrc.ec.europa.eu*).

In the framework of the European project CoForChange (predicting the effects of global change on forest biodiversity in the Congo Basin region) we propose a new method of satellite imagery analysis to characterize the spatial patterns of tropical forest in Central Africa. We used 10-year time series remotely sensed data from TERRA-MODIS sensor to identify the variations of forest photosynthetic activity intensity within a synthetic year. The processing was done using the 16-days enhanced vegetation index (EVI) data. We crossed the resulting information with a data base of field inventories provided by forest companies (Central African Republic, Republic of Congo, and Cameroon). We found that the vegetation types detected with satellite imagery match with a gradient of evergreen dominance. These results are of crucial importance to predict spatial variations of carbon stocks and fluxes, because evergreen/deciduous forests (i) have contrasted annual dynamics of photosynthetic activity and foliar water content; (ii) differ in their community dynamics; and (iii) differ in ecosystem processes. This detailed spatial and temporal information should provide a better basis to monitor carbon in this poorly known region.

Carbon assessment of a tropical rainforest: evaluating a REDD baseline in northeastern Madagascar. Harifidy, R.R., Rajoelison L.G. (*Université d'Antananarivo, Madagascar; rrharifidy@moov.mg; g.rajoelison@yahoo.fr*), Eckert S., Hergarten C., Ehrensperger A. (*University of Bern, sandra.eckert@cde.unibe.ch; Christian.Hergarten@cde.unibe.ch; Albrecht.Ehrensperger@cde.unibe.ch*).

The United Nations Framework Convention on Climate Change (UNFCCC) is specifically encouraging developing countries like Madagascar to develop methodologies on carbon assessment. The research presents a methodology to assess above-ground biomass in tropical forests combining satellite and biomass inventory data in a lowland rainforest in northeast Madagascar. Biomass inventory data are related to an atmospherically corrected SPOT5 multispectral dataset, both acquired in 2009, by calculating biomass estimates for two distinguished and classified forest classes: "low degraded forest" and "degraded forest." The corresponding rates of carbon within those two classes are calculated and adapted to a SPOT5 multispectral dataset of 2004 and a SPOT4 panchromatic dataset of 1991 to analyze the carbon stock development during the past 18 years and develop a model to establish the historical baseline for a future REDD mechanism implementation. The forest classification of 2009 was validated by field data. The accuracy of the classification derived from the SPOT4 panchromatic dataset of 1991 was assessed by simulating its

specific spectral characteristics with the SPOT5 2009 dataset. The results of the analysis and the model demonstrate that degradation and deforestation in tropical forests can be assessed and that degradation has an important impact on carbon stock.

The use of optical remote sensing for the assessment of deforestation and degradation. Hirschmugl, M. (*Joanneum Research, Austria; manuela.hirschmugl@joanneum.at*), Schardt, M. (*TU Graz, Austria; mathias.schardt@joanneum.at*).

As the REDD process was endorsed in the COP13 meeting in Bali, an official guidance notes the REDD Decision-/CP.13 "Reducing emissions from deforestation in developing countries: approaches to stimulate action," urges countries to develop pilot projects that "explore a range of actions, identify options and undertake efforts, to address the drivers of deforestation relevant to their national circumstances." Thus it was also identified that the role of earth observation (EO) is indispensible as a technology and tool for carbon stock assessment. To demonstrate the feasibility of the REDD programme, countries must therefore take action to increase their capacity to: (a) conduct national forest inventories and maintaining these inventories over time using available technologies such as remote sensing; (b) identify deforestation hotspots and calculate deforestation rates and resulting GHG emissions; (C) establish emission baseline reference levels (with reference to forest cover changes over an historical time period); and (d) assess and monitor emissions related to forest degradation. The paper will show to what extent optical satellite remote sensing data is an appropriate tool to fulfill these user requirements. The work presented was carried out in Cameroon within the GSE- Forest Extension project.

Criterion-based procedures applied to Landsat TM data for variable selection in an automated classification schema for Bavarian forests. López Hernández, J.Y., Koch, B. (*Freiburg University, Germany; jlopez@ula.ve; juan.lopez@felis.uni-freiburg.de; ferninfo@felis.uni-freiburg.de*), Ueffing, C. (*Germany*, *uuc@gmx.net*).

Global Landsat TM and ETM+ data files from last year are accessible for free. The classic variable selection methods are based on some statistical suppositions that could force us to reject some variables without knowing if they could be useful to describe the forest in the area. Some Bavarian forests force us to analyze more variables than classic NDVI (normalized difference vegetation index). The shadows of clouds and hills are very often confused with water bodies. We prepared the NDVI, four tasseled cap (TC) bands, and texture for every optical band (bands 1 to 5 and 7). With this set of 17 variables we selected using Bayes Information Criterion (BIC), Akaike Information Criterion (AIC), and applied principal component analysis to find the variables that best describe the forest cover. The result shows that there are very important variables to use in classification for some areas and in other areas are different. The NDVI was always selected and some original bands were often selected. The time and iterations used for computation of the classification showed important reductions and the approach could be used to speed up the classification calculation for forest discrimination.

Estimation of above-ground biomass in tropical forests for mapping carbon sequestration using radar satellite images. Nga, N.T., Hussin, Y.A., Weir, M. (*Institute for Geoinformation Science and Earth Observation; the Netherlands; nguyen21895@itc.nl; hussin@itc.nl; weir@itc.nl*).

Greenhouse gas (GHG) emission has been one of the most urgent issues worldwide as the main anthropogenic cause of climate change. Global efforts to reduce the concentration of GHG have been marked by the establishment of international agreements. For instant, article 4 of United Nations Framework Convention on Climate Change (UNFCCC) mentioned the reduction and prevention of anthropogenic emissions of GHG. Forests cover nearly one-third of the earth's land surface and account for almost half of its terrestrial carbon pool. Recently, UNFCCC has considered the need to reduce carbon emissions from deforestation and degradation (REDD) in developing countries as one central effort to combat climate change. Tropical forests account for a majority of land cover types in Ghana. There is a need for quantification of above-ground biomass and carbon sequestration in these forests. Remote sensing methods for biomass estimation are more successful in boreal and temperate forests than in tropical forest. Research on radar remote sensing showed that SAR images have the potential to estimate biomass in tropical forests. This research focuses on estimation and mapping of above-ground biomass and sequestrated carbon of tropical forest using multi-frequency and multi-polarized radar images.

Long-term net primary production and carbon budget prediction at different spatial scales using the 3-PG model. Tomé, M., Fontes, L., Minnuno, F., Tomé, J., Pereira, J.S. (*Instituto Superior de Agronomia, Portugal; magatome@isa.utl.pt; luisfontes@isa.utl.pt; francescom@isa.utl.pt*; *joseatome@isa.utl.pt; jspereira@isa.utl.pt*).

Interest in net primary productivity (NPP) modelling and carbon budget estimation increased following the signing of the Kyoto Protocol as countries began to develop methodologies to quantify the carbon balance and terrestrial ecosystem carbon sequestration. In Portugal, NPP modelling is particularly important for production forests (eucalyptus and pine). Therefore, the use of process-based models that simulate forest ecosystem dynamics for this purpose gained relevance. Such models, integrating the main physical, biogeochemical, and physiological processes involved in forest growth and development, give a mechanistic description of the interactions between the living plants and their environment and are able to assess the energy balance and the cycling of water, carbon, and nutrients within a given ecosystem. This presentation describes the use of the 3-PG model for estimation of NPP of Portuguese production forests at different spatial scales: plot, stand, landscape, and regional.

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Above-ground carbon estimated throughout IKONOS II satellite in Tarumã watershed, Manaus, Am, Brazil. Matos, F.D.A., Higuchi, N. (*National Institute of Amazon Research, Manaus, Brazil; fmatos@inpa.gov.br; niro@inpa.gov.br*), Kirchner, F.F. (*Paraná Federal University, Brazil; kirchner@ufpr.br*).

The study aimed to estimate a primary forest's above-ground carbon parameters, by correlating data from IKONOS II satellite and field surveys. The wet biomass was obtained by indirect method using models developed in the region. Original bands and synthetics images such as atmospheric resistant vegetation index, normalized difference vegetation index, principal components, tasseled cap, and spectral linear mixture model were used in this study. The analysis was done in 500 stands of 400 m^2, where

biomass values in stands ranged from 2 to 13.45 Mg The spectral reflectance average of 25 pixels was used for modeling, representing each stand of 400 m². Carbon and satellite data were integrated using statistical procedures, by applying linear multiple regression analysis by stepwise method. The selected model by statistical procedure presented R2ajust = 1,24 e o Syx = 1,99 Mg/400m2, was spatialized in an image and presented by a map. The modeling with IKONOS II satellite data showed tasseled Cap4, and ARVI variables were the ones that are best correlated with the carbon. The carbon map can be used as baseline information for future landscape level studies such as quantifying regional carbon.

Impact of forest degradation on carbon density in soil and vegetation of sal forests in the part of northern India using geospatial technique. Singh, S.P. (*Indian Institute of Remote Sensing; India; singh22170@alumni.itc.nl*), Hussin, Y.A. (*International Institute for Geoinformation Science and Earth Observation; the Netherlands; hussin@itc.nl*), Singh, S. (*Indian Institute of Remote Sensing; India; sarnam@iirs.gov.in*).

Carbon mitigation through forests has recently been recognized as one of the most important ecosystem services with specific reference to global warming and implication of Kyoto Protocol. Forests are crucial for ecological functions, by regulating the climate and water resources. Forest ecosystems store nearly two-thirds of terrestrial C and have a larger C density than any other land uses. Support to reduce emissions from forest deforestation and forest degradation (REDD) was adopted in the Bali Action Plan of the United Nations Framework Convention on Climate Change (UNFCCC) in 2007. REDD is considered a relatively low-cost greenhouse gas mitigation option and also has now emerged as one of the key areas for fighting global warming. Siwalik Hill sal forests are a very good example of the northern Indian natural forests. The emphasis of management of such forests has shifted from production to biodiversity conservation and ecological functions. The objectives of this study were to determine the variability in soil organic carbon SOC and vegetation carbon in different forest density classes of sal forests; estimate loss of carbon density compared to the potential of carbon sequestration with respect to forest degradation; and study relationships among SOC, biomass carbon, and forest degradation.

Evaluation of applicability of medium-resolution satellite data by combining with field data for forest carbon stock estimation in Korea. Yim, J.S. (*Kookmin University, Republic of Korea, jsyim@kookmin.ac.kr*), Jung, I.B., Cho, H.K. (*Korea Forest Research Institute, Republic of Korea, leohunter@naver.com; hcho@forest.go.kr*), Shin, M.Y. (*Kookmin University, Republic of Korea, yong@kookmin.ac.kr*).

In large-area forest resource assessments, medium-resolution satellite data have been popularly used as an ancillary source. This study was conducted to evaluate the applicability of three satellite data (Landsat TM-5, ASTER, and SPOT-4) for estimating forest carbon stocks in Korea. Field data from the 5th Korean national forest inventory, which were collected for 3 years (2006–2008), were used as training data in k-nearest neighbor (k-NN) estimator. Estimates by combining field data and three different satellite data were assessed by using the leave-one-out cross validation method, in which root mean square error and bias in terms of accuracy were compared. The estimates using ASTER produced smaller estimation errors than those using Landsat TM-5 and SPOT-4. In relation to an available number of training data in k-NN estimator, the training data are generally affected by horizontal reference areas and swath widths by satellite data. Although ASTER detected the smallest swath width (60 km), it was found that ASTER imagery provides more useful data sources with respect to accuracy of estimates, cost-effectiveness, and sustainable supply when field data collected in over 2 years are used as training data.

F-07 Forest monitoring and inventories by means of LiDAR, photogrammetry and HR satellite data

Organizers: Mathias Schardt, *Joanneum Research Institute of Digital Image Processing, Austria, mathias.schardt@joanneum.at;* Tomasz Zawila-Niedzwiecki, *Forest Research Institute, Poland, tzawila@ibles.waw.pl.*

Estimating growth factors based on stand level using airborne LiDAR data. Cho, H.K. (*Korea Forest Research Institute, Republic of Korea; hcho@forest.go.kr*), Kwak, D.A., Lee, W.K. (*Korea University, Republic of Korea; tulip96@korea.ac.kr; leewk@korea.ac.kr*), Lee, S.H. (*Korea Forest Research Institute; frishlee@forest.go.kr*).

The objective of this study was to estimate stand-level forest growth factors—dominant tree height, mean tree height, mean diameter at breast height (DBH), mean stem volume, and the number of trees per ha (Nha)—for Korean pine (*Pinus koraiensis*), using airborne LiDAR data. Above-ground biomass based on stand level was computed. For estimating those factors from LiDAR data, percentile data (0th, 10th, . . . , 100th) reflected above-the-crown base height. Consequently, the coefficients of determination of LiDAR-estimated dominant and mean tree height were 0.77 and 0.85 respectively. When LiDAR percentile data were used, the coefficients of determination of DBH and mean stem volume were estimated to be 0.83 and 0.85, relatively high. The number of trees per ha was estimated by segmentation of the canopy height model (CHM), derived from LiDAR data by subtraction of the digital terrain model (DTM) from the digital surface model (DSM). Thereby, LiDAR-derived above-ground biomass, can then be estimated from the stem volume using the biomass conversion and expansion factors (BCEF; 1.29) proposed by the Korea Forest Research Institute.

Landscape-level mapping of forest stand structure and type by combining multispectral reflectance and radar backscatter using K-mean algorithm. Han, X., Myint, M.M., Gregoire, T.G., Oliver, C.D. (*Yale University, USA; xuemei.han@yale.edu*; *maungmoe.myint@yale.edu*; *timothy.gregoire@yale.edu*; *chad.oliver@yale.edu*).

Accurate assessment of forest type and stand structure on the landscape level has been of great interest among a variety of scientists and practices because of their significance in forest management for timber production and ecological or wildlife conservation. Remote sensing techniques provide a promising tool to serve this purpose, but accurate assessment has been

challenging. In this study, we used the northeastern China/Russia boundary as study site and applied two innovative approaches for landscape-level mapping of forest stand structure and type. First, we developed a K-mean algorithm to integrate pixel-based and object-based image classification. Second, we combined multispectral reflectance with LANDSAT image and radar backscatter with ALOS/PALSAR image. Our results shows that compared to ordinary processing (with accuracy approximately of 30%), the accuracy of forest stand structure and type classification is significantly increased to 72.7% and 76.08% with these two innovative approaches. In conclusion, these two newly developed technique are effective in forest stand structure and type monitoring. In the last part, we also demonstrate the application of this landscape-level mapping to sustainable forest management for Amur tiger conservation and protective forest harvesting planning.

Estimation of above-ground biomass of mangrove forest using crown area obtained from high-resolution satellite data. Hirata, Y., Tabuchi, R. (*Forestry and Forest Products Research Institute, Japan, hirat09@affrc.go.jp; tabuchi@ffpri.affrc.go.jp*), Lihpai, S., Anson, H. (*Pohnpei State Government, Federated States of Micronesia, retired; Herson_anson@yahoo.com*), Fujimoto, K. (*Nanzan University, Japan; kfuji@ps.nanzan-u.ac.jp*), Kuramoto, S. (*Forestry and Forest Products Research Institute, Japan; shkura@ffpri.affrc.go.jp*), Mochida, Y. (*Yokohama National University, Japan; mochida@edhs.ynu.ac.jp*).

Mangrove forests in tropical and subtropical countries have various functions including carbon stocking. This study aims to develop methods for identifying species and for estimating above-ground biomass in mangrove forests from high-resolution satellite data. Two QuickBird multi-spectral and panchromatic data were acquired for this study. Study plots were established in Pohnpei Island and an atoll in the Federated States of Micronesia. Allometric equations between stem diameter and sunny-crown area for every mangrove species were derived from the field survey. Sunny-crown areas were extracted from QuickBird panchromatic data. The highest digital numbers of each band of QuickBird data within each extracted sunny-crown area were used to identify mangrove species. The above-ground biomass was estimated in each plot as a function of stem diameter derived from the sunny-crown area using the allometric equations. The estimates of above-ground biomass obtained from high-resolution satellite data analysis were 7–27% underestimation as compared with those obtained from field survey. The results indicated the possibility of utilization of high-resolution satellite data to estimate the aboveground biomass of mangrove forest in wide area.

Mapping of thermal belts on the mountain slope by Landsat ETM+ data. Hong, M.G., Kee, T.Y., Chun, U.H., Kim, C. (*Kookmin University, Republic of Korea; hd21351@kookmin.ac.kr; taeyoung@kookmin.ac.kr; chuh86@kookmin.ac.kr; choenkim@kookmin.ac.kr*).

Recently efforts to calculate information about forests by using the satellite images for efficient forest management have progressed actively. Thermal belts on the mountain slope are usually characterized by elevation, aspect, and shape of the mountain. Fractal analysis of thermal belts on the mountain slope using remotely sensed data have rarely been studied. In this study, surface radiant temperatures derived from Landsat ETM+ thermal infrared images of 6 April 2003 and 29 January 2002 were used to study the detection and fractal analysis of thermal belt on the mountain slope in Mt. Bukhan. We also divided research areas into several sections, computing fractal dimension from fractal analysis. For the fractal analysis, we used the divider method, which had been successfully applied so the thermal behavior of different landscape pattern features could be better understood. Detection of thermal belts on the mountain slope increased the spatial variability of surface radiant temperature, resulting in higher fractal dimension values. The result delineates that fractal analysis of thermal belts on the mountain slope are able to be quantified with the fractal dimension.

Assessment of coniferous forest carbon sequestration in the northern Rocky Mountains, USA, using LiDAR remote sensing, field surveys, and a forest growth model. Hudak, A.T. (*U.S. Forest Service, USA; ahudak@fs.fed.us*), Strand, E. (*University of Idaho, USA; evas@uidaho.edu*), Vierling, L.A. (*University of Idaho, USA; leev@uidaho.edu*).

Methods of monitoring forest carbon sequestration across large spatial scales will rely on remote sensing data, especially LiDAR, from which above-ground carbon stores can be accurately estimated. In this study, LiDAR was collected in 2003 and 2009 across 20,000 ha in northern Idaho, USA, along with field inventory plots measured these same years to quantify forest carbon stores due to growth and harvest disturbance. Allometric equations were used to estimate biomass for 2,317 trees tallied, across nine coniferous and two deciduous species. Tree biomass estimates were aggregated to the plot level and predicted from LiDAR height, density, and intensity metrics calculated within the 0.04 ha plots. The 2003 and 2009 empirical biomass models were then applied to predict biomass at the 20-m pixel level across the landscape. The 6-year differences in carbon stores were aggregated to the stand level and validated with independent stand exam data. Tree measures were also input into the forest vegetation simulator (FVS) to predict carbon sequestration over the next century. We found that growth and harvest have offsetting impacts on carbon sequestration in the short term, and recommend harvest levels that will sustain coniferous forests as a net carbon sink over the long term.

Spatial monitoring of a complex forest: inventory of a Pro Silva Demonstrational Forest by means of terrestrial laser scanning. Király, G. (*University of West Hungary, Hungary; kiraly.geza@emk.nyme.hu*), Csépányi, P. (*Pilisi Parkerdő Forest PLC., Hungary; csepanyi.peter@pprt.hu*), Brolly, G. (*University of West Hungary, Hungary; gbrolly@emk.nyme.hu*), Kálmán, M. (*Pilisi Parkerdő Forest PLC., Hungary; kalman.miklos@pprt.hu*).

There is an approximately 10-ha area of Pro Silva Demonstrational Forest in the Pilis Mountains, Hungary, where a detailed terrestrial laser scanning survey was performed from 38 surveying points. The aim of the survey was to establish a spatially detailed inventory for long-term monitoring, and to help the planning and daily management. The point clouds have been transformed to the Hungarian Unified Map Projection System, called EOV, based upon traditionally surveyed reference points. The digital elevation model (DEM) has been produced by the active surface method. The stem mapping has been performed semi-automatically, based on the points 1.3 m above the terrain. All the stems have been modeled by truncated cones in 10-cm elevation steps. The crown surface of the forests has been modeled by a new method, based on crowns of single trees. The spatial 3-D distribution of the stems, and the quality of every thicker stem, have been evaluated by the means of the point cloud. The results can help management planning based on Pro Silva rules, and also serves as a base for long-term monitoring of this forest.

Using optical data and small footprint LiDAR for plot-level estimation of forest biomass in a central European landscape. Latifi, H. (*University of Freiburg, Germany; hooman.latifi@felis.uni-freiburg.de*), Nothdurft, A. (*Forest Research Institute, Germany; arne.Nothdurft@forst.bwl.de*), Koch, B. (*University of Freiburg, Germany; barbara.koch@felis.uni-freiburg.de*).

The nearest neighbor methods may improve the spatial predictions of forest attributes. In this study, multiple predictors from CIR orthoimages, thematic mapper data, and small footprint LiDAR were used for nonparametric predictions of biomass in a mixed temperate forest in southwestern Germany. Three distance measures—including the euclidean distance, Mahalanobis distance, and MSN method—were used together with Breimans random forests. An evolutionary genetic algorithm (GA) search was applied to prune the initial 113 covariates. Prediction errors computed by cross-validations were compared across all examined methods and data sources. The GA search selected predictors that led to higher precisions of the nearest neighbor predictions based on euclidean and Mahalanobis distances, while MSN and the random forests gained poorer results following the covariate selection. The GA search proved to be unstable in multiple runs, as it selected differing optimal variable sets for different classifications of the response variable. The LiDAR-based height metrics proved to be the most frequent variables selected by GA search for biomass predictions. The random forests predictions proved to surpass other examined approaches. Moreover, MSN and random forests come with an additional benefit as they make use of the unreduced data set.

Use of satellite data sets to analyse vegetation structure and to predict bird habitat in temperate woodlands, southwestern Australia: a case study in the great western woodlands. Lee, P.S., Mackey, B.G., McElhinny, C., Berry, S.L. (*Australian National University; peter.lee@anu.edu.au; brendan.mackey@anu.edu.au; chris.mcelhinny@anu.edu.au; sandy.berry@anu.edu.au*).

The Great Western Woodlands (GWW) is an extensive and continuous temperate woodland region (about 16 million hectares) in southwestern Australia. Despite its dry and infertile conditions, it provides habitat for many native species. To study this valuable habitat, particularly of native bird species, an approach to the prediction of bird habitat was developed using remotely sensed data. Four different kinds of satellite data were used as main sources for analysing vegetation structure, generating vegetation structure-related thematic maps, and then a comprehensive landscape model from the maps. Field data were used for investigating correlations between each satellite data set and field measurement. To classify bird habitat functional groups, bird habitat information extracted from literature and bird census data for the GWW region were collected. Each thematic map represented specific vegetation structural components such as height and density with high accuracy. Predicting the bird habitat functional groups using the landscape model was reliable and the results were validated through the bird census data. Developing the vegetation structure-based model in relation to a suite of satellite data was successful. Therefore, with more accurate habitat information, this model can provide a better bird habitat prediction for the GWW and possibly other regions as well.

Application of low-cost UAV for silvicultural forest management. Lopatin, E. (*University of Eastern Finland, Finland, and Russian Academy of Sciences; eugene.lopatin@uef.fi*), Kolström, T. (*University of Eastern Finland, Finland; taneli.kolstrom@uef.fi*).

The unmanned aerial vehicle (UAV) has been considered as a high potential important tool for practical forestry. As it can fly at low elevation, it provides very high resolution data from which extraction of detailed information is possible with high accuracy. Further, it is cloud-independent and enables information on demand by flying below the clouds. Currently UAVs are mainly used for military purposes and still are not common in the civil sector. This research project aimed to test the UAV-based remote sensing approaches for young-stand forest management. The accuracy of the UAV-based forest regeneration inventory was tested. It showed that the accuracy of the spatial location identification is ±2 cm; the accuracy of height measurements is ±3 cm, the accuracy of the species recognition 93%. The use of UAV could provide the necessary data for young-stand management based on the stand's structure. A particular driving force has been the possibility of reducing costs. The technology could be transferred to the practical silvicultural work by increasing the automation of the data processing through web-based services and by demonstrating the costs and benefits of the developed technology.

Airborne laser scanning in tropics: industrial plantations in Brazil and REDD mapping of natural forests in Lao PDR. Maltamo, M., Tokola, T., Packalén, P., Vauhkonen, J. (*University of Eastern Finland, Finland; matti.maltamo@uef.fi; timo.tokola@uef.fi; petteri.packalen@uef.fi; jari.vauhkonen@uef.fi*).

Airborne laser scanning (ALS) data have been widely utilized in forest inventory purposes in different parts of the world. In this presentation we show some results concerning both industrial plantations and natural forests in tropics. In single-tree species plantations, growing stock is even-aged with regular spatial patterns. The role of ALS is to provide forest inventory information that replaces traditional field measurements and that is suitable for decision-making in plantation forestry. In Veracel, Brazil, this was done by estimating required stand attributes of the applied growth and yield model with very high accuracy by using ALS data. Additionally, this information was wall-to-wall mapped to the whole inventory area with hexagons for forest planning purposes. Mapping of deforestation and forest degradation was carried out in tropical forests in Laos. The initial verification was carried out by comparing ALOS AVNIR satellite data, ALS data, and digital aerial photographs. The best prediction models based on ALS data had results below 20% RMSE for biomass and carbon. The proposed mapping system is a combination of full-area coverage obtained by satellite data, a sample of high resolution remote sensing data (e.g., ALS), and a set of field sample plots.

Principles of derivation of tree biomass volume on the basis of terrestrial digital photos. Marušák, R. (*Czech University of Life Sciences, Czech Republic, marusak@fld.czu.cz*), Tauber, R. (*Research and Consultancy in Forestry, Czech Republic, renetauber@seznam.cz*).

Complex utilization of trees including their thin parts (biomass) is becoming more and more important at the present time in the Czech Republic. Therefore, there is a big need to derive biomass volume in the local area. The paper describes the methodology for a local model of stem shape and tree crown volume developed for purposes of total tree volume calculation on the base of terrestrial photogrametry. We applied the DendroScanner system, which uses digital pictures of the evaluated tree and its measurable parameters: tree height and diameter at breast height. Originally it was derived for calculation of stem volume of coniferous trees and broadleaved trees of regular form. The system is based on measuring tree parameters by digital pictures. To evaluate

precision and accuracy of this method, stem volume derived from the pictures and real stem volume of cut trees was compared. Mean quadratic error of ±2% was obtained. A mathematical model of the relation between tree volume and crown parameters (crown height and width) of broad-leaved trees was derived. The paper presents principles of tree parameters measured by digital pictures and consequent derivation of a local model of tree volume.

Estimation of species-specific growing stock by airborne laser scanning data. Packalén, P., Maltamo, M. (*University of Eastern Finland, Finland, petteri.packalen@uef.fi*; *matti.maltamo@uef.fi*).

Most airborne laser scanning (ALS) studies have concentrated on predicting total stand characteristics. There are many reasons why tree species are often ignored: the study might have no link to practical requirements, there might be no need for species-specific information (e.g., single species plantation), or tree species estimation might just be considered too difficult (e.g., very many tree species exist). However, recently, increasing numbers of studies have been published that do consider tree species. This is a logical trend because tree species are among the most important attributes in forest inventory and cannot be ignored in operational applications. In the tree-level inventory by ALS data, the task is to classify individual trees by species and then to predict tree attributes by species-specific models. However, in many studies only species classification is performed but the estimation by tree species is ignored. In the case of the area-based method, species-specific attributes must be estimated directly for a group of trees. In both approaches ALS data are often combined with optical images in order to increase the accuracy of estimates. The inherent characteristics of species-specific estimation by ALS data, methods, and their pros and cons are presented.

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Spectral characteristics of satellite imagery using national forest inventory data in Korea. Chung, D.J., Park, J.H., Ma, J.L. (*National Forestry Cooperatives Federation, Republic of Korea; cdj3663@nfcf.or.kr; jazztrumpet@nfcf.or.kr; jforest@nfcf.or.kr*), Hwang, H.T. (*Korea Forest Service, Republic of Korea; h581@foa.go.kr*), Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; shkim@forest.go.kr*), Nor, D.K. (*National Forest Cooperatives Federation, Republic of Korea; ndk1108@nfcf.or.kr*).

This study attempts to analyze the relationship between forest volume and age based on 5th NFI data and spectral characteristics of satellite imagery using ASTER sensor in Korea. The study area of Gangwon-do on the Korean Peninsula was selected. Most of the land in Gangwon-do is mountainous, with an elevation range from 100 to 500 m (46%) and 500 to 1,000 m (43.4%), which is the highest rate in Korea, while high mountainous regions over 1,000 m represent 5%. And the main tree species in Gangwon-do are *Pinus densiflora* and *Quercus mongolica*. Forest stand volume and age had negative correlation with spectral reflectance in all the bands (blue, green, red, SWIR). With increasing of stand volume and age, spectral reflectance decreased. The spectral reflectance of band1 showed the highest correlation between stand volume and spectral reflectance among the VNIR wavelengths. The spectral reflectance bands 1, 2 (visible wavelength) and stand age have higher correlation than other bands. The correlation coefficients between forest volume and vegetation indices have a low relationship. This result indicates that the reflectance of the blue band may be an important factor to improve the potential of optical remote sensing data to estimate forest volume and age.

Object- and pixel-based classification of tree species using high-resolution Quickbird imagery. Chung, S.Y., Yim, J.S., Shin, M.Y. (*Kookmin University, Republic of Korea; wally@kookmin.ac.kr; jsyim@kookmin.ac.kr; yong@kookmin.ac.kr*).

Remote sensing is essential to assess land covers, to monitor their changes, and to collect forest resource information. With high-resolution satellite data, it is possible to classify land covers by tree species. The object- and pixel-based approaches in supervised classification have been mostly applied to classify tree species using high-resolution satellite data. The main objective of this study is to compare map accuracies and kappa coefficients by both classification approaches using the high-resolution Quickbird imagery. A total of 398 tree data for 11 tree species were used as training data. Land covers were classified into 4 coniferous and 7 deciduous tree species, and 3 non-forested classes (roads, waters, and agricultural areas) based on raw spectral values. Results showed overall accuracy was 42.96% and the kappa coefficient was 0.39 by the pixel-based classification, while those by the object-based classification were 75.88% and 0.74, respectively. This result means that the object-based classification is more suitable to classify land covers at tree species level when using the high-resolution Quickbird imagery.

Assessing burn severity in Mediterranean pine forests using SAR satellite data. De la Riva, J., Tanase, M. (*University of Zaragoza, Spain; delariva@unizar.es; Mihai.Tanase@tma.ro*), Santoro, M. (*Gamma Remote Sensing AG, Switzerland; santoro@gamma-rs.ch*), Pérez-Cabello, F. (*University of Zaragoza, Spain; fcabello@unizar.es*).

Burn severity can be assessed using synthetic aperture radar (SAR) images since they contain information related to forest structure. The backscatter coefficient obtained from SAR has been investigated—in relation to optical satellite data—to assess forest fire burn severity. TerraSAR-X, ERS-1/2, ENVISAT ASAR, and ALOS PALSAR images were used. Statistic analysis was performed to assess the average backscatter as a function of burn severity level after stratifying the data by local incidence angles. Determination coefficients were used to quantify the relationship between radar data and burn severity estimates. The analysis showed that at HH and VV polarizations the backscatter increases with burn severity for X- and C-bands because of the lower attenuation due to the consumption of the needles, the subsequent exposure of the small twigs and branches with higher backscattering potential, and the increased backscatter from the ground. Cross-polarized (HV) backscatter decreases with burn severity at all SAR frequencies due to decreasing number of available scattering elements. This study indicates that SAR data could be used for burn severity evaluation in Mediterranean environments. Backscatter showed potential for burn severity estimation when the local incidence angle is accounted for.

Assessing post-fire forest recovery in Mediterranean pine forests using SAR satellite data. De la Riva, J., Tanase, M. (*University of Zaragoza, Spain; delariva@unizar.es; Mihai.Tanase@tma.ro*), Santoro, M. (*Gamma Remote Sensing AG, Switzerland; santoro@gamma-rs.ch*), Pérez-Cabello, F. (*University of Zaragoza, Spain; fcabello@unizar.es*).

Synthetic aperture radar (SAR) data have been used to establish the relationship between backscatter and forest recovery in a Mediterranean pine forest. TerraSAR-X, ERS-1/2, ENVISAT ASAR, and ALOS PALSAR images were used. The sensitivity of

SAR data to forest recovery was assessed using fire scars from different periods and single date radar imagery. The investigation focused on fire scars 1 to 57 years old for which the average cross-polarized backscatter was computed and compared to the values of the neighboring unburned forest. X-band cross-polarized backscatter showed low sensitivity to vegetation recovery, the average backscatter increasing by only 1–2 dB between the most recent fire scar and the remaining forest. The existing biomass was sufficient to practically saturate the signal. C-band data showed increased sensitivity to fire scar age whereas L-band had the highest potential for differentiating between forest recovery stages. The cross-polarized backscatter variation between burned and unburned forest was around 4 dB at C-band and increased to around 8 dB at L-band. SAR data was useful for forest recovery monitoring in Mediterranean environments, showing the highest sensitivity to different stages of forest re-growth for L-band cross-polarized backscatter.

Estimation of forest canopy structure on an individual-tree basis by the object-based imagery analysis using aerial photographs. Kayahara, S., Itaya, A. (*Mie University, Japan; 507330@m.mie-u.ac.jp; itaya@bio.mie-u.ac.jp*).

Historical census of trees that constitute a forest contributes to elucidate long-term forest dynamics. Many ecologists are interested in what kind of trees died and were recruited in a forest. Aerial photographs have been the most popular remote-sensing tool used in forestry. Historical aerial photographs of many areas are available, and are of high spatial resolution. These aerial data are thus effective for use in the historical or temporal analysis of a forest canopy structure. By using high-resolution images, it is possible to detect forest structure more easily than lower resolution images. However, due to the high spatial resolution, automatic classification of such imagery based only on the spectral characteristics of the features can become difficult, especially in spectrally homogeneous areas. Object-based imagery processing techniques overcome this problem by incorporating both spectral and spatial characteristics of objectives. In this study, we used aerial photographs and object-based imagery processing techniques to estimate a forest canopy structure on an individual-tree basis. As a result, our method of using digital aerial data was an effective way of analyzing a forest canopy structure. Shapes, colors, textures, and tree heights obtained from aerial photographs were effective in estimation of a forest canopy structure.

Topographic effects-related NDVI characteristics over compartment forest canopy. Kee, T.Y., Chun, U.H., Hong, M.G., Kim, C. (*Kookmin University, Republic of Korea; taeyoung@kookmin.ac.kr; chuh86@kookmin.ac.kr; hd21351@kookmin.ac.kr; choenkim@kookmin.ac.kr*).

NDVI (normalized difference vegetation index)is a numerical indicator that can be used for vegetation vitality measurements derived from canopy reflectance in the red and near-infrared wavebands. The differential reflectance in these bands provides a means of monitoring density and vigor of green vegetation growth by using spectral reflectivity. The possible range of values is between −1 and 1, but the typical range is between about -0.1 (NIR less than VIS for a not very green area) to 0.6 (for a very green area). The purpose of this study is to analyze distribution characteristic of the NDVI according to compartment, elevation, and aspect in Kwangneung Experiment Forest of South Korea, which consists of 65 compartments. We generated DEM from 1:5000 scaled digital map and extracted NDVI from ortho-rectified QuickBird imagery. Using information of compartment forest canopy, we analyzed the relationship with the distribution characteristics of the NDVI according to elevation and aspect. Understanding distribution characteristics of the NDVI can identify vegetation vitality as standards for sustainable development and can judge topographic elements based on the data of application for the correlation analysis.

Estimation of forest biomass using GIS·RS techniques in Jeonbuk Province, Korea. Kim, H. (*Jeollabuk-do Forest Environment Research Institute, Republic of Korea; kh4548@korea.kr*), Kim, H.J., Seo, B.S., Lee, S.H. (*Chonbuk National University, Republic of Korea; badboy0837@jbnu.ac.kr; seobs@jbnu.ac.kr; leesh@jbnu.ac.kr*).

For the scientific and accurate estimation of forest biomass, this study selected the forest located in Jeonbuk Province as of late 2007 as its subject, and estimated its biomass multilaterally using national statistics data, biomass conversion factor, and geographic information system (GIS) and remote sensing (RS) techniques. The results of estimating biomass using national statistics data (methods 1, 3, 5) by forest type; forest type and age class; and species were 41,348,737 tons (method 1), 38,048,820 tons (method 3), and 39,825,501 tons (method 5), respectively; while using GIS·RS techniques (methods 2, 4, 6) were 34,089,744 tons (method 2), 32,867,460 tons (method 4), and 32,726,381 tons (method 6), respectively. Meanwhile, after grouping by estimation quantities by using national statistics data and GIS·RS techniques respectively, we conducted independent-sample t tests. As a result, there were statistically significant differences in methodology by estimation quantities (p-value = 0.003 < α = 0.05). From this result, it could be concluded that multilateral methods along with the current estimation method should be considered when estimating national-scale forest biomass as well as forest biomass of Jeonbuk Province.

Quantitative analysis of land-cover change area using landsat TM data and administrative data. Lee, J.S., Park, D.H. (*Kangwon National University, Republic of Korea; jslee72@kangwon.ac.kr; dhrdmlrltk@naver.com*), Phua, M.H. (*Universiti Malaysia Sabah, Malaysia; pmh@ums.edu.my*).

LULCC (land use and land cover change) is one of the most important driving forces of disturbances on the Earth's surface. This study discusses the detection of land cover changes in Kangwon Province, Korea, using multitemporal Landsat TM and ancillary data. We compared the performance of normalized difference vegetation index (NDVI), normalized burn ratio (NBR) and normalized difference water index (NDWI) from multisensor data in the image differencing method for detecting the disturbances between 1999 and 2000. We performed geometric and radiometric corrections for the multitemporal Landsat TM data satellite data. The ancillary data, built into GIS database, consists of spatial forest management data, administrative boundary, forest type, and road networks. Furthermore, the ARD and burned area masks were acquired from interpretation of aerial-photos and ground-truthing. The accuracy of the detection rate in land cover change area was better in the order of NBR, NDVI, and NDWI. As the best detection method, the NBR was successful in capturing disturbance differences with an accuracy of 89%. The spatial distribution of disturbances was also analyzed.

Partitioning and classification of degraded forest land cover in North Korea using the segment-based classification method. Lee, S.H., Kim, E.S., Cho, H.S. (*Korea Forest Research Institute, Republic of Korea; frishlee@forest.go.kr*; *drummer1@snu.ac.kr; hcho@forest.go.kr*).

In North Korea, forests have been intensively degraded by forest land reclamation for food production and logging for firewood since the mid 1970s. In particular, degraded forest occupies a large-scaled area in Hyesan. For the purpose of determining a potential area of A/R CDM project in Hyesan, degraded forest was classified as unstocked forest, converted crop land in forest land, and denuded forest. For this, we used 2.5 m SPOT pan-sharpened images and a segment-based classification method. Effective division among classes needs to determine a suitable scale of segments and optimum band combination considering texture information. As results, it was shown that scale factor 40/shape factor 0.3 generated more suitable scaled segments. Also, an optimum band combination was [band1 + band2 + band3 + GLCM dissimilarity (band2) + GLCM homogeneity (band2) + GLCM standard deviation (band3)]. The segment-based classification method using texture bands (accuracy: 80.4%) was more accurate than the existing method that used only spectral bands (accuracy: 70.3%). Especially, GLCM texture bands were effective to divide forest from unstocked forest.

Exploiting ozone concentration measurements from satellite remote sensors for forest monitoring: a feasibility study. Melgani, F., Mahlknecht, G., Pasolli, E. (*University of Trento, Italy; farid.melgani@disi.unitn.it; g.mahlknecht@studenti.unitn.it; pasolli@disi.unitn.it*), Gottardini, E., Cristofori, A., Cristofolini, F. (*FEM-IASMA, Italy; fabiana.cristofolini@iasma.it*), La Porta, N. (*FEM-IASMA, Italy; elena.gottardini@iasma.it; antonella.cristofori@iasma.it; nicola.laporta@iasma.it*).

Trentino region, situated in the northeastern Italian Alps, has a relatively long history of forest monitoring. Recently, a particular interest has been given to measurement of tropospheric ozone concentrations, given its well-known potential phytotossic effect. Ozone precursors—such as nitrogen oxides, carbon monoxide, and volatile organic compounds—in the presence of sunlight, may react in the atmosphere. Industrial emissions, motor vehicle exhaust, and chemical solvents are the major anthropogenic sources of these chemicals. The aim of the study is to understand the correlation between this pollutant and forest health dynamics. In this context, in order to obtain large-scale maps of ozone concentration, we performed a feasibility study that aims to assess the potentialities offered by satellite remote sensors such as the ozone monitoring instrument (OMI) and the tropospheric emission spectrometer (TES) sensors of the Aura mission and the SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY) sensor of the Envisat mission. These sensors provide products such as the total column and the profile of the ozone concentration for a given geographical area. Results of the feasibility study are reported and discussed, showing the strong limitations characterizing these sensors for their use in forest monitoring.

Systematic control methods of pine wilt disease using ortho-photos and UAV. Nakakita, O., Nakamura, K. (*Forestry and Forest Products Research Institute, Japan; nakakita@ffpri.affrc.go.jp; knakam@affrc.go.jp*), Ota, K. (*SEIBU Landscape Co., Ltd, Japan; naporuto@yahoo.co.jp*), Hoshizaki, K. (*Akita Prefectural University, Japan; khoshiz@akita-pu.ac.jp*), Matsuura, K., Takehana, M., Itagaki, T. (*Kyouritsu Air Co., Ltd., Japan; cxqhx035@ybb.ne.jp; takehana@k-air.co.jp; kouken-i@beige.plala.or.jp*).

Pine wilt disease has caused substantial damage in pine forests in Japan. The infested trees by the vector beetle scattered in a wide forest area are difficult to find. Aerial photos are promising to solve the problem; they can cover a broad area with high resolution, and the best date or timing to capture the image for this analysis can be controlled. Position data were measured from aerial photos used for the field navigation system and the unmanned aerial vehicle (UAV) system. The best timing for taking aerial photos in the northern Japan by the field study was from middle October to early November. The photo scale was 1:10,000, and the film was near-infrared color film. True ortho-photos were produced from aerial photos. The position data, which interpreted the infested trees, were transferred to a handy PDA computer with GPS and used to guide field navigation in the forest. The topography data of aerial photos and the position data were installed in an automatic flight navigation system of a small helicopter (UAV) and used to control precisely for the remote area, which is otherwise difficult to access.

Derivation of 3-D crown models by photogrammetry and radargrammetry. Schardt, M. (*Graz Technical University, Austria; mathias.schardt@joanneum.at*), Perko, R., Raggam, H. (*Joanneum Research, Austria; roland.perko@joanneum.at; hannes.raggam@joanneum.at*).

Aerial images and satellite remote sensing have long been successfully used for measuring various forest inventory and environmental parameters. Forest parameters that can be derived from these data are for example tree species, tree age, crown closure, and forest health. By means of new and innovative sensor technologies—such as digital multi-stereo camera systems, LiDAR systems as well as very high resolution stereo data provided by space-borne SAR-systems (TeraSAR and CosmoSkyMed)—and the availability of appropriate digital image processing capacities, three- dimensional information such as vertical stand structures can be obtained. The paper will compare the potential of LiDAR technology, multi-stereo photogrammetry, and radargrammetry (SAR–stereo) for the assessment of canopy roughness and tree/stand height. The comparison has been carried out in two different Austrian test sites located in flat and hilly terrain; one test site is covered with mixed forests stands and the other with pure coniferous stands. Accuracy assessment of 3-D canopy models / tree heights derived from these technologies is performed by independent terrestrial measurements in order to obtain sound statistics on the level of accuracy.

F-08 Innovation in the forest sector – maximizing the sector's competitiveness

Organizers: Lyndall Bull, *Australian National University, Australia, lyndall.bull@anu.edu.au;* Eric Hansen, *Oregon State University, USA, eric.hansen2@oregonstate.edu*; Ewald Rametsteiner, *University of Natural Resources and Applied Life Sciences, Austria, ewald.rametsteiner@boku.ac.at.*

Sectoral patterns of cooperation and its effects on innovation in wood-based manufacturing industries in Europe: evidence from the fourth EU community innovation survey. Aggestam, F. (*European Forest Institute, Austria, filip.aggestam@boku.ac.at*), Ewald, R. (*FAO, Italy, ewald.rammetsteiner@fao.org*), Weiss, G. (*European Forest Institute, Austria, gerhard.weiss@boku.ac.at*).

Using data from the fourth European Community Innovations Survey (CIS4) of the European Union, this paper analyses the impact of collaborations on innovation among enterprises in the wood-based sectors (NACE 20–21, 22 and 36–37). CIS4 enables us to consider the case of collaborative partners and sources of information utilised by wood-based industries (e.g., suppliers, customer firms, and public research institute). Using an enterprise-level dataset (as opposed to a dataset organized by partnerships), we consider how enterprise and sectoral characteristics (e.g., given partner type and enterprise size) affect product and process innovation rates. The results indicate that there are relevant differences both with regards to whom and where various wood-based industries choose to initiate collaborative projects and its impact on innovation rates. For instance, government or public research institutes were overwhelmingly considered as the most important sources of information, but for collaborative partners, the manufacturing sectors in question first and foremost cooperate with their own suppliers, clients, and customers. Enterprise size also plays a significant role as, for example, small- and medium-sized enterprises rank the importance of institutional sources of information as more important. Thus, different sources of information, collaborative activities, and enterprise size have varied implications for R&D and innovativeness.

Best practices in quality management for innovation performance. Leavengood, S. (*Oregon State University, USA; Scott.Leavengood@oregonstate.edu*), Anderson, T. (*Portland State University, USA; tima@etm.pdx.edu*).

In many business sectors today, focus on quality as a competitive tool has been replaced by a focus on innovation. Research exploring connections between quality management, innovation, and company performance indicates that quality is necessary but insufficient in today's business environment. In short, the task facing managers is how to adapt their management practices to achieve innovation performance in addition to quality performance. To answer this question, forest products manufacturers were surveyed about their quality management practices and performance with respect to both quality and innovation. Survey results were analyzed to identify two categories of high-performing firms: those that were achieving primarily quality outcomes and those that were achieving both quality and innovation outcomes. Executives from three firms in each category were interviewed to provide detail on the management practices used by the companies. The interviews were examined to identify similarities and differences in practices between the two categories of firms. Results indicate that firms achieving both quality and innovation performance take a more proactive approach to (1) identify industry best practices; (2) cross-train and empower employees; and (3) identify and communicate customer needs. Specific best practices in these areas are discussed.

Innovation research in the wood industries: a synthesis of Swedish experiences. Roos, A., Stendahl, M., McCluskey, D., Hugosson, M. (*Swedish University of Agricultural Sciences, Sweden; anders.roos@sprod.slu.se; matti.stendahl@sprod.slu.se; denise.mccluskey@sprod.slu.se; marten.hugosson@sprod.slu.se*).

Advisors to Swedish wood industry firms advocate enhanced rates of innovation. To promote innovation, traditional research has emphasised the competencies that firms require to develop new products—such as broad needs assessment, idea generation, and market launch competencies. More recent research has highlighted the need for service innovation, and that networking and customer relationship competences are also key for successful innovations. Accordingly, innovation research ought to address the interconnectivity of development as well as marketing activities. This presentation assesses recent Nordic research and spot research needs, and presents a framework for enhancing knowledge about successful innovation in wood industries and mechanisms to enhance firms' innovation rates. The findings are based on qualitative and quantitative research on how customer needs are formed and how new ideas are generated, developed, and spread across the wood industry and in the market. We refer to innovation theories, including models on attitudes and preferences as well as diffusion. We conclude by recommendations to researchers and practitioners about the theoretical and practical challenges that face firms in the wood industries**.**

Knowledge exchange supports the adoption of innovations in Canada's forest sector. Smith, G.K.M. (*Natural Resources Canada, Canada; gusmith@nrcan.gc.ca*), Beaulieu, G. (*FPInnovations, Canada; gerald.beaulieu@fpinnovations.ca*).

The Canadian forest sector requires the adoption of innovations along the full value chain to secure a competitive position on world markets. Case studies from FPInnovations and the closely aligned Canadian Wood Fibre Centre of Natural Resources Canada serve to map the adoption of innovations in the domains of forest management planning and forest products manufacturing. The case studies elucidate the function of knowledge exchange agents who facilitate the sharing of scientific, technological, and organizational knowledge. Knowledge exchange operates on several levels to influence policy, planning and operations, all of which determine the success of adoption. Conclusions are drawn about critical factors for adoption, differences between adoption in the forest management domain (natural science) compared to the manufacturing domain (engineering science), and challenges posed by an economic downturn in the industry. Adoption rates in the natural sciences typically are slower than in the engineering sciences, and examples are provided. In the Canadian context, provincial partner organizations prove essential to the delivery of innovations to operational practice. The ability of industry to harness innovation along the value chain linking forest fibre supply to manufacturing and markets is shown to be essential to competitiveness.

Reducing poverty through innovation systems in forestry: lessons learned from Nepal's community forestry programme. Uprety, D.; Ojha, H.; Thapa, J. (*ForestAction, Nepal; dharma.uprety@gmail.com; ojhahemant1@googlemail.com; jt@forestaction.wlink.com.np*), Bushley, B. (*University of Hawai'i at Manoa, USA; bushley@hawaii.edu*).

There have been various attempts to engage states, markets, and communities in managing natural resources to achieve both conservation and poverty reduction. In Nepal, a participatory approach to forest management popularly known as "community forestry" (CF) has proven effective in conserving forests and meeting livelihood needs of forest-dependent communities. Since 1978, CF has evolved at both the local institutional and national policy levels. However, uneven socioeconomic relations, power dynamics, cultural contexts, and other factors pose a challenge for sustainable livelihoods. Moving away from traditional research and extension services, a new emphasis on innovation systems has emerged. This approach demands greater attention to interactions among actors in knowledge creation, dissemination, and application. This research draws on the decade-long experience of ForestAction in adaptive, collaborative processes and management approaches, self-monitoring, and participatory action and learning with 60 CF user groups in three districts of Nepal. Preliminary results reveal effective forest management and

governance innovations, adoption of planning and self-monitoring in enterprise development, and marketing of forest products and services to user groups. Furthermore, CF service providers and collaborators use more adaptive and collaborative approaches and are more responsive to the demands and concerns of forest users and other socially marginalized groups.

Potential of employees in production innovation in China's forest products industry: case studies in wood-based furniture enterprises. Yu, N., Mühlsiegl, R. (*Albert-Ludwigs-University Freiburg, Germany; yu.na@fobawi.uni-freiburg.de; reiner.muehlsiegl@fobawi.uni-freiburg.de*), Shen, L.-M. (*Nanjing Forest University, China, Shenlimingda@hotmail.com*), Lewark, S. (*Albert-Ludwigs-University Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*).

Innovation is one key element of forest products industry development. In the past decade, the significant success of innovation in China´s forest products industry was mainly achieved by implementing new working systems or improving existing ones, mainly as a result of using automatic machines, advanced information technology, or production process reengineering. Based on the MTO-model (man-technology-organisation), human, technological, and organisational factors should be considered with equal weight during the innovation process. But so far a lack of academic and practical studies on the human side has resulted in limited success of production innovation in China´s forest products industry. An exploratory study was conducted to reveal the relationship between the nature of work and the motivation potential of employees in production innovation in China´s wood-based furniture enterprises. Interviews and a questionnaire survey based on the job diagnostic survey (JDS) were carried out in four cases, which were in different phases of production innovation. Finally, two main questions will be answered in the study: what are the impacts of technology innovation on the human side and vice versa?, and, How can the human potential better be used within the processes of production innovation?

Posters

Product and process innovations and investments in fixed assets in wood-based industries: evidence from the European Community Innovation Survey (CIS). Aggestam, F. (*European Forest Institute, Austria; filip.aggestam@boku.ac.at*), Rametsteiner, E. (*FAO, Italy; ewald.rammetsteiner@fao.org*), Weiss, G. (*European Forest Institute, Austria; gerhard.weiss@boku.ac.at*).

Using the Community Innovation Survey of the European Union data for 16 European countries, this paper explores the connection between public financial support (at local, regional, national, and EU-levels); product and process innovations; and its relationship to investments in fixed assets (acquisition of machinery, equipment, and software). The focus is on manufacturing sectors involving wood and products of wood; pulp, paper and paper products; publishing and printing; manufacturing n.e.c; and recycling. The results show significant variations across sectors and enterprise sizes, not only concerning innovation rates and investment choices (acquisition of fixed assets as part of innovation expenditures), but also the impact of public financial support. It was found that public financial support, in most cases, increases the probability of product and process innovations. It also increases investment in fixed assets, particularly for small enterprises within the publishing and printing sector and medium-sized enterprises among manufacture of wood and of products of wood; pulp, paper and paper products. Further, enterprise size and geographical proximity between the funding institution and the enterprise also influences the innovation and investment patterns. Thus, public financial support has a varied but generally positive impact on innovative activities and the investment in fixed assets.

Innovativeness and its impact on social responsibility: comparing U.S. firms with global competitors in the forest sector. Han, X., Hamner, R., Hansen, E. (*Oregon State University, USA; xiaoou.han@oregonstate.edu; hamn3788@vandals.uidaho.edu; eric.hansen2@oregonstate.edu*).

Innovation is important for industry and economics and can take the form of new products, processes, and new business systems. Innovativeness can be understood as the measure of a company's intention of adopting an innovation and has two important antecedents: market orientation and learning orientation. A market-oriented company places its focus on the market and can easily adapt to its changes, while a learning-oriented company has a strong intention to learn new things. Corporate social responsibility (CSR) is an issue that most large companies are currently grappling with. The basic idea is that a corporation has not only economic but also social and environmental responsibilities for society.Thus, if a company is innovative, which is supposed to be market-oriented and learning-oriented, it should follow the market trend and learn new things, and as a result be socially responsible because CSR is a market trend in the forest sector and it is something new. This research investigates market orientation and learning orientation as key antecedents to firm innovativeness. In addition, it is theorized that more innovative firms are likely to be more active in implementing social responsibility practices.

Innovation in the forest sector. Hansen, E., Knowles, C., Leavengood, S. (*Oregon State University, USA; eric.hansen2@oregonstate.edu; chris.knowles@oregonstate.edu; scott.leavengood@oregonstate.edu*).

Forest industry innovation research has experienced rejuvenation in recent years as global competitiveness of manufacturing industries has become a critical policy issue at national and regional levels. Research at the Oregon Wood Innovation Center covers a wide array of innovation-related topics with goals of enhancing our understanding of innovation and increasing the competitiveness of Oregon's forest industry. Past studies have focused on (1) assessing the current state-of-the-art in new product development and innovation in the industry, (2) developing a better measure of firm innovativeness, and (3) relating organizational climate to firm innovativeness and performance. Results show that firms tend to emphasize process innovation rather than product or business systems innovation, they can adapt current quality management practices to increase focus on innovation performance, and a positive climate for innovation has an indirect but positive impact on firm performance. Ongoing work investigates the relationship between innovativeness and a variety of concepts such as social responsibility, quality, market orientation and learning orientation. This poster will highlight the most important findings from these studies. Finally, the poster will outline important innovation-related research opportunities.

Perceptions and willingness of Swedish private forest owners toward increasing forest productivity. Hemström, K., Mahapatra, K., Gustavsson, L. (*Mid Sweden University, Sweden; kerstin.hemstrom@miun.se; krushna.mahaptra@miun.se; leif.gustavsson@miun.se*).

Increased forest productivity in Swedish forests increases the potential biomass supply and use of biomass-based products. This increase may be achieved through innovative methods of forest fertilisation, the use of exotic tree species, and clonal forestry. The potential of such silvicultural measures, however, lies in the forest owners' willingness to adopt them. Taking measures that increase productivity may have advantages for the forest owner, but it might also affect biodiversity, forest vulnerability, cultural environments, landscape aesthetics, and recreational opportunities associated with the forest. These issues may influence the forest owners' decision to adopt measures that increase productivity. In Sweden, half the forested land area is owned by private forest owners. This study present the results of a mail-in questionnaire study of he Swedish private forest owners, giving a greater understanding of their willingness to increase productivity, their attitude towards silvicultural methods that increase productivity, and what trade-offs they expect in terms of risks and opportunities if implementing such methods. Our study gives a better understanding of the opportunities to increase forest productivity in Sweden.

Recovery and utilization of wastepaper: diffusion of innovations perspective. Hujala, M., Puumalainen, K., Tuppura, A. (*Lappeenranta University of Technology, Finland; maija.hujala@lut.fi; kaisu.puumalainen@lut.fi; anni.tuppura@lut.fi*), Toppinen, A. (*University of Helsinki, Finland; anne.toppinen@helsinki.fi*).

The consumption of recovered paper in paper and board production has been in continuous growth during recent decades. According to the FAO, the use of wastepaper today exceeds the use of wood pulp as a raw material. This development has been boosted by technological progress and good price competitiveness of recycled fiber, but also by environmental awareness—in both producer and consumer ends—and regulation that has influenced the demand for wastepaper. In our paper we explore whether environmental and institutional factors—such as diffusion of corporate social responsibility and indicators of environmental awareness at country level, socio-cultural characteristics and economic development—play a significant role in country's waste paper recovery and utilization rates. We built two prediction models, a diffusion model and an explanatory model, and tested them on panel data of 22 leading paper-producing countries controlling the effects of, for example, virgin fiber availability, waste paper price, and shares of paper grades produced. Our results indicate that recovery and utilization rates continue to grow, but there are differences across countries. It also seems that so-called softer factors have an impact on use and recovery of wastepaper at the country level.

Enhancing industry innovation through the Oregon Wood Innovation Center: lessons learned after 5 years. Knowles, C., Leavengood, S. (*Oregon State University, USA; chris.knowles@oregonstate.edu*; *scott.leavengood@oregonstate.edu*).

The Oregon Wood Innovation Center (OWIC) was established in December 2005 as a joint initiative of Oregon State University's (OSU) College of Forestry and Extension Service. OWIC's mission is to improve the competitiveness of Oregon's wood products industry by fostering innovation in products, processes, and business systems. A key function of the center is to serve as the primary link between university research and needs and opportunities in the forest industry. OWIC helps firms foster all three types of innovations by serving as a "clearinghouse" to facilitate networking within the industry and to connect manufacturers to the research community and to other assistance providers. The establishment of OWIC created a new brand for the wood products extension efforts at OSU. The first 5 years presented many challenges, including communicating the new brand to the wood products industry, maintaining focus on the target audience, and building relationships with Oregon's green building industry. This presentation will address the challenges associated with the establishment of OWIC, discuss lessons learned and success stories during the first 5 years, and discuss opportunities for future development.

Commercialization potential of viscoelastic thermally compressed (VTC) wood. Macias, N.R., Knowles, C., Kutnar, A. (*Oregon State University, Slovenia;*), Kamke, F. (*Oregon State University, USA; natalie.macias@oregonstate.edu; chris.knowles@oregonstate.*edu; *andreja.kutnar@oregonstate.edu; fred.kamke@oregonstate.edu*).

The way wood is grown for commercial use is changing throughout the world. Plantations exist globally; trees are intensively managed to produce wood for a specific end use. Many plantation species can be harvested 10 to 12 years after planting, but have low mechanical properties. The viscoelastic thermal compression (VTC) process combines mechanical compression, heat, and steam to densify any wood species. VTC wood has increased strength, hardness, and stiffness compared to regular wood; the density of wood increases 2–3 times, and proportional increases are seen in mechanical properties. To determine whether there is a market for VTC wood, interviews will be conducted with professionals throughout the forest products industry, architects, and structural engineers. The goal of the interviews is to obtain information concerning potential applications for VTC wood, benefits to its introduction, and possible barriers to commercialization. All interviews will be audio recorded, transcribed, and analyzed using qualitative software. It is anticipated that the most commonly suggested applications will include laminated veneer lumber, plywood, concrete forms, and flooring. Adding value to fast-growing, low-strength species will be a benefit to its introduction, and potential barriers to commercialization are expected to include cost and the industry's reluctance to change.

Innovation in the U.S. furniture industry. Pirc, A. (*University of Zagreb, Croatia; andreja.pirc.pirc@gmail.com*), Vlosky, R. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu*).

Innovation can be a significant source of competitiveness for a company or industry sector. The United States is the largest importer and consumer of wood furniture in the world. In a 2009 study, we examined innovation in the U.S. wood furniture sector. In this presentation we will discuss a theoretical model and empirical testing of the role that innovation plays in competitiveness for furniture manufacturers in the U.S. Results indicate that relationships between firm innovative performance and competitiveness are complex. Innovation was found to depend on many internal and external firm factors including organizational structure, culture, and the industry's global competitive environment.

An overview of innovation and entrepreneurship behaviour in Slovakian forestry. Sarvašová, Z. (*National Forest Centre, Slovakia; sarvasova@nlcsk.org*), Šálka, J. (*Technical University Zvolen, Slovakia; salka@vsld.tuzvo.sk*).

The present study analyses the innovation and entrepreneurship behaviour in the forestry sector of Slovakia. The study is based on information collected by the Project IPOLES, supported by the Slovak Research and Development Agency. Forest holdings (n = 257) represented by their owners or managers were the information source. Data were collected via mail and email surveys in state and non-state forest holdings during the year 2009. The questionnaire was focused on innovation and entrepreneur activities during the previous 3 years. The ownership type appeared to be important for innovation activity of forest holdings. Higher innovation activity was reported by state-owned enterprises, contradicting the hypothesis based on the theory of property rights, according to which the highest entrepreneurial and innovation activity could be observed in private holdings. Instead, innovation correlated positively with the holding size. The results with respect to factors that foster forest owners to introduce successful innovations indicate their capacity for increasing economic efficiency, improving their competitiveness, and take advantage of emerging technologies and opportunities. The main obstacles for adoption and application of innovation are high transaction costs, lack of own funds, and tax load.

F-09 Forest biomass utilization for bio-energy: technology, economics, and environment

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Effect of harvesting method on the nutrient content of logging residues and nutrition of Scots pine on drained peatlands. Hytönen, J., Moilanen, M. (*Finnish Forest Research Institute; jyrki.hytonen@metla.fi; mikko.moilanen@metla.fi*).

Whole-tree harvesting is rapidly increasing due to high demand for fuel chips. In whole-tree harvesting, nutrient removal is higher than in cut-to-length harvesting in which nutrient rich branches and unmerchantable top sections are left on the site. There is a concern that whole-tree harvesting impairs site productivity, especially on mires drained for forestry. We studied in six field experiments the effects of harvesting intensity in first thinning of Scots pine stands on the amount and nutrient content of logging residues. Also the growth and nutritional status of two Scots pine stands during the 5-year post-thinning period were studied. The amount of logging residues left on site was highest after cut-to-length harvesting. In whole-tree harvesting the amount of logging residues left on the site was 33–66% of that of stem-only harvesting. Consequently, considerable amounts of nutrients bound in the logging residues were also left on site even after whole-tree harvesting. When compared with peat nutrient stores, removal of potassium and boron was greatest, especially in whole-tree harvesting. Regardless on the differences in the nutrient amounts left on the site, harvesting method had during the first 5 years only minor effect on foliar nutrient concentrations of the remaining Scots pine trees.

Forest bioenergy in the Koreas: an integrated techno-biophysical and socio-economic approach. Kraxner, F.T., Leduc, S., Tak, K.I., Aoki, K. (*International Institute for Applied Systems Analysis, Austria; kraxner@iiasa.ac.at; leduc@iiasa.ac.at; leotak@kookmin.ac.kr; aoki@iiasa.ac.at*), Yang, J., Yamagata, Y. (*National Institute for Environmental Studies, Japan; yang.jue@nies.go.jp; yamagata@nies.go.jp*).

Korea is one of the most densely populated and urbanized countries in the world, with a forest area of about 63%. The country's renewable energy target is 5% and about 1/3 of this is supposed to be covered by forest bioenergy. The objective of this paper is to analyze the potential bioenergy supply from natural and plantation forest in Korea and to create a location map for CHP bioenergy plants, applying a spatially explicit optimization model of the supply chain of bioenergy and forest sector industries. This engineering approach is accompanied by a socio-economic analysis of the forest bioenergy sector based on studies from Korea, Japan, and Austria. In this article, we argue that incentives to increase forest biomass utilization for bioenergy are essential for a sustainable renewable energy system in Korea. Further, economic effects in the area of rural development are discussed, as well as the positive consequences on forest management, and environmental effects such as flood prevention or greenhouse gas emission reduction. The paper concludes with the finding that combined experiences from reforestation and forest bioenergy use in South Korea might serve as a bridge-building function and lever for a sustainable economic development in North Korea.

Unveiling counterproductive carbon mitigation incentives. Lippke, B.R., Oneil, E. E. (*University of Washington, USA; blippke@u.washington.edu; eoneil@u.washington.edu*).

Incentives motivate change but carbon incentives frequently cause unintended consequences. Life cycle inventory and analysis (LCI/LCA) modeling of forest products tracks carbon and other services from the forest pool to products, including displacement of fossil emissions when wood substitutes for fossil fuels or fossil intensive products. Incentives that do not target uses that displace the most emissions will likely steal the feedstock from more effective uses, increasing rather than decreasing emissions. We apply life cycle models to identify positive and negative leverage points in reducing carbon emissions. Ethanol subsidies, forest carbon credits, and renewable energy standards steal the feedstock of higher leverage uses, while a carbon tax effectively penalizes the largest emitters. Reducing the cost of collecting forest residuals promotes new uses, thereby reducing emissions although not necessarily rewarding best uses for carbon or habitat. Incentives to use wood for displacing the most fossil intensive products—such as steel and concrete—are least likely to steal feedstocks from more effective carbon uses. While only the carbon tax provides the proper price signal with the highest reward for the greatest carbon emission reduction, being careful to select incentives that support high-leverage carbon offsets can be productive although not optimal.

Spatial analyses of biomass costs for large-scale bioenergy plants in Norway. Trømborg, E., Rørstad, P.K., Havskjold, M., Solberg, B. (*Norwegian University of Life Sciences; Norway; erik.tromborg@umb.no; per.rorstad@umb.no; monica.havskjold@umb.no; birger.solberg@umb.no*).

New targets for renewable energy production have put strong attention to the feasibility of large-scale plants for production of wood pellets, heat and power, and liquid biofuels based on wood in Norway. In this paper we estimate regional supplies of different biomass sources such as harvesting residues, pulpwood, and energy wood. Historical harvesting volumes of roundwood are used to define likely future roundwood supply in order to give a positive description of residual supply. We analyze how regional biomass supply, transport costs, import opportunities and local biomass demand affect the feasibility of large scale bioenergy plants in Norway. The results show the trade-offs between economies of scale and increasing biomass procurement and transport costs, and that location close to appropriate harbor facilities is important to secure biomass supply in the short run for larger plants. The results also show how challenging it is to increase domestic biomass supply in the short-run at prices that compete with imported wood. The paper discusses how excess supply analyses can be used to analyze cost of biomass products with limited intersectoral demand (e.g., harvesting residuals), whereas equilibrium models are more feasible for analyses of products like wood chips and pulpwood.

Posters

Wood pellet quality standard of South Korea. Cho, S.T., Lee, S.M., Ahn, B.J., Lee, O.K., Choi, S.H. (*Korea Forest Research Institute, Republic of Korea; chost@forest.go.kr; lesoomin@forest.go.kr; bjahn@forest.go.kr; oklee@forest.go.kr; choish@forest.go.kr*).

In 2008, the Korean government declared the slogan, 'Low Carbon, Green Growth' for the future. Subsequent to this, the Korean wood pellet market got a great driving force in the renewable energy field. The Korea Forest Research Institute (KFRI) prepared the Korean wood pellet quality standard in 2009. This standard strictly limits the raw material for wood pellet to virgin wood. Under this quality standard, even recycled wood untreated with chemicals is prohibited as a raw material for wood pellet production. Wood pellet is classified into three types—woody pellet, bark pellet, and common pellet—by the origins of raw materials in this standard. Bark contents in the pellet play an important role in this classification. Therefore, bark contents of the woody, bark, and common pellet are < 5%, 5–51%, and >51%, respectively, based on the dry weight. Quality grade of wood pellet in the standard is divided into four levels based on 12 items including diameter, length, bulk density, mechanical durability, calorific value, ash contents, etc.

Enhancement of biomass production in the transgenic poplars expressing *trans*-zeatin secretion gene. Choi, Y.I., Noh, E.W., Han, M.S., Lee, J.S., Kim, H.J. (*Korea Forest Research Institute, Republic of Korea; yichoi99@forest.go.kr; ewnoh@forest.go.kr*; *mshan99@forest.go.kr*; *jslolee@forest.go.kr*; *haejunggogo@hanmail.net*), Choi, K.S. (*ChungNam National University, Republic of Korea; kschoi@cnu.ac.kr*).

Transgenic poplars were developed by expressing a bacterial trans-zeatin secretion gene (*tzs*) under the control of AUX promoter (pAUX) of *Agrobacteriun rhizogenesis*. The transgenic poplar clones were compared with the non-transgenic controls for their growth performances in the nursery trial. Northern blot analysis showed that relative expression levels of tzs by pAUX were approximately 200- to 300-fold lower than those by CaMV35S promoter (*p35S*). Cellular cytokinin levels in pAUX-tzs and p35S-tzs poplars were 118 pg/g and 600 pg/g respectively. The p35S-tzs transgenic plants showed the typical cytokinin-induced phenotypes, such as multiple axillary shoots, thick stems, narrow leaves, and absence of roots, resulting in its being impossible to transplant to the nursery. On the other hand, the pAux-tzs plants also enhanced cytokinin levels but they looked normal except for increased numbers of shoots per plant. Although the pAux-tzs plants grown in the nursery contained smaller leaves and showed slight retardation in their height growth, enhanced biomass production was observed due to increased number of shoots per plant. These results suggest that hardy phenotypes could be generated by moderate expression of the tzs gene and that they could be used to increase biomass production under a short rotation.

A techeconomic analysis of PF resin production using bio-oil derived from forest residue by fast pyrolysis. Gou, J., Chang, J.; Xu, S., Ren, X., Si, H., Han, Y., Huang, Y. (*Beijing Forestry University; jinsheng.gou@gmail.com; cjianmin@bjfu.edu.cn; supershewa@163.com; renxueyong@126.com; sihui@bjfu.edu.cn; hyx.m.s@163.com; annabelleyu@163.com*).

Technology advancements continue to be made in the development of energy alternatives and high value-added chemicals from renewable resources. Bio-oil (derived from forest wood by fast pyrolysis) systems for heat, power or CHP, transportation fuel, and chemicals are all nearing demonstration or industrial status. Previous studies show that phenol-formaldehyde (PF) resin production using bio-oil as a substitute for the fossil phenol, has a great potential for fewer environmental effects and less cost. In our present work, technological evaluation was investigated on the PF resin production chain of feedstock supply, bio-oil production, and PF resin preparation. Dynamic economic analysis and sensitivity analysis were performed based on the factors of feedstock and operation cost, capital investment, fossil prices trends, selling price of new PF resin, etc. The result shows an enormous economical benefit of this utilization methods of wood waste or forest residue. The feedstock cost is the most important factor to the benefit from the sensitivity analysis, and has a negative relationship with plant scale. Consequently the feedstock supply and its cost is the main issue that needs to be evaluated for later industrial development.

Determination of the moisture content in wood chips with dual energy X-ray absorptiometry. Hultnäs, M., Fernandez Cano, V. (*Swedish University of Agricultural Sciences, Sweden; Mikael.Hultnas@sprod.slu.se; victor.fernandez.cano@gmail.com*).

The worldwide bioenergy industry is substantially growing each year and has become an increasingly important competitor for wood raw material. To keep up in the competition, it is necessary to focus on optimizing processes. This to make it possible to achieve a clear environmental approach to gain acceptance in the eyes of the consumers. It is therefore very important to have control of the moisture content in wood chips to run processes at an optimal level, which would also significantly optimize the economical outcome. In this study we tested and evaluated dual energy X-ray absorptiometry as a potential technique to determine the moisture content in wood chips of pine, spruce, and different mixtures of them. This new technique has its origin in the medical application industry, but it also has the potential to be applied to all organic materials. The results show excellent consensus with the reference method (gravimetric method), with an average difference of -1.8%. For repeatable measurements on

the same sample, the standard deviation has been 0.70%. The conclusion of this study states that it is possible within a minute to determine the moisture content in spruce, pine, and mixtures thereof, with a high accuracy.

Development of breathable flexible container for chopped wood biomass. Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; iwaoka@cc.tuat.ac.jp*), Jinkawa, M., Moduna, M., Yoshida, C., Nakazawa, M. (*Forestry and Forest Products Research Institute, Japan; jin@ffpri.affrc.go.jp; mozuna@ffpri.affrc.go.jp; yoshidac@ffpri.affrc.go.jp; naka1978@ffpri.affrc.go.jp*), Furukawa, K. (*Gifu Prefectural Research Institute for Forests, Japan; furu@forest.rd.pref.gifu.jp*).

Wood biomass is recognized as alternative energy. However, it is not yet popular in Japan because the extraction and transportation cost of forest biomass is expensive due to their low energy density and high water content. Therefore, it is necessary to develop compression and drying systems. Our project aims to develop a low-cost production system of forest biomass, and several types of production systems are discussed. In one of these systems, branches and tops are chopped by a processor at the same time as processing and stored in flexible container. For this system, a processor with chopping mechanism and a breathable flexible container are being developed. The purpose of this study is to introduce the new breathable flexible container and to discuss its ability to dry chopped biomass stored inside. For this purpose, two types of materials for flexible containers are compared. As a result, the water content of chopped biomass in a breathable material decreased significantly rapidly; however, the humidity at the top part of model containers was especially high. This result indicated that a ventilation mechanism at the top part of the container is necessary. According to these results, two types of experimental flexible container are being manufactured.

Cash from slash: an interactive tool for calculating the profitability of forest fuels. Jacobson, S., Larsson, W. (*The Forestry Research Institute of Sweden, Sweden; staffan.jacobson@skogforsk.se; william.larsson@skogforsk.se*).

The demand for forest fuels is increasing in Sweden. Among groups of forest owners there has been some scepticism to harvest logging residues, mainly due to the risk of reduced tree growth. It is generally assumed that better knowledge of the profitability of the forest fuel concept will increase the interest of this practice. Hence, a decision-support program for analyzing the economics from the forest owner's point of view of harvesting forest fuels was developed. This dynamic tool is based on a large number of varying assumptions and prerequisites that the individual user is guided through. In- and outgoing figures are presented in the same sheet, enabling quick analyses of different scenarios. The economical effects of harvesting forest fuels will be illustrated in the form of present net values at differing calculative rates of interest. Calculated results are presented as the "point of break-even", i.e., the lowest financial compensation the forest owners must be offered in order to achieve a nil return. The software deals with a large number of silvicultural and economical aspects. Effects on tree growth, soil compaction, scarification, and planting costs, as well as the need for compensatory measures, are discussed in accompanying informative texts.

Analysis of social cost of wood fuels (chips, pellets) and fossil fuel emission. Kim, J.S., Choi, Y.S. (*Kangwon National University, Republic of Korea; jskim@kangwon.ac.kr; zigoo0402@hanmail.net*).

In the midst of worldwide efforts to reduce greenhouse gases, particularly CO_2, the use of fossil fuel, the main factor for producing greenhouse gases, actually has been promoted as the alternative to wood fuel. In this study wood fuels, wood chips, and wood pellets, as well as a fossil fuel, kerosene, were compared for their environmental friendliness. The emission of CO_2, NO_X, SO_X, and PM10 was converted to social cost on each fuel. With 12 MW, the presumable annual fuel consumption per household, the emission of CO_2 for wood chips, wood pellets, and kerosene was applied to be 0.36 ton, 0.48 ton, and 3.81 ton respectively. Considering the price trends of the market, \$15 was set as unit(ton) cost of CO_2, and the social costs of NO_X, SO_X, PM10 per ton were set as \$10,467, \$13,786, and \$38,678. The annual social costs of wood chips, wood pellets, and kerosene per household were \$300, \$151, and \$161 respectively. Therefore, as we can see, the wood pellets cost the lowest, and these results can be used as a basis for determining future government policies for taxation and to support and subsidize the fuel industries.

Characterization of KOH-activated carbon prepared from wood-tar. Kwon, G.J., Kim, N.H. (*Kangwon National University, Republic of Korea*; *gjkwon@kangwon.ac.kr; kimnh@kangwon.ac.kr*), Kim, D.Y. (*Dongguk University, Republic of Korea; sbpkim@dongguk.edu*).

Wood-tar is generated as a by-product during charcoal manufacturing. Chemical activation with KOH is an effective method to prepare activated carbon with highly developed porosity. In this work, wood-tar was used as a precursor for the preparation of activated carbon fibers by chemicals activated with KOH. Wood-tar mixed with KOH at the ratios from 1:1 to 1:5 was treated in the temperature range from 700 to 900 °C. Pore properties as specific surface area and pore size distribution of activated carbons were characterized using the Barrett-Joyner-Halenda method and the DFT method based on the N_2 adsorption isotherm at 77 K. The surface area of activated carbons from the wood-tar increased with increasing the temperature. Interestingly, at the 800 °C the increasing of the amount of KOH made a decrease of the surface area. Thus, the most significant factor affecting the specific surface could be the activation temperature. The maximum specific surface area (1,148 m^2g^{-1}) was obtained in the condition of 3:1 of KOH/wood-tar at 900 °C. From scanning electron microscopic, it is suggested that the surface morphology of pores on activated carbons from wood-tar was significantly influenced by the amount KOH.

Evaluation of spent mushroom compost (SMC) as renewable fuel materials. Lee, S.M., Choi, S.H., Lee, O.K., Ahn, B.J., Cho, S.T. (*Korea Forest Research Institute, Republic of Korea; lesoomin@forest.go.kr; choish@forest.go.kr; oklee@forest.go.kr; bjahn@forest.go.kr; chost@forest.go.kr*).

In Korea, mushroom composts are composed of lignocellulosics such as wood saw dust, rice hulls, sugar beets, etc. In this study, the potential value of spent mushroom compost (SMC) was investigated as a renewable energy resource when it was commercially pelletized. The four types of SMCs produced in Korea were tested for their heating value, moisture content, ash content, and CHNS content. The moisture contents of four SMCs were around 50%. Owing to this, a drying process of SMCs would be a major energy consumption process in the pellet production. The heating values of SMCs were between 17.2 and 19.3 MJ/kg after being fully dried. From the results of elemental analysis, carbon contents of dried SMCs were between 45.2 and 49.0% which is lower than that of wood and it could be a reason for the low heating values. Hydrogen contents were between 5.8 and 6.4%, while sulfur was not detected in any of them. Nitrogen contents were determined between 0.7 and 1.7% range, which is relatively

high and is supposed to be from the hyphae remaining in the SMCs. This suggests that the pellets produced from SMCs cannot fulfill the Korean quality standard for residential use.

The effect of raw materials' diameter on wood pellet quality. Lee, S.M., Ahn, B.J., Lee, O.K., Choi, S.H., Cho, S.T. (*Korea Forest Research Institute, Republic of Korea; lesoomin@forest.go.kr; bjahn@forest.go.kr; oklee@forest.go.kr; choish@forest.go.kr; chost@forest.go.kr*).

The effect of raw materials' diameter on wood pellet quality was investigated, especially with raw materials obtained from 'forest tending' in Korea. Japanese larch and mixed hardwoods were examined. The samples were divided into 3 groups in each species based on the diameter and were named as 'small'(under 6 cm), 'medium'(6 cm–18 cm), and 'large'(over 18 cm). All samples were crushed to small particles 2–6 mm in size. The bark contents of Japanese larch and mixed hardwood were 10–20% and 20–30%, respectively, based on dry weight. After drying, the raw materials were pelletized using a roll-die type press. Under the Korea wood pellet quality standard, the results of quality analysis showed ash content was an important factor that affects on the quality grade of the pellet. In Japanese larch, the ash content of raw materials including bark was between 0.3 and 0.4% (dry basis) in 'medium' and 'large', respectively, whereas it was higher than 1% in 'small'. In case of the mixed hardwood, all groups had ash contents higher than 1.5%, which is considered due to the bark.

Energetic characterization of the chips produced from whole plants of Mediterranean pine trees. Marchi, E. (*Florence University, Italy; enrico.marchi@unifi.it*), Blasi, S., Sirna, A., Lo Monaco, A., Picchio, R. (*Tuscia University, Italy; sandrosirna@unitus.it; lomonaco@unitus.it; r.picchio@unitus.it*).

The growing environmental quality deterioration linked to greenhouse gases, mainly carbon dioxide, and the limited availability of fossil energy sources call for increased efforts in energy saving and utilization of renewable energy systems, where woody biomass plays a major role. The aim of this work was the energetic characterisation of wood chips obtained from whole trees of *Pinus nigra* A. The trees were from thinning. The study area was located in Umbria region (central Italy), in a black pine reforestation (33 years old) with normal density and high coverage degree. The following characteristics were recorded: moisture, bulk density, and higher heating value (HHV). The average bulk density of the wood chips was 146.07 ± 9.97 $kg_{d.m.}/m^3$. It increased significantly with increasing moisture, as shown by a regression analysis ($R^2 = 0.918$). The average HHV of wood chips of black pine was 20.78 ± 0.40 $MJ/kg_{d.m.}$, i.e., slightly higher than that of chips from deciduous broadleaves due to higher resin content. Other important energy parameters were investigated such as ash content, hydrogen and nitrogen content, and the influence of two commercial sizes of chip (P 16 and P 45) on bulk density.

Mechanical bending causes tension wood formation with modification of lignin biosynthesis in *Liriodendron tulipifera.* Moon, D.H. (*Kookmin University, Republic of Korea; duranmoon@hanmail.net*), Kwon, M. (*Korea University, Republic of Korea; mikwon@korea.ac.kr*), Sin, S.J. (*Chungbuk National University, Republic of Korea*), Choi, J.W. (*Seoul National University, Korea*).

Lignin, the second most abundant plant biopolymer after cellulose, is a complex aromatic heteropolymer that results from the oxidative coupling of three monolignols, *p*-coumaryl alcohol, coniferyl alcohol, and sinaphyl alcohols. Because of its structural complexity and difficulty in degradation, genetic engineering has been mainly focused on the down-regulation of lignin content and/or alteration of lignin structure for the pulp and paper industry and more recently for the bioethanol industry. Several lignin biosynthetic regulators have been recently isolated and characterized primarily in *Arabidopsis thaliana*. In order to get better insight for the control of lignin biosynthesis in tree species, we induced the tension wood in the stem of 2-year-old yellow poplar (*Liriodendron tulipifera*) by mechanical bending. Lignin content was significantly reduced in the tension wood as determined by histochemical analysis and Klason lignin method. In addition, the monomeric composition of lignin was altered in the tension wood compared to the opposite wood as determined by DFRC (derivatization followed by reductive cleavage) method. Expression analysis via quantitative real-time RT-PCR support that mechanical bending causes modification of lignin biosynthesis not only in the monolignol biosynthesis but also in the monolignol polymerization at transcription level.

Exploring the variability of biomass distribution in individual forest trees. Rivoire, M. (*National Institute for Agrononomic Rresearch, France; rivoire@nancy.inra.fr*), Deleuze, C. (*Office National de Forêts, France; christine.deleuze@onf.fr*), Longuetaud, F. (*National Institute for Agrononomic Research, France; longueta@nancy.inra.fr*), Saint-André, L. (*CIRAD, France; standre@cirad.fr*), Morneau, F. (*IFN/Inventaire Forestier National, France; francois.morneau@ifn.fr*), Vallet, P. (*Cemagref, France; patrick.vallet@cemagref.fr*), Bouvet, A. (*FCBA, France; alain.bouvet@fcba.fr*), Gauthier, A. (*National Professional Centre for Forest Owners, France; alice.gauthier@cnppf.fr*).

Nowadays, fossil fuels represent more than half the total energy consumption in developed countries. As biomass is a renewable resource and fixes carbon when growing, there is a strong interest to use it as energy, as bio-fuel, and in construction. In some countries like France, ambitious plans for increasing harvest have been made until 2020 (namely +35% of annual wood harvesting). When dealing with such stakes, an accurate and reliable estimation of forest resource is needed. When they are built from empirical approaches, traditional biomass equations are hampered by difficulties to extrapolate to other species and site conditions. To build biomass models that are as robust as possible, it is important to explore the variability for many species on a whole country. We gathered biomass measurements from the main seven French forest organizations into a unique database. This dataset includes volume and/or biomass for around 150,000 trees from 1920 to 2009, half of them having been precisely measured up to 0- or 4-cm diameter in stems and branches, and more than 1 million trees from the National Forest Inventory. Here we show interesting results and analyses, linked to theoretical considerations of biomass distribution in trees.

Sustainable bioenergy development in the Southern U.S. Stanturf, J.A., Perdue, J.H., Buford, M.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us; jperdue@fs.fed.us; mbuford@fs.fed.us*), Stokes, B.J. (*Department of Energy, USA; Bryce.stokes@go.doe.gov*).

Energy produced from biomass sources has been suggested as one way to mitigate greenhouse gas emissions; they are regarded as carbon neutral. Recently, the "greenness" of biofuels is questioned as to their energy efficiency and carbon neutrality, or their effects on food security and biodiversity. A recent U.S. Department of Agriculture/Department of Energy report projected that

approximately 342 million dry tonnes of biomass annually could come from converting from 16 to 24 million hectares of agricultural land to perennial grasses, trees, and other crops. This would add an additional 2.4 to 5.8 quadrillion BTUs of renewable energy. Much of this production could come from the southern U.S., where forest ownership is predominantly private, and be in the form of pine, hardwood, or mixed species. The potential of growing wood for energy in the southern U.S. is large and can be expanded by considering new approaches including growing dense stands and thinning heavily; interplanting hardwoods with nitrogen-fixing legumes; using fast-growing *Populus*, *Pinus*, *Salix*, or *Eucalyptus*; coppice; genetic modification; and alternative weed control. Sustainability criteria that include protecting the resource base, maintaining biodiversity, achieving carbon and climate neutrality, and attaining a neutral or positive energy balance will be evaluated.

F-10 Managing the data deluge: the challenge of emerging technologies

Organizer: Roger Mills, *Oxford University, UK, roger.mills@ouls.ox.ac.uk.*

FORNIS: building an online network of forestry information of sub-Saharan Africa. Britwum Acquah, S. (*Forestry Research Institute of Ghana, Ghana; sbritwum@csir-forig.org.gh/s_britwum@yahoo.com*), Mikkola, E. (*Finnish Forest Research Institute/ METLA, Finland; mikkola@iufro.org*), Kleine, M. (*IUFRO-SPDC, Austria; kleine@iufro.org*), McCracken, R. (*U.S. Forest Service, USA; rmccracken@fs.fed.us*).

In an effort to improve communications and decision making, the Forestry Research Network for sub-Saharan Africa (FORNESSA) established an online gateway for exchanging forestry and natural resource information in sub-Saharan Africa. This Web site and associated tools enable the collect information for various FORNESSA institutions to disseminate credible scientific information in an organized, coherent, and timely manner. Specifically, the FORNESA Information Service (FORNIS) is designed to provide information concerning past and current research relating to forest policy and governance, climate change, poverty alleviation, and forestry utilisation/products/trade in Africa. This gateway also provides contact information to experts in these fields of study and upcoming events with the intent of facilitating transfer among experts and policy makers in this area of the world. This presentation will examine actions taken to unify and work with core members of FORNESSA (the coalition of the willing) in order to build the online service. FORNIS has met and overcome numerous logistical and technical challenges in order to develop, deploy, and maintain this service. Success, failures, and adjustments in practical implementation and governance will be presented along with a site demonstration and discussion with the creators and content providers of FORNIS.

How to build a better Web site: designing for effective technology transfer. McCracken, R.D. (*U.S. Forest Service, USA; rmccracken@fs.fed.us*).

Incorporating usability in Web interface design is a critical part of professional Web site design, particularly when competing for user attention in an environment with exponential growth of online information. With increase in the number and diversity of Internet users and available technologies for design, usability goes beyond using heuristic suggestions in Web site design. By understanding and applying scientific methods in design, an institution's online presence can lead to effective, efficient, and memorable user experience. While no complex Web site can be designed to meet all user needs, the iterative and adaptive process of applying usability engineering ensures that technology products fit with core users' expectations and assumptions to insure successful completion of desired tasks. This paper and presentation will discuss the business imperative of usability along with user-centered analysis, information architecture, navigation design, writing for online content, detail page design, and usability testing.

Developing a toolkit for data management. Mills, R.A. (*Oxford University Library Services, UK; roger.mills@ouls.ox.ac.uk*).

The traditional challenges of managing data for re-use are compounded rather than simplified by modern technologies. The exponential increase in quantity of data to be stored, the difficulty in selecting that percentage that is likely to be of long-term value, the choice of data format to ensure long-term accessibility, and the application of appropriate metadata to assist discovery all pose major, and costly, management issues that have yet to be solved. This paper reviews some of the actions being taken by major institutions around the world and seeks to identify trends that can assist in devising a data management plan, appropriate structures for management teams, and those areas where collaborative action could be fruitful in ensuring valuable data is not lost. It will form the basis for a panel discussion in which members of IUFRO Unit 6.03 Information Services and Knowledge Organisation will, in conversation with the audience, endeavour to identify key components of a toolkit providing targeted guidance to foresters facing data management problems, to be further developed by the group as a future online service.

Maximising access and minimising bias in evidence-based forestry: the case for a collaborative register of data. Petrokofsky, G. (*University of Oxford, UK; gillian.petrokofsky@plants.ox.ac.uk*).

Journal articles, frequently cited as important sources of information, are not the only, or most important, source of information for policy formulation or policy-relevant research. Much valuable environmental information is not published in peer-reviewed journals, but in 'grey' ('fugitive') literature. This includes reports published independently by organizations (working papers, occasional papers, reports on websites), which are infrequently indexed in bibliographic databases and inadequately retrieved by search engines. Systematic reviews—acknowledged to be the gold standard for summarizing, appraising, and communicating results and implications of otherwise unmanageable quantities of research—include fugitive literature and journal articles, provided they meet agreed inclusion criteria. Systematic reviews utilizing meta-analysis include data collected according to robust methodology even if they have not been analysed in journal articles. Medicine—which pioneered systematic reviews, recognizing the need for retrieval of hard-to-access data—established a register of controlled clinical trials, CENTRAL, which includes information not indexed in bibliographic databases. Systematic reviewing for environmental and forestry decision-making is at an early stage. This paper draws on experiences with recent systematic reviews and proposes establishing a comparable register of data and fugitive literature as a resource for those preparing systematic reviews to answer questions for sustaining society and the environment.

A forestry education platform for Central America and Caribbean countries: FAO experience. Santos, V., Grylle, M. (*FAO, Italy; vanda.ferreira@fao.org; magnus.grylle@fao.org*).

It is apparent that there is a huge amount of forestry information databases available in the Central America and Caribbean region. In spite of this, forestry educational material is difficult to find, as there is no obvious way finding it. Therefore, there was a consensus in the group of participants of the First Regional Forestry Education Workshop hosted in Cuba in November 2009 that a web-based option of this nature is needed. FAO has been chosen to build and host such platform. The main function of the platform is to serve as a repository for available forestry education material, with links to national, regional, and global forest information bases (libraries and others). The platform will also include links to forestry schools showing their study plans. The basic idea is not to duplicate repositories of already existing material but to use links as much as possible. The material can be easily uploaded but the evaluators will review it and will decide if it should be made available. The main beneficiaries of the initiative are teachers, professors, researchers, forestry students of technical schools, under- and post-graduate training institutions, and faculties.

Institutional repositories: a solution for preserving forestry information in Ghana. Sraku-Lartey, M. (*Forestry Research Institute of Ghana, Ghana; msrakulartey@hotmail.com*).

Huge amounts of research data are being generated on a regular basis, and processing this volume of information is proving to be a challenge for many information professionals. Several technologies have emerged in recent times for managing the huge amounts of information being generated, key ones being the development of institutional repositories. The momentum for establishing institutional repositories has been building very fast in institutions of higher learning in many countries. However, this concept is yet to catch on in developing countries such as Ghana. This paper describes the potential for establishing an institutional repository at the Forestry Research Institute of Ghana as a solution for preserving the institutional memory of the institute. A lot of local forestry content is generated regularly through project and technical reports, most of which are stored individually by researchers either on their personal computers or in their offices as paper documents. These documents are often very detailed and useful for supporting other research projects. Grey literature such as annual reports, technical notes, and research briefs also abounds. Issues discussed include the purpose for establishing such a service, contents that will be accepted, potential users, and key stakeholders of the system.

The Oregon Spatial Data Library: a public resource. Wirth, A.A., Rempel, M.G. (*Oregon State University Libraries, USA; andrea.wirth@oregonstate.edu; marc.rempel@oregonstate.edu*), Walsh, K. A. (*Institute for Natural Resources, USA; kuuipo.walsh@oregonstate.edu*), Avery, B.E. (*Oregon State University Libraries, USA; bonnie.avery@oregonstate.edu*).

This presentation provides an overview of the tools and functionality of the Oregon Spatial Data Library (OSDL), partnerships formed to enhance dataset contribution, and user feedback informing the next development phase. Oregon is a natural-resource-rich state. Those natural resources cut across many jurisdictions. All of these use and create data about the state on a regular basis. With this in mind, the targeted primary users for the OSDL are the staff within federal, state, county, and municipal government agencies, and within the sovereign tribes. The OSDL (http://spatialdata.oregonexplorer.info/) provides public access to reliable and up-to-date spatial data about Oregon. Currently all Oregon statewide framework data are available from this site and serve as "base data" for GIS applications supporting research, business, and public services. More than 200 spatial datasets were accessible at its launch in November 2009. Collaboration with the University of Oregon Libraries will increase that number substantially in 2010. The OSDL joins the Oregon Department of Administrative Services Geospatial Enterprise Office, Oregon State University Libraries, the Institute for Natural Resources, and other dataset providers in a common goal: curation of spatial data for maximum use and minimum duplication of effort.

Posters

Browsing forest information in AR space with a smartphone. Fujiwara, A., Saito, K., Nakamura, K. (*University of Tokyo, Japan; akio@uf.a.u-tokyo.ac.jp; kaoru@nenv.k.u-tokyo.ac.jp; nakamura@nenv.k.u-tokyo.ac.jp*), Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; iwaoka@fe.rn.tuat.ac.jp*), Kobayashi, H., Ando, K. (*The University of Tokyo, Japan; hill_koba@cyber.t.u-tokyo.ac.jp; chutzpah@ecc.u-tokyo.ac.jp*).

Information on forest research sites now can be browsed on the Internet, using technology of database, GIS, digital data logger, field worker's blogs, etc. Augmented reality (AR) is hot technology as a tool for live direct or indirect views of a physical real-world environment whose elements are merged with (or *augmented* by) virtual computer-generated imagery–creating a mixed reality. It can be very useful for field researchers or visitors to explore big archives of survey data or real-time sensor data on site. Recently, using satellite Internet access, solar cell, fuel cell, and WiFi technologies, Internet access became available in forest areas where there is no power supply, no telephone, and weak mobile phone radio. Furthermore, modern smartphones with WiFi, GPS, and solid state compasses make it cheaper to build an AR system. We built an AR forest information system with these technologies and devices experimentally on Chichibu LTER site, the University of Tokyo. On this site, we can view sensor data and survey data, etc. over real-forest images. Especially for visitors, it is helpful to access excursions on this site. This study is a part of Cyberforest research project.

Human computer biosphere interaction: background information communication with telepresence of entities in a forest through a network. Kobayashi, H., Saito, K., Fujiwara, A., Nakamura, K. (*University of Tokyo, Japan; hill_koba@cyber.t.u-tokyo.ac.jp; kaoru@nenv.k.u-tokyo.ac.jp; akio@uf.a.u-tokyo.ac.jp; nakamura@nenv.k.u-tokyo.ac.jp*), Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; iwaoka@cc.tuat.ac.jp*), Ando, K. (*University of Tokyo, Japan; chutzpah@ecc.u-tokyo.ac.jp*).

The songs of small birds, the trickling of a stream, and the sounds of insects moving about in the forest represent the diversity of organisms. The Human Computer Biosphere Interaction in CyberForest project creates such a bioacoustical interaction between distant wildlife in a remote forest and local users through a networked remote-controlled speaker and microphone. It expresses the unique bioacoustic beauty of nature and allows users to interact with a forest in real time through a network, to acoustically

experience a distant forest soundscape, thus merging humans and nature without great environmental impact. This novel interactive sound system can create a sense of forest between users and a remote soundscape through chorus-like experience of interspecific and believable interaction in augmented reality between the users and wildlife, enabling users to feel a sense of belonging to nature even in the midst of a city. This paper describes the theory of interaction between humans and the biosphere through the design process of developed interfaces: in Tokyo University Forest in Chichibu and an uninhabited subtropical forest on Iriomote Island, Japan.

A data management flowchart. Mills, R.A. (*Oxford University Library Services, UK; roger.mills@ouls.ox.ac.uk*).

Successful data management to ensure long-term accessibility and maximise return on the investment entailed in its creation requires careful planning, which should ideally begin in the earliest stages of project design. This ideal is often not achievable if research is to be based on older data, which may exist in many formats and have been gathered over many decades. Nevertheless any project will benefit from clarity in the disposition of existing resources, format translations to be applied, any harmonisation procedures, structure and storage of analysed outputs, rights and security issues, and many others. Depending on the volume of data to be handled, storage may involve agencies outside the research group, and close interaction will be required to ensure objectives are met in a timely manner. Generally this will involve a dedicated team comprising research scientists, IT specialists, and librarians, who will tailor solutions to meet research objectives. Such teams are a relatively new concept and this poster aims to illustrate the stages in identifying key targets for a data management team, the skills required and the issues to be considered.

Moscow State Forest University as a Russian coordinator of Global Forest Informational Service (GFIS). Sanaev, V.G., Valentin, S., Chumachenko, S.I., Yakovleva, A.I. (*Moscow State Forest University, Russian Federation; rector@mgul.ac.ru; shalaev@mgul.ac.ru; chumachenko@mgul.ac.ru; yakovleva@mgul.ac.ru*).

GFIS (www.gfis.net) was built as a global partnership, across sectors and institutions, and aims to maximize the value of all forest information resources and providers worldwide. Through a bottom-up approach, partners determine the volume, coverage, and type of information they would like to share through GFIS. The Russian coordinator of the project is Moscow State Forest University. There is a clear need for integration of Russian forest science to international scientific society. Taking into consideration existing language barriers, some compromise between stakeholders should be found. One of the connecting links between the Russian forest sector and other countries is the site <www.gfis.ru>, supported by MSFU. Work on creation of the pilot version of Russian segment of GFIS was completed in 2006. Now an analyst from MSFU coordinates work on fixing changes of the chosen Internet pages, translates into English, and places it on a server <www.gfis.ru>. The site contains information about forest sector news from national to local levels, news of regional forest services, institutions of Russian Academy of sciences, forest colleges, and NGOs. Most actual information is transferring to the main GFIS resource, <gfis.net>, and thereby is available to all interested persons in the world.

Data management at Santa Catarina State Floristic and Forest Inventory (IFFSC) in southern Brazil. Vibrans, A.C. (*Universidade Regional de Blumenau, Brazil; acv@furb.br*), Miszinski, J., Mio de Souza, J. (*EPAGRI/CIRAM, Brazil; joelma@epagri.sc.gov.br; julianasouza@epagri.sc.gov.br*), Lingner, D.V., Gasper, A.L., Schorn, L.A., Sevegnani, L., Marcolin, M. (*Universidade Regional de Blumenau, Brazil, deboravanessa_ef@gmail.com; algasper@gmail.com; lschorn@furb.br; sevegn@furb.br; marcolin@furb.br*).

Data management of Floristic and Forest Inventory of Santa Catarina (IFFSC) aims to provide a geo-referenced on-line database directed to decision-makers and the public. Under construction since 2007, the inventory consists of integration and digitalization of the state's four existing herbaria, field inventory *strictu senso*, including detailed floristic surveys within and around sample units, assessment of genetic structure of redlist plant populations, and study of socio-economic importance of forest resources. All collected specimens are stored in the project's herbaria with complete metadata-sets in environments connected to on-line databases like *speciesLink* and GBIF. Derivative information and reports on sample units are available to the public on-line; field raw data and general data-files are available for registered users, in order to encourage multiple uses by governmental agencies and researchers. Exact coordinates of sample units are randomly offsetted in downloadable files to safeguard landowners' privacy. The map-server displays sample unit locations and reports of field observations, species composition, indices, and quantitative data by sample unit and geographic units (e.g., municipalities, districts, watersheds). Inventory is to be continued in a 5-year cycle, measuring 20% of the state's forests every year, with financial resources provided by State Research Agency (FAPESC) and National Forest Service (SFB).

General Posters: Emerging Technologies in the Forest Sector

Optimizing multiple log landing locations for ground-based timber harvesting. Aracena, P., Contreras, M., Chung, W.D. (*University of Montana, USA; pablo.aracena@umontana.edu; fondemix@hotmail.com; woodam.chung@umontana.edu*).

Locating log landings for ground-based harvesting is an important task in forest operations planning. There are theoretical approaches developed to determine the optimal location of a single log landing for a given harvest unit, but no tool has been available for optimizing multiple log landing locations. Forest operations planners still rely on rules of thumb and their field experience for locating landings without consideration of all possible options. We developed a computer model to automatically determine the number and location of log landings that minimize total harvesting costs for a user-defined timber harvest unit. Using a digital terrain model derived from LiDAR data, the model finds the least-cost landing locations, while considering skidding and landing and spur road construction costs. The model is also able to take into account terrain conditions and potential obstacles that might restrict the movement of ground equipment such as steep terrain, wetlands, or streams. We assumed that volume is uniformly distributed over the area and landings may be located at any point within the harvest unit. The model has been applied to several hypothetical harvest units to evaluate the effects of design factors such as terrain conditions and spur road construction costs.

An integrated stand growth model for oak and its application. Hong, L., Lei, X., Tang, S., Lu, Y. (*Chinese Academy of Forestry, China; honglx@caf.ac.cn; xdlei@caf.ac.cn; stang@caf.ac.cn; ylu@caf.ac.cn*).

Mongolian oak (*Quercus mongolica* Fisch. ex Turcz.) is one of the main forest species with timber and ecological benefits in northeast China. It is necessary and valuable to develop the growth and management model of oak to regulate its management practice. This study developed an integrated stand growth model of oak (ISGM_Oak) using data from 62 permanent plots observed from 1997 to 2007. ISGM_Oak is a group of nonlinear simultaneous equations that include: (1) basal area growth model; (2) self-thinning model; (3) dominant tree height growth model or site index curves; (4) relationship between average tree height and dominant tree height; (5) form height model; (6) density index definition; and (7) basal area and stand volume formula. The method of nonlinear error-in-variable simultaneous equations is used to estimate the parameters of ISGM_Oak, so the parameter estimation of the group of correlated equations in ISGM_Oak is unbiased and the equations are compatible. The average relative errors for estimation of number of trees per hectare, mean diameter, and volume were 0.7%, 0.9%, and 3.0%, respectively. The ISGM_ Oak model can be used to simulate the stand growth and make decision on stand density management with different site index and stand density.

Three-dimensional light transfer model based on vertical point-quadrant method and a Monte Carlo ray tracing approach for *Fagus crenata* canopy on Naeba Mountain in Japan. Iio, A., Kakubari, Y., Mizunaga, H. (*Shizuoka University, Japan; atsuiio@agr.shizuoka.ac.jp; afykaku@agr.shizuoka.ac.jp; mizunaga@agr.shizuoka.ac.jp*).

For reliable estimation of canopy photosynthesis (P_{canopy}), canopy space of a *Fagus crenata* stand was divided into an array of small three-dimensional voxels (0.0125 m^3), and leaf area density (LAD) of all voxels was determined by vertical point quadrat method. The LAD distribution was then imported into a ray tracing program based on turbid medium analog, and voxel light environment was simulated on a half-hour time step. To compensate for the problem of non-random leaf dispersion within a voxel, branch SPAR (foliage silhouette to projection area ratio) was used as light extinction coefficient of Beer's law, and within-voxel variations in leaf photosynthetic photon flux density ($PPFD_{leaf}$) was simulated by Monte Carlo ray tracing approach presented by Stenberg. Stand LAI based on the point quadrat method resulted in a value of 4.81 $m^2\ m^{-2}$, comparable with LAI measured by the litter trap method, 4.54 $m^2\ m^{-2}$. The light simulation showed reasonable estimates of within-voxel frequency distribution of $PPFD_{leaf}$ for P_{canopy}, throughout the canopy. Neglecting the within-voxel variations in $PPFD_{leaf}$ caused about 22% overestimation of P_{canopy} during the summer period, implying that light heterogeneity even within a small voxel must be considered for realistic estimation of P_{canopy}.

Forest inventories using strip survey. Imaña-Encinas, J. (*University of Brasilia, Brazil; jose.imana@gmail.com*), Silva Ribeiro, G. (*ribero_gustavo@hotmail.com*), Sobreira Ferreira, J. C. (*juliosobreira@gmail.com*), Imana, C.R. (*christian_bsb@hotmail.com*).

The growing demand for wood without increasing the occupied area—as well as consideration for quality improvement, product valuation, and optimization of results—contribute to the need for improving survey models. The methodology of forest inventories has a direct influence on the economic benefits of an enterprise. Inventories carried out in two forest enterprises with an annual cut of more than 10,000 hectares of *Eucalyptus* spp. were analyzed and compared with strip survey inventories. In these strips the dasometric diameters according to Weise and Hohenadl were used to calculate the volume. The inventories by strip sampling were as efficient as the models that considered plots of fixed areas. Data collection in the field was supported by mobile technology such as palm-top and netbook. The results were obtained directly on site in the corresponding stand. When comparing the results of both inventories (enterprise and the strip survey model), there was a difference of less than 4.5% recorded between the final values measured in m^3/ha. It was concluded that strip survey inventories could improve conventional inventories by considerably reducing the consumption of time and resources.

Establishment of optimal forest management planning through the comparative analysis of classical and modern forest yield regulation methods. Jang, J.Y. (*Kangwon National University, Republic of Korea; a2136@kangwon.ac.kr*), Woo, J.C. (*Kangwon National University, Republic of Korea; jcwoo@kangwon.ac.kr*).

The purpose of forest management in Korea is now to foster timber resources being available in the future through the sustained and efficient management of forest resources. First of all, the main focus is to establish the forest management plan, including economical, environmental, and ecological functions of the forest according to the requirements of the present era. However, there are now few research studies about decision-making support systems and forest management planning. This study is to establish the optimal forest management plan for decision-making of forest resource management through the comparative analysis between classical yield regulation methods (area allotment method, volume allotment method, and area and volume verification method) and mathematical programming techniques (linear programming, integer programming, dynamic programming and goal programming). In this study the research forest of Kangwon National University was selected for the study area. For forest inventory, the main plot was set to 1-km distance with the form of the regular square, and four auxiliary plots were set to 250-m distance, also with the form of regular square. For the research forest total, 33 main plots and 165 auxiliary plots were set and investigated.

Extracting apoplastic succus from tender *Schefflera octophylla* stems by microdialysis. Jiang, G., Jin, H., Wang, W., Li, R. (*Dalian Nationalities University, China; guobinj@126.com; jhua@dlnu.edu.cn; wangwei15df@hotmail.com; rihong619@163.com*), Yin, W. (*Beijing Forestry University, China; yinwl@bifu.edu.cn*).

The plant cell apoplast, which consists of all the compartments beyond the plasma membrane, is implicated in a variety of functions during plant growth and development as well as in plant defence responses to stress conditions. There are many problems in studying apoplast methods because apoplast can not be separated from plant tissue. In particular, it is more difficult to implement in dynamic analysis of living plant apoplastic components. This study assumed that apoplastic fluid (succus) can be obtained by microdialysis when *Schefflera octophylla* cultured in pots were used as materials. Dialysis fluid was collected during different time periods after probe of microdialysis inserted into living tender stems, and the ion concentration and malate

dehydrogenase (MDH) activity of the dialysis fluid were determined. The results showed that Na^+, K^+, and Ca^{2+} concentration of the dialysis fluid gradually tended to stability and MDH showed no activity from 120 minutes after the probe was inserted into living tissue. The results proved that the dialysis fluid collected was not polluted by intracellular fluid of damaged cells and was pure apoplast in *Schefflera octophylla* tender stem. This microdialysis technique provides a new method for obtaining apoplastic fluid *in-vivo* conveniently and quickly.

A landscape-grade assessment methodology for forest landscape management in South Korea. Jung, H.Y. (*Kangwon National University, Republic of Korea; sea33sky@naver.com*), Park, C.W. (*Korea Forest Research Institute, Republic of Korea; pcwpcw@forest.go.kr*), Lee, G.G. (*Kangwon National University, Republic of Korea; gglee@kangwoan.ac.kr*).

Most Koreans have been exposed to various forest landscapes in their daily lives, since about 64% of the land is mountainous areas of temperate forests. The Korea Forest Service, in the Ministry for Food, Agriculture, Forestry and Fisheries, has been pilot-testing the Landscape-Grade Assessment Methodology (LGAM) that was recently developed in order for the agency to manage the outstanding forest landscapes. This study focused on the development process of grading methodology for forest landscape assessment, including national forest inventory system, national and local forest landscape assessment, selection of areas in which landscape management should be required, landscape managing grades, and the results of a pilot test study. As a result, Korea's lands were designated into four classes—"landscape conservation area (I)", "landscape buffer area 1 (II)", "landscape buffer area 2 (III)", and "landscape transition area (IV)"—and a total of 100 units, which were selected through the LGAM. The LGAM that was developed by this study has been currently going through several final expanded pre-tests for the government to utilize it in actual policy for introducing one of the key polices to manage and design outstanding forest landscapes in South Korea.

Optimized decision supporting system for forest management in Korea. Kim, Y.H., Won, H.K. (*Korea Forest Research Institute, Republic of Korea, alliedkim@gmail.com; hkwon@forest.go.kr*).

Recently the objectives of forest management become more and more complex to achieve its economic, ecological, and social sustainability. Forest planning is now requested to provide a management solution that sustain or optimize the potential of forest functions. To facilitate sustainable forest management in Korea, the forest lands were classified into 6 function zones, for which different management approaches were applied. In this study, we developed a decision supporting system that produce management solutions which minimized harvesting costs while achieving even-flow of harvest volume. A multiple-objective formulation based on the Tabu Search heuristic algorithm was used, along with several constraints requested for sustainable forest management in Korea. Also the system was able to allow scheduling of forest management prescriptions differentiated for the 6 forest functions. To validate the developed system, we applied the system to generate a management solution for the Gwangneung experimental forest of Korea Forest Research Institute. We found that the system was able to provide a reasonable management solution for the several management objectives and constraints. It is expected that the resulted management solution would be adopted in the operational plan of the study site.

Detecting wetwood in the wood of *Ficus glabrata,* Kunt of the natural forests of Urabá Chocoano, using Acoustic Tomograph Fakopp 3D Muñoz, A., Pérez, M., Londoño, A. (*Universidad del Tolima, Colombia; amalvarez42@hotmail.com; monapo23@hotmail.com; alondono@ut.edu.co*).

The Acoustic Tomograph Fakopp 3D was used to identify the presence of wet wood in the species *Ficus glabrata*, Kunt in the natural forest of Urabá Chocoano (Colombia). The time that a sound wave needs to pass through the transversal section of the wood was measured, which allowed an identification of the presence of internal defects by means of a non-destructive method. The scan was done in a transversal section of the trunk of 11 trees of diameters between 30.75 and 40.05 cm. The pieces of wood were cut in each evaluated section. The differences in the transmission speed of the wave were shown in colours. The colours green and yellow showed no apparent damage (0%), although the yellow zones contained more humidity then the rest of the healthy wood. The colours red and purple corresponded to wood with fissures, damaged marrow, and existence of wetwood; and blue stain indicated the percentage of damage in the transversal section from 0.4% to 24.4%. The results suggest that the Acoustic Tomograph 3D can be used efficiently for detecting wet wood in *Ficus glabrata* trees.

Development of a mountain ridge distinction program using GIS. Park, Y.K., Lee, H.S., Jeon, J.H. (*Korea Forest Research Institute, Republic of Korea; parkkyu1@forest.go.kr*; *seton21@ymail.com; junjeon@forest.go.kr*).

The elevation standard of 50/100, one of the standards for conversion permission in mountainous districts, is difficult to apply because the topographic condition status of mountainous districts varies. Also the lower end of the mountainous districts standard was not clear, so it runs into trouble in its application process. So it is required to clearly define the lower end of the mountainous districts and to develop a ridge distinction program. In this study, a Ridge Distinction Program based on GIS was developed to improve the elevation standard. To minimize errors within the classification process, the watershed areas were defined at 30 ha. The lower end of the mountainous districts was defined by a forest boundary based on the forest type map that was developed by Korea Forest Research Institute. The peak of the mountainous districts was defined as the highest point within the site. According to the case study, the developed program was able to give a similar classification of the ridge mountainous districts composed to the current classification. Thus, this result indicated that it is adequate to adopt the ridge distinction program to land-use conversion of mountain districts.

A study on route extraction technique for forwarders using image processing. Ryousuke, S. (*University of Tokyo, Japan; rshira@fr.a.u-tokyo.ac.jp*), Kazuhiro, A., Toshiaki, T. (*Utsunomiya University, Japan; aruga@cc.utsunomiya-u.ac.jp; tasaka@cc.utsunomiya-u.ac.jp*), Hideo, H. (*University of Tokyo, Japan; sakaih@fr.a.u-tokyo.ac.jp*).

We developed a running route extraction algorithm to automate forwarder driving, using stereo image processing. Automation of forest operations should bring about significant effects on labor saving and the cost reduction, but it is very difficult to achieve due to the complexity of forest operations and characteristics of forest environments. Therefore we attended to hauling operations

that use a forwarder, which is relatively simpler than other forest operations. The method discussed in this study consists of three parts: (1) a method to reproduce terrain by stereo image processing; (2) a method to extract road surface from terrain, which was reproduced; and (3) a method to improve accuracy in the resulting surface by detecting vegetation on roadsides that causes errors on terrain reproduction, by using color information of source images. We took stereo images on the road in Utsunomiya University forest in Funyu, and examined the method mentioned above. As the result, we confirmed that terrain has been reproduced successfully, and approximately 86 percent of extracted pixels were on the position of actual road surface in the source images.

A "sense of forest" from audiovisual telepresence of forest phenology through real-time streaming and archive systems at the Tokyo University forest in Chichibu, central Japan. Saito, K., Fujiwara, A., Nakamura, K. (*University of Tokyo, Japan; kaoru@nenv.k.u-tokyo.ac.jp; akio@uf.a.u-tokyo.ac.jp; nakamura@nenv.k.u-tokyo.ac.jp*), Iwaoka, M. (*Tokyo University of Agriculture and Technology, Japan; iwaoka@fe.rn.tuat.ac.jp*), Kobayashi H., Ando K. (*The University of Tokyo, Japan; hill_koba@cyber.t.u-tokyo.ac.jp; chutzpah@ecc.u-tokyo.ac.jp*).

If forest images and ambient sounds are recorded and accumulated over a long period as some highly realistic sensory information, they will become material that can help us perceptively understand changes in the forest over a long period of time. The long-term history of world-wide forests can be perceptively shared if this material as digital media is distributed over the Internet. Also, if the present images and sounds of a recording site can be distributed on a real-time network, we can intuitively comprehend a global forest environment today. Such collected data of the forest environment are called "cyberforest," while the perceptive understanding of and act of sharing gained from cyberforest is called a "sense of forest." With the recorded images and real-time audio streaming obtained by a forest-view monitoring robot camera set at the Tokyo University Forest in Chichibu as a cyberforest research project, this study reports investigations on the technology of a forest-view monitoring distribution system by executing an application test of cyberforest on the Internet; this study also reports some "sense of forest" cases that resulted from cyberforest.

The study of the automatic forest road design technique considering shallow landslides with LiDAR data of the Funyu experimental forest. Saito, M., Goshima, M., Aruga, K., Matsue, K., Shuin, Y., Tasaka T. (*Utsunomiya University, Japan; 50008953003@st.tuat.ac.jp; aruga@cc.utsunomiya-u.ac.jp; matsue@cc.utsunomiya-u.ac.jp; shuin@cc.utsunomiya-u.ac.jp; tasaka@cc.utsunomiya-u.ac.jp*).

In this study, the technique to automatically design the forest road considering soil depth and shallow landslides using LiDAR data was examined. First, in order to develop shallow landslides risk map of the Funyu Experimetal forest, the slope stability analysis by the unlimited length slope stability analysis formula was conducted. The soil depth was surveyed at 167 points of simple penetration tests, and frequency distributions of the soil depth estimated the soil depth as logarithmic normal distributions with 5 classes of slope angles and 4 classes of the average depth of water catchment area. The soil depth map in the experimental forest was made using the mode values of lognormal distributions. Then, the shallow landslides risk maps in the experimental forest by the slope stability analysis were also made using these soil depth distributions. Finally, the automatic forest road design technique with high accuracy DTM and shallow landslides risk map was developed using cubic spline interpolation and dynamic programming. The program could minimize the amount of the earthwork costs by avoiding shallow landslides risk areas. The program could easily design an environmentally sound low-volume road automatically.

The importance of using the correct tree architecture in structural-functional process-based models. Schneider, R. (*Université du Québec à Montréal, Canada; schneider.robert@courrier.uqam.ca*).

Initial planting density of the major softwood species was lowered for several reasons. The effect of this change in policy on stand yield and wood quality is, however, not completely understood. To address these concerns for jack pine, we undertook the adaptation of PipeQual, a structural-functional process-based model developed by Annikki Mäkelä for Scots pine, which can be used in predicting certain wood properties. The model adaptation concentrated on the differences in tree architecture between both pine species. For jack pine, the nodal (whorls at the end of the yearly shoot) and internodal whorls (whorls produced during the growing season) are treated separately. The first step consists in predicting from the total stem foliage biomass, the biomass that is in each type of whorl. The number of whorls per shoot is predicted by a cumulative logistic model. Different foliage biomass distributions are then applied to the nodal and internodal whorls. The model sensitivity to tree architecture was then verified. Very few differences were observed at the stand and tree levels, whereas discrepancies appear at the whorl level. In light of these results, it can be seen that the importance of tree architecture depends on the scale of the desired results.

Sapwood and heartwood taper, and their dynamics. Schneider R. (*Université du Québec à Montréal, Canada, schneider.robert@courrier.uqam.ca*).

Sapwood area is important for defining product quality of certain species, and is often modeled using the pipe model theory. Moreover, pipe model theory is the basis of carbon allocation in several process-based models. However, the need arises to express it in dynamic terms through sapwood reuse and turnover for growth model engines. Studying the sapwood and heartwood dynamics is nevertheless not an easy task. We propose an empirical methodology to try and quantify these dynamics. The approach combines sapwood area taper functions with height and dbh interpolation models to get an insight in the turnover rates. The first step is to predict the yearly sapwood area taper from the empirical functions. Heartwood area is produced when there is a decrease in sapwood area between 2 consecutive years. When the tree is fully grown, the predicted sapwood and heartwood areas can then be compared with the observed values. These comparisons can then be used to get a useful understanding in the sapwood to heartwood turnover rates. The derived turnover rates are then related to within-tree variables such as height, age, and foliage biomass above the observation point. Although complete dynamic processes cannot be decomposed, net turnover rates can be quantified.

Designing forest road networks for best path modeling using GIS. Son, J.Y., Suk, S.I., Sakurai, R., Nitami, T., Sakai, H. (*University of Tokyo, Japan; jiyoung@fr.a.u-tokyo.ac.jp; hl5fca@fr.a.u-tokyo.ac.jp; sakurai@fr.a.u-tokyo.ac.jp; nitami@fr.a.u-tokyo.ac.jp; sakaih@fr.a.u-tokyo.ac.jp*).

Forest road construction for harvesting operations have always been subjected to certain limitations. We developed a method for designing forest road networks for best path modeling using GIS. Priority areas extracted from the planning area by using such factors as forest types, slopes, geology, stratum (back slope or opposite slope). Forest roads were evaluated against construction costs using GIS, and 3-D bird's-eye views were used to check forest road locations on the slopes. The forest road alignment and information in this study provides an initial foundation on which GIS can be used for similar analyses in forest road planning. The results could reduce the labor for surveying and provide the most cost-effective options. It is not only useful for forest transportation planning, but also for identifying environmental risks associated with road construction. This methodology revealed that the minimum density of forest road construction can help mitigate the loss of ecological services to logging pressure and lead to greater financial benefit in future operations.

Adaptive speed control using acceleration sensor and GPS for the cable yarding system. Suk, S.I (*University of Tokyo, Japan; hl5fca@fr.a.u-tokyo.ac.jp*).

A new control system has been developed that is based on acceleration sensor and GPS by Zigbee radio data network. This scheme has been implementing acceleration feedback control for optimal carrier speed control. In general, during expected loading conditions, though acceleration of carrier increased more than cable load, existing methods cannot control the speed of a carrier less than a constant. Under this system: (1) reduced load on skyline and carrier through the effect of optimum speed, (2) achieve more high speed between existing mechanical or hydraulic control methods, (3) have automatic control for load and unload position memorized by GPS and acceleration sensor, (4) enable carrier acceleration and deceleration speed setup to be done automatically, and (5) remote controller has only 2 buttons (up/down) for ease in operating. Acceleration sensor and remote control data are processed by the 2.4 GHz Zigbee radio network and 32 bit ARM microprocessor. The effectiveness of a task is high since the unattended operation is possible based on GPS data. This control system can expect operational efficiency and cost saving.

Remote sensing in the tactical level of forest planning: users' expectations and a possible framework. Takao, G., Priyadi, H., Nursal Ikbal, W. (*Center for International Forestry Research, Indonesia; gtakao@cgiar.org; hpriyadi@cgiar.org; wnursal@cgiar.org*).

Implementation of remote sensing in the tactical level of forest planning has been often hampered by obstacles such as costs, user's capacity, and/or gaps between the remote sensing experts and users. Nevertheless, ambitious managers at the local level want to utilize the technology by themselves for their autonomous managements. According to our survey of forest/land management practitioners in Indonesia, however, they want to introduce the technology with a minimal effort due to their limited margin of resources for the new technology in addition to the regular management operations. A key for success is in the cooperation between the remote sensing experts and the users, and among the users. Thus, there are needs for forest monitoring systems with remotely sensed data that promote such cooperation by defining and dividing their roles as clearly as possible. We propose a framework of monitoring forest/landcover changes for forest management practitioners, which consists of provision of prior information on the land by the users, image processing and classification by the experts, and an independent evaluation embedded in the management.

RFID locating system for machinery silviculture and timber harvesting. Toshio, N., Suk, S.I. (*University of Tokyo, Japan; nitami@fr.a.u-tokyo.ac.jp; hl5fca@fr.a.u-tokyo.ac.jp*), Satoshi, A. (*E-Vision Engineering Co. Ltd, Japan; s-abe@e-v-e.jp*).

A system, using RFID (Radio Frequency IDentification), was developed to find location of subjects for an operating unit of forest by machine. The design strategy uses a low frequency passive RFID reader to detect the location, and the data in the forest work area will be processed by using a super long-reach vehicle for silvicultural operation. It actually consists in designing a high power-low frequency transmitter, two type of receivers for RSSI (received signal strength indication) and RFID data receiving, and a microprocessor based control circuit. Passive RFID tag contains identification data, such as species of trees, for inventory database. By using this technology, a forest machine operator grasps the information of each discrete tree. Individual tree data is applied to GIS software simulation and results can be easily applied in the field. Operational efficiency will be increased with the combined RFID and GIS-based work flow systems;, moreover, this system is adaptive to timber harvesting machine operation. The system is tested on a super long-reach arm vehicle, adoptable even on steep hillsides.

Development of field tools for digital mapping with a tablet PC. Yoo, B.O., Ryu, J.H., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; boyoofri@forest.go.kr; jhryu99@forest.go.kr; shkimfri@forest.go.kr*).

This study was carried out to develop a tablet-PC-based customizing system for field digital mapping. Field Investigation System (FIS) tools were developed in MS visual studio 2005 as a professional GIS, with all the tools for creating and maintaining a GIS solution, and an interface designed for outdoor use with a tablet PC. The major contents and functions of FIS developed in this study were as follows. FIS has the benefit of accessibility to display exact locations in various spatial data with position information received from the interaction of GPS. FIS can be used to record and manage much field information on which field investigation is done, with the help of the memo tool, field-sheet tool, calculating distance and area with measuring tool, as well as editing forest type. FIS therefore offers all the essential tools of a GIS, yet is integrated in a fast and practical interface designed for users who utilize Digital-Ink to add or modify graphic and text elements in a cartography. It is possible to do field investigation effectively using FIS developed in this study. Accordingly, investigation and time costs can be reduced and field-work productivity will be improved.

Theme G: Frontiers in Forest and Tree Health

G-01 Forest health in a changing environment

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Posters

Factors influencing trees health state in Benin forests. Atindogbé, G., Vodouhe, F., Fonton, N. (*University of Abomey-Calavi, Benin; dawesfr@yahoo.fr; vodouhefifanou@yahoo.fr; hnfonton@bj.refer.org*), Lejeune, P. (*Gembloux Agro-Bio Tech University of Liege, Belgium; lejeune.p@fsagx.ac.be*).

A healthy tree can better resist environmental disturbances even in harsh climate. The objective of this work is to identify the factors that influence the health status of the trees in Benin forests. Data were collected during the first national forest inventory (2007) and relates to 1,928 plots. Data concerning location, measurements, and field characterization were collected. Trees were classified according to their status: good, broken crown, rot, wound, or more than one defect. The proportions of trees according to their health status were calculated and a logistic regression was performed to identify factors that determine tree quality. Results show that the type of soil and natural resource management strategy are key factors. Over 30% of tree defects related to the wounds. Wildlife habitats are the most affected (60% of trees presenting defects due probably to the frequent passages of bush fires). At the national level several trees species present defects. The two most affected species are: *Afzelia africana* and *Crossopteryx febrifuga* (85% and 80% of defects respectively). The results suggest a need to sensitize the population regarding better management of some tree species and encourage the managers of wildlife reserves to decrease the frequency of management fires.

Effect of environmental changes on tree health: a case study of insect infestation (*Squamura disciplaga* Swinhoe) on urban ornamental trees. Chung, A.Y.C., Ong, R.C., Nilus, R., Hastie, A. (*Sabah Forestry Department, Malaysia; arthur.chung@sabah.gov.my*; *robert.ong@sabah.gov.my*; *reuben.nilus@sabah.gov.my*; *Alexander.Hastie@sabah.gov.my*).

Changes in the environment have affected the health of the urban ornamental ashoka trees (*Polyalthia longifolia*) and sandbox trees (*Hura crepitans*). A total of 15 ashoka trees and 18 sandbox trees at the Sandakan Tennis Club in Sabah, Malaysia, were severely attacked by the bark borer *Squamura disciplaga* Swinhoe (Lepidoptera: Metarbelidae). Both are new hostplant records for this moth species. Generally, borers attack only trees that are stressed or injured. In this case, the trees were under stress and weakened due to the construction of a new highway that was adjacent to the trees. There was sea water intrusion during the construction. The affected area became waterlogged and the environmental changes (detrimental road construction conditions) had adversely affected the health of the ornamentals, which subsequently led to the infestation by the bark borers. Promoting vigorous tree growth should be considered the primary approach for borer management. However, the severely infested trees were recommended to be replaced with suitable species that could tolerate water-logged environment, rather than putting effort in treating and improving the tree health.

Effects of temperature on leaf endophytic fungi in Japanese beech (*Fagus crenata*) and evergreen red oak (*Quercus acuta*). Fukuda, K., Hashizume, Y. (*University of Tokyo, Japan; fukuda@k.u-tokyo.ac.jp; hasizume@nenv.k.u-tokyo.ac.jp*), Sahashi, N. (*Forest and Forest Products Research Institute, Japan; sahasi@affrc.go.jp*).

Fungal endophytes are commonly found in tree leaves and supposed to play important roles in the forest biodiversity. Climate change can affect not only on biodiversity of tree species, but also on fungal assemblages. In order to predict the effect of climate change on fungal endophyte assemblages in tree leaves, leaf endophytes of Japanese beech (*Fagus crenata*) and Japanese evergreen red oak (*Quercus acuta*) trees were investigated in distant localities under different climate. In Japanese beech leaves, *Ascochyta fagi* was highly dominant at every site, and the infection density (ID) of this fungus was higher at sites with low maximum air temperatures in summer. In Japanese evergreen red oak, the dominant fungus showed altitudinal difference. In the lower altitudes, *Tubakia rubra* was common dominant fungus in two localities 1,000 km apart, while in the upper altitude, different fungi were dominant at different mountains. The temperature-growth curves of the dominant endophytes showed correspondence to their geographic distributions and their dominance. These results suggest that the fungal endophyte in tree leaves can also be influenced by climate change.

Effects of nitrogen supply on the growth and photosynthetic characteristics of hybrid larch F_1 seedlings. Imori, M., Watanabe, M., Kim, Y.S., Mao, Q. (*Hokkaido University, Japan; masakazu.imori@gmail.com; nab0602@for.agr.hokudai.ac.jp; soilys@for.agr.hokudai.ac.jp; maomerry@for.agr.hokudai.ac.jp*), Kita, K. (*Hokkaido Forestry Research Institute, Japan; kita@hfri.pref.hokkaido.jp*), Koike, T. (*Hokkaido University, Japan; tkoike@for.agr.hokudai.ac.jp*).

Future increases in nitrogen deposition have been predicted to change tree growth and thereby might alter the forest ability as terrestrial carbon sinks. To clarify the effects of nitrogen supply on hybrid larch F_1 (F_1: *Larix gmelinii* var. *japonica* × *L. kaempferi*), which is expected to be a large carbon sink, we grew 3-year-old seedlings of F_1 in brown forest soil with added nitrogen as NH_4NO_3 solution at zero (control) and 50 kg N ha^{-1} $year^{-1}$ (N-treatment) during two growing seasons in the experimental nursery located in northern Japan. The N-treatment increased height and diameter growths, and needle biomass. Although foliar N concentration in N-treatment was higher than that in control in the middle of second growing season, there was no difference between two treatments during the other periods. Photosynthetic activity and photosynthetic nitrogen use efficiency were lower in N-treatment than in control in the late of the second growing season and from the middle to late of the second growing season, respectively. In conclusion, nitrogen deposition at 50 kg N ha^{-1} $year^{-1}$ enhances growth of F_1 seedlings, which was attributed not to increase in photosynthetic activity but to increase in needle biomass.

Ecophysiological response of hybrid larch F_1 to nitrogen and phosphate application. Mao, Q., Watanabe, M., Makoto, K., Imori, M., Kita, K., Koike, T. (*Hokkaido University, Japan; maomerry@for.agr.hokudai.ac.jp; nab0602@for.agr.hokudai.ac.jp; baobab@for.agr.hokudai.ac.jp; masakazu@for.agr.hokudai.ac.jp; kita@hfri.pref.hokkaido.jp; tkoike@for.agr.hokudai.ac.jp*).

Hybrid larch F_1 (*Larix gmelinii* var. *japonica* × *L. kaempferi*) is a promising species for reforestation and plantation in northern Japan. Nitrogen (N) deposition to forest ecosystems has increased rapidly due to industrialization and urbanization. On the other hand, phosphate (P) is considered as one of the limiting factors for tree growth in cool temperate forest as well as N. Therefore, we must clarify the response of hybrid larch F_1 to various N and P availabilities. Three-year-old seedlings of hybrid larch F_1 were grown in eight experimental treatments consisting of four N treatments (0, 20, 50, and 100 kg N ha^{-1} $year^{-1}$) in combination with two P treatments (0 and 50 kg P ha^{-1} $year^{-1}$) on potted brown forest soil for one growing season. The N application increased biomass and net photosynthetic rate (*A*) of the seedlings, while P supply did not affect them. Photosynthetic nitrogen use efficiency (PNUE) is positively correlated with *A* as well as N concentration in the needle. We found positive correlation between *A* and concentrations of P, K, and Mg. These results indicate that not only N but also the other nutrients would limit *A* and consequently the growth of hybrid latch F_1.

Study on responses of horntail wasps to volatiles from its host plants. Matsumoto, T., Sato, S., Tokoro, M. (*Forestry and Forest Products Research Institute, Japan; mtakeshi@ffpri.affrc.go.jp; shigeho@ffpri.affrc.go.jp; tokoro@ffpri.affrc.go.jp*).

Horntail wasps with the symbiotic fungus *Amylostereum laevigatum* cause star-shaped discoloration of the wood of *Cryptomeria japonica* (sugi) and *Chamaecyparis obtusa* (hinoki) through transmission of the symbiotic fungus at the time of oviposition. Since such wood discoloration cannot be detected before the wood has been cut, it is a serious economic problem for foresters, and so it is important to understand the mechanisms of oviposition preference. Horntail wasps are classified as secondary wood-feeding insects that can attack and utilize only weakened, stressed, and freshly cut trees as hosts. In general, secondary wood-feeding insects utilize the characteristics and specific secondary volatile constituents emitted from weakened and/or stressed trees, and when trees are felled. Therefore, it is important to investigate the volatile constituents from host plants and the behavior of the insects. We conducted an olfactory bioassay using an olfactometer to clarify the responses of three horntail wasps (*Urocerus japonicus*, *U. antennatus,* and *Xeris spectrum*) to volatiles. In the present study, we discuss the relationship between the behavior of horntail wasps and the volatiles from host plants.

Adaptation of *Heterobasidion parviporum* from different climate regimes in Euroasia. Müller, M. (*Finnish Forest Research Institute/METLA, Finland; michael.mueller@metla.fi*), La Porta N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*), Ekojärvi, J., Korhonen, K. (*Finnish Forest Research Institute/METLA, Finland; jaana.ekojarvi@metla.fi; k.korhonen@metla.fi*).

The work was related to the most economically destructive fungal disease of the conifer forests in the boreal hemisphere, *Heterobasidion annosum* s.l. Sixty-three *H. parviporum* isolates originating from geographically distant and climatically varying environments (Finland, Denmark, Italy, and Central Siberia) were cultivated at eight temperatures between 6 °C and 33 °C on Norway spruce sawdust as the only substrate. Decomposition activity was determined as the production of CO_2. The aim was to investigate the relationship between climatic data of the *H. parviporum* sources and strain growths at different temperatures. Optimal temperature for decomposition ranged between 20° and 30 °C. The activity of all isolates decreased drastically at temperatures from 30° to 33 °C. The highest between-isolate variations in DR were at the extremes of the applied temperature scale, at 33° and 6 °C. The Italian and Siberian isolates were collected from several locations in which the climate varied considerably, and the highest monthly average temperature of each district partly explained the DR of the isolates at 6 °C ($p = 0.017$). The highest monthly average temperature of the location correlated negatively with the DR of *H. parviporum* at 6 °C. Hence, local climate affects significantly the DR of *H. parviporum*.

Factors influencing loblolly pine (*Pinus taeda* L.) stand health on Fort Benning, Georgia, USA. Ryu, S.R. (*University of Alberta, Canada; soung.ryu@ualberta.ca*), Wang, G. (*Clemson University, USA; gwang@clemson.edu*), Walker, J. (*U.S. Forest Service, USA; joanwalker@fs.fed.us*).

Loblolly pine (LBP) is the most widely planted pine in the southeastern U.S. and provides habitat for many species, including the endangered red-cockaded woodpecker (RCW). Approximately 2/3 of RCW groups depend on LBP stands at Fort Benning. LBP is suspected to be in high mortality condition, which may risk the RCW sustainability. The main objectives are to evaluate the current status of LBP health and to identify possible causal factors of mortality. We installed 89 plots (30 m × 30 m) in mature (>38 years) stands and measured aspect, slope, soil hardness, diameter at breast height, light exposure, and crown vigor class (CVC; 1 = good, 2 = fair, and 3 = poor). Stand age, site index, soil texture, and management history were retrieved from inventory data. Most stands were generally healthy, while few were relatively poor; 3 stands >20% LBP in CVC3 and 8 stands with >20% dead LBP. Site index and soil hardness were positively and significantly ($p < 0.05$) correlated with % LBP in CVC1 ($r = 0.22$ and $r = 0.29$, respectively) and negatively correlated with % LBP in CVC3 ($p = –0.19$, $p = 0.07$ and $r = –0.21$, $p = 0.05$, respectively). Site index and soil hardness tended to increase in finer soils. Suspected high LBP mortality might be an anecdotal consequence of recent severe drought.

Expected impacts of climate change on *Ips typographus* in the Czech Republic. Turčáni, M., Hlásny, T., Zajíčková, L. (*Czech University of Life Sciences, Czech Republic; turcani@fld.czu.cz; hlasny@fld.czu.cz; zajickova@fld.czu.cz*).

We present the results of an analysis of climate change impacts on the distribution and voltinism of *Ips typographus* in spruce forests of the Czech Republic as underlying information for their sustainable management. The projections are based on the recent generation of high resolution climate change scenarios developed within the frame of 6th FP project CECILIA (Central and Eastern Europe Climate Change Impacts and Vulnerability Assessment, 2006–2009). We focus on two future time periods: 2021–2050 and 2071–2100. Period 1961–1990 is used as the reference. Such scenarios allowed for the prognosis of expected increase in number of fully developed generations of *Ips typographus* as well as of the acceleration of development of particular developmental stages. On these bases, we identified the regions where bark beetle-related forest disturbance regime can be

altered, and impacts on forest health and integrity may occur. Such tendencies have already been observed in recent years in many regions in Europe. Subsequently, optimal control measures and forest conversion strategies were proposed for all of these regions in order to minimize the expected losses.

The geography distribution and outbreak prediction of *Tomicus* species in southwest China under climate scenarios. Wang, H.B., Zhang, Z., Li, X., Li, G. (*Chinese Academy of Forestry, China; wanghb@caf.ac.cn; zhangzhen@caf.ac.cn*; *lixia2003@126.com*; *lmz9827@yahoo.com.cn*), Wang, Z. (*Forest Pest Control and Quarantine Bureau of Yunnan Province, China; ynsffz@vip.km169.net*), Tong, Q. (*Puer Research Institute of Forestry of Yunnan Province, China; pelkstq@163.com*).

The aim of the research was to reveal the current distribution and predict the future changes and outbreak probability of the three pine shoot beetle species, *Tomicus yunnanensis, T. minor*, and *T. brevipilosus*, which occurred heavily on native Chinese pine, *Pinus yunnanensis* in Yunnan province, southwest China, and were never clearly known as to the distribution by the damages and morphology before. The actual data sources for the pests were collected from history pest monitoring records of Yunnan Forest Pest Control and Quarantine Bureau from 1985 to 2007, and also from some new supplement field sampling in 2008 and 2009. The analysis software was Diva-GIS with the Bioclim and Domain model. Local history climate data and scenarios were from derivation by Diva-GIS from Worldclim with 2.5 minutes resolution. The most influential factors on occurrence of the beetles were temperature related factors. The distribution of the *T. yunnanensis* and the *T. minor* were more overlapped than *T. brevipilosus*, which was shown more abundant in southeastern area that the other two in southwest region of China. Under future climate change the *Tomicus* species distribution might be north and west forward.

Effects of elevated CO_2 concentration on the growth and photosynthesis of hybrid larch F_1 seedlings. Watanabe, M., Mao, Q., Novriyanti, E. (*Hokkaido University, Japan; nab0602@for.agr.hokudai.ac.jp; maomerry@for.agr.hokudai.ac.jp; keenove@for.agr.hokudai.ac.jp*), Kita, K. (*Hokkaido Forestry Research Institute, Japan; kita@hfri.pref.hokkaido.jp*), Ueda, T. (*DALTON, Japan; t-ueda@dalton.co.jp*), Takagi, K., Sasa, K., Koike, T. (*Hokkaido University, Japan; kentt@fsc.hokudai.ac.jp; sasa@fsc.hokudai.ac.jp; tkoike@for.agr.hokudai.ac.jp*).

Hybrid larch F_1 (*Larix gmelinii* var. *japonica* × *L. kaempferi*) is one of the most important species not only for timber production but also for absorption of atmospheric CO_2. To assess the ability of hybrid larch F_1 in the future environment, we investigated growth and photosynthetic response of hybrid larch F_1 seedlings to elevated CO_2 concentration. Three-year-old seedlings of hybrid larch F_1 were grown on fertile brown forest soil or infertile volcanic ash soil and exposed to 500 μmol CO_2 mol^{-1} in a free air CO_2 enrichment system located in northern Japan for 2 years. Regardless of soil types, the exposure to elevated CO_2 did not affect photosynthetic capacity in first and second growing season: higher net photosynthetic rate were maintained under elevated CO_2. The growth of the seedlings grown under elevated CO_2 was higher than that under ambient CO_2. We found decrease of dry matter allocation to root. These results suggest that elevated CO_2 may stimulate the growth of hybrid larch F_1; however, the reduction in dry matter distribution to root induced by elevated CO_2 may increase the risk of the other stresses such as drought and strong wind.

Decline of *Pinus sylvestris* var. *mongolica* in semiarid sandy land ecosystem of North China. Zhu, J.J. (*Chinese Academy of Sciences, China; jiaojunzhu@iae.ac.cn*), Kang, H.Z. (*Shanghai Jiaotong University, China; kanghz@sjtu.edu.cn*), Yan Q. L. (*Chinese Academy of Sciences, China; yqliae@yahoo.com.cn*), Wu, X.Y. (*University of Engineering & Technology, Liaoning Province, China; wyh@scichina.org*).

Pinus sylvestris var. *mongolica* (MP) was introduced into semi-arid sandy land of North China half a century ago. However, the introduced MP forests exhibited decline after about 35 years of introduction. The decline is characterized by three traits: shorter lifetime than the natural forests, tree dieback and death, and no natural regeneration. On the basis of long-term observations and a series of intensive experiments conducted in both introduced and natural MP forests on sandy land, we found that the introduced MP forests grew faster than natural forests because of the higher heat and more rainfall at the introduction sites in the early stage. However, the conditions at the introduction sites did not fit further growth and development of the MP trees after about 30 years since the introduction, and have exhibited tree growth slow down; vigor decreased; top, twigs, and needles withered; and diseases and insects occurred. The natural regeneration failure was caused by lack of ectomycorrhizal fungi, which were vital to MP seedling survival but destroyed by extreme temperature. Management techniques such as "patch MP forest" or "MP Savanna" and intensive thinning were suggested for alleviating the decline.

Seasonal variation of physiological parameters of *Cupressus sempervirens* L. clones on the most northern edge of its Italian distribution, and correlation with environmental factors. Zorer, R., Eccel, E., Bertamini, M., La Porta, N. (*FEM-IASMA, Italy; roberto.zorer@iasma.it; emanuele.eccel@iasma.it; massimo.bertamini@iasma.it; nicola.laporta@iasma.it*).

When some ornamental Mediterranean trees begin moving northward under the impact of climate change, we should assess whether the level of adaptability to the new environment can overcome some critical climatic event. In the case of cypress, *Cupressus sempervirens* L., over a period of 2-1/2 years the quantum use efficiency of photosystem II (FV/FM) of *C. sempervirens* was monitored in a nursery of Trento (northeastern Italy) to study the effects of air temperature (AT) on the photosynthetic efficiency of 99 different clones and to derive information on the natural distribution of cypress. A significant positive correlation ($r = 0.64$, $p < 0.001$) was found between mean AT and FV/FM over the 29-month period and especially in spring and autumn. Minimum values of FV/FM have been observed in winter. Moreover, for the assessment of critical environmental factors for cypress we correlated mean values of quantum use efficiency with daily AT data and temperature-based indices to identify the driving factors of the physiological changes. Maximum value of correlation ($r = –0.85$, $p < 0.001$) was found with 10-days cold degree-day running sums before sampling and with a threshold of 2.0 °C for daily minimum air temperature.

Response patterns of woody plants to sap-feeding herbivores. Zvereva, E., Lanta, V., Kozlov, M. (*University of Turku, Finland; elezve@utu.fi; vojlan@utu.fi; mikoz@utu.fi*).

While outbreaks of defoliators attracted the attention of ecologists decades ago, sap-feeding insects have been overlooked in many ecosystem-level studies. We assessed the general patterns and sources of variation in the effects of sap-feeding herbivores on the fitness of woody plants through a meta-analysis of 272 effect sizes calculated from 52 papers. Sap-feeders significantly reduced growth (–31.1%), reproduction (–15.1%), and photosynthesis (–29.5%). Seedlings suffered more than older trees; the effects were similar in deciduous and evergreen species. Different plant parts, in particular below- and above-ground organs, responded similarly to damage. The strongest effects were caused by mesophyll and phloem feeders; generalists reduced plant fitness to a greater extent than specialists did. Experiments conducted in greenhouses yielded stronger negative effects than field experiments; shorter (less than 12 months) experiments showed bigger growth reduction than longer experiments; infestation of experimental plants caused stronger effects than natural levels of herbivory. Studies conducted at higher temperatures yielded stronger detrimental effects of sap-feeders on their hosts. We conclude that sap-feeders impose a more severe overall negative impact on plant fitness than do defoliators, mostly due to the lower abilities of plants to compensate for sap-feeders' damage in terms of both growth and photosynthesis.

G-02 New insights into roles of ophiostomatoid fungi in bark beetle-fungus symbioses

Organizers: Diana Six, *University of Montana, USA, Diana.six@cfc.umt.edu*; Mike Wingfield, University of Pretoria-FABI, South Africa, mike.wingfield@fabi.up.ac.za.

Host-tree phytochemistry has non-additive effects on mycangial fungi isolated from *Dendroctonus brevicomis.* Davis, T.S., Hofstetter, R.W. (*Northern Arizona University, USA; tsd3@nau.edu; rich.hofstetter@nau.edu*), Foster, J.T. (*MGGEN, USA; jeff.foster@nau.edu*).

Some tree-killing bark beetles engage in obligate mycophagy during larval development. For beetles that colonize pine hosts, mutualistic fungi are exposed to a terpenoid-saturated environment. While the effects of individual monoterpenes on fungal radial growth have been previously tested, the combined effects of multiple monoterpenes representing actual pine phenotypes is poorly understood. Here, we report on the influence of six individual monoterpenes, four monoterpenoid-based phenotypes, and three concentration levels on the radial growth of 17 strains of mycangial fungi isolated from the western pine beetle, *Dendroctonus brevicomis*. Increasing monoterpene concentration levels negatively affected fungal growth rates. Fungal growth rates were highest in media amended with alpha-pinene and myrcene; intermediate in delta-3-carene, beta-pinene, and limonene; and fungi failed to establish in media amended with terpinolene. Interestingly, fungi did not respond to phenotypic combinations in a way that was predictable from fungal performance in media amended with individual monoterpenes: fungal (radial) growth rates were highest in a mixed phenotype containing equivalent levels of all major monoterpenes, intermediate in alpha-pinene dominant and delta-3-carene dominant phenotypes, and lowest in a rare beta-pinene dominant phenotype. The results of these experiments are discussed in the context of forest ecology.

Who are killing the trees—the beetles or the fungi? Krokene, P. (*Norwegian Forest and Landscape Institute, Norway; paal.krokene@skogoglandskap.no*).

The interaction between conifers, ophiostomatoid fungi, and bark beetles is a key factor in conifer ecosystems worldwide, since combined beetle-fungus attacks may cause massive tree mortality, huge economical losses, and landscape-level ecological changes. For more than a century researchers have been arguing about who is responsible for tree mortality in bark-beetle-attacked trees: the beetles themselves or their associated fungi. As in many such polarized debates, the best answer probably lies somewhere in between the extremes. The beetles are obviously central in tree killing, as they are actively selecting suitable host trees, short-circuiting tree defenses by boring straight into the relatively defenseless cambial area, and causing mechanical damage to the phloem. However, ophiostomatoid fungi are equally obvious contributors to tree death since nearly all tree-killing bark beetles are associated with such fungi; these fungi are able to colonize and kill healthy phloem and sapwood far beyond the beetle tunnels; and many fungi can kill healthy trees in experimental mass-inoculations. Thus, the trees are facing a beetle-fungus complex that probably acts synergistically to overwhelm tree defenses. The beetles' mass-attack strategy is central to the success of the beetle-fungus complex, since multiple attacks deplete tree defenses and speed up tree-killing.

Role of ophiostomatoïd fungi in beetle establishment on conifers, novel hypotheses. Lieutier, F. (*Université d'Orléans, France; francois.lieutier@univ-orleans.fr*).

A relationship between Ophiostomatoïd pathogenicity and conifer bark beetle aggressiveness does not exist, making fungal pathogenicity a poor parameter to appreciate the fungus role in beetle establishment on trees. We demonstrate that fungus ability to stimulate tree defenses is closely related to beetle aggressiveness. The gain for bark beetle populations to be associated with fungi would thus not be tree killing, but stimulation of tree defenses, resulting in lowering the critical threshold above which tree resistance is exhausted and beetle attacks succeed, making fungus ability to stimulate tree defenses a valuable parameter to appreciate the fungus role. Beetle establishment on trees would proceed in two successive steps: (1) stimulation of tree defenses in the phloem and superficial sapwood by fungal species adapted to this task, until tree resistance is exhausted; (2) fungal growth into sapwood and beetle invasion of phloem, leading to tree death. Sapwood invading fungal species are not the most efficient in stimulating tree defenses. We suggest that sapwood invading fungi are "cheaters," taking advantage of tree defense exhaustion. The fungal complex can be completed by species controlling phloem extension of the other two fungal categories. Bringing nutrients to beetle progeny can be a fourth fungal role.

Problems with the classic paradigm: what we have learned applying symbiotic theory to the study of bark beetle-fungus symbioses. Six, D.L. (*University of Montana, USA; diana.six@cfc.umt.edu*), Wingfield, M.J. (*University of Pretoria, Republic of South Africa; mike.wingfield@fabi.up.ac.za*).

It has been more than 100 years since it was first noted that trees killed by bark beetles became stained by fungi. This underpinned the hypothesis that these fungi may play an important role in the death of beetle-attacked trees. Since that time, the notion that tree-killing bark beetles require fungal pathogens to overcome tree defenses and to incur tree mortality (the classic paradigm, CP), has formed the basis for most research on these interactions. Importantly, despite numerous studies on the subject, no conclusive evidence exists supporting the CP. Indeed, if one applies symbiotic theory to the study of these associations, considerable evidence accrues against its validity. We argue that the distribution of virulent associates and the timing of tree death relative to colonization by fungi show the CP to be invalid. We further suggest that phytopathogenicity exhibited by symbiotic fungi plays little or no role in providing benefit to beetles, but rather that it is of greater value to the fungi.

Novel associations between wood-inhabiting insects and pathogens threaten forests. Wingfield, M. J., De Beer, W., Roux, J. (*University of Pretoria, Republic of South Africa; Mike.Wingfield@fabi.up.ac.za; wilhelm.debeer@fabi.up.ac.za; jolanda..roux@fabi.up.ac.za*), Six, D.L. (*University of Montana, USA; Diana.Six@umontana.edu*).

Wood-inhabiting insects such as bark and wood-boring beetles are among the insect pests of forest trees that have been most extensively moved into new environments through global trade. Many of these insects live in association with pathogens, and the movement of the beetles to new environments can equally involve the movement of their associates. Where these associates are tree pathogens, such as in the case of the Dutch elm disease fungi and the pine wood nematode, they might encounter new and possibly even more effective insect vectors. New associations that are much less well-understood are those where introduced insects carry organisms that are not considered important in their areas of origin. These novel associations could, however, result in symbiotic organisms not typically considered pathogens, reaching new hosts and consequently resulting in serious tree diseases. Likewise, the introduction of pathogens such as *Ceratocystis* spp., many of which have loose relationships with insects, can result in novel beetle/ pathogen associations and significant new disease problems. Such diseases are difficult to predict, increasing in number and they apparently represent new and important threats to global forests.

G-03 Effect of multiple ecosystem stressors on tree and forest ecosystem health

Organizer: Nancy Grulke, U.S. Forest Service, USA, ngrulke@fs.fed.us.

Effects of soil type, fertilization, and drought on carbon allocation to root growth, secondary metabolism, and ectomycorrhizae of *Betula papyrifera* Marsh. Bonello, P., Kleczewski, N.M., Herms, D.A. (*Ohio State University, USA; bonello.2@osu.edu; nklecz1980@gmail.com; herms.2@osu.edu*).

We investigated how different soils and nutrient availability drive below-ground carbon allocation patterns, ectomycorrhizal (EM) associations, and drought tolerance of paper birch (*Betula papyrifera*) seedlings. Seedlings were grown in the greenhouse in either subsoil or topsoil in factorial combination with two fertilization and drought regimes. We quantified root and total seedling dry biomass, starch, soluble sugars, soluble phenolics, lignin, and EM abundance. In unfertilized topsoil, total plant biomass and root biomass were approximately 9 times higher than in unfertilized subsoil, but the root weight ratios (RWR) did not differ between soils. Root soluble phenolics and lignin were higher in unfertilized subsoil than in unfertilized topsoil, whereas EM abundance was significantly higher in unfertilized topsoil that in unfertilized subsoil. In topsoil, fertilization decreased root biomass and EM abundance and increased root phenolics and lignin. In contrast, fertilization of subsoil increased root biomass but decreased root phenolics and lignin, while EM abundance was unaffected. In both soil types fertilization reduced RWR. Across soil types, EM abundance was negatively correlated with root soluble sugars, root phenolics, and lignin, but this was driven mainly by the responses in the topsoil treatment. Drought reduced total plant biomass, root biomass, and RWR.

Climate change and air pollution: expected multiple stressors in tomorrow's forests. Bytnerowicz, A., Preisler, H., Schilling, S., Grulke, N. (*U.S. Forest Service, USA; abytnerowicz@fs.fed.us; hpreisler@fs.fed.us; sschilling@fs.fed.us; ngrulke@fs.fed.us*).

Air pollution is an integral part of climate change. Numerous pollutants participate in complex processes that influence ambient temperature and precipitation. Among air pollutants, tropospheric ozone is an important greenhouse gas and a strong phytotoxic agent. Ammonia, nitrogen oxides, nitric acid vapor, and sulfur oxides contribute to the atmosphere cooling through formation of fine aerosols that reflect solar radiation. However, these nitrogenous (N) gases also have a warming effect since they increase N deposition, which in turn leads to a release of nitrous oxide, a powerful greenhouse gas. Elevated concentrations of all these pollutants have various phytotoxic effects, while increased N deposition may affect ecological integrity of forests and other ecosystems. Levels of air pollutants change in time and space, and their effects on vegetation will depend on climatic conditions and many other abiotic and biotic factors. Historical changes and patterns of spatial and temporal distribution of ozone, N pollutants, and N deposition in a context of changing climate, especially ambient temperatures and precipitation, will be presented. Discussion of potential interactive relationships between those factors and their effects on forest will be provided with a special emphasis on the Sierra Nevada and San Bernardino Mountains in California.

Contrasting ozone sensitivity of related evergreen and deciduous shrubs. Calatayud, V., Cerveró, J., Marco, F. (*Fundación CEAM, Spain; vicent@ceam.es*), Sanchez-Peña, G. (Ministerio de Medio Ambiente y Medio Rural y Marino, Spain), Sanz, M.J. (*Fundación CEAM, Spain*).

Visible injury and physiological and antioxidant responses against enhanced ozone leaves have been studied in two pairs of evergreen-deciduous species (*Pistacia terebinthus* vs. *P. lentiscus*; *Viburnum lantana* vs. *V. tinus*) in open top chambers (OTCs). The observed responses were not genus-dependent but related to the leaf habit strategy. Ozone induced widespread visible injury in the two deciduous species (*P. terebinthus* and *V. lantana*), while symptoms were absent in the two evergreen plants (*P. lentiscus* and *V. lantana*). Ozone-fumigated plants of the two deciduous species experienced a significant decline in light saturated CO_2 assimilation (A_{sat}), and stomatal conductance to water vapour (g_s), while these parameters were not significantly affected in their evergreen relatives. Leaf yellowing, associated with significant reductions in chlorophyll content (SPAD) and maximum

quantum efficiency of photosystem II (F_v:F_m), was also observed in *P. terebinthus*. Under the well-irrigated experimental conditions, differences in g_s were not related to the observed responses. Total antioxidant capacity measured by FRAP assay and in reduced ascorbate between species of the same genus (evergreen vs. deciduous) were not significantly different. These results support the hypothesis that Mediterranean evergreen shrubs have a higher capacity to tolerate ozone stress than deciduous shrubs.

Can micronutrient stress exacerbate the health of acacia and eucalypt plantations? Dell, B. (*Murdoch University, Australia; B.Dell@murdoch.edu.au*).

Industrial tree plantations in many parts of East and Southeast Asia and Australia occur on sites where productivity has increased by overcoming soil infertility constraints. However, in spite of continued improvements in fertiliser prescriptions and the management of organic matter, micronutrient deficiencies are still problematic in the region. With the growing threats of pests and diseases to the plantation sector, it is timely to consider whether constraints in soil micronutrient supply are likely to predispose plantations to increased damage from biotic stressors. This paper focuses on boron (B), as soils with low B content are widespread in SE Asia. It also addresses acacia and eucalypt plantations, as these dominate the plantation sector. The theme will be explored using observations of tree health in a range of environments (e.g., southern China, northern Vietnam, Australia) where the impact of biotic stressors is increasing over time and incursions of new pests and diseases are being reported. The impact of climate change (increased rainfall, increased drought) on the severity of B disorders in the future will also be considered.

Influence of traffic on pH value and organic matter content of roadside soil in the Changbai Mt. Nature Reserve. Jin, Y.H., Li, S. (*Chinese Academy of Sciences*, *China; jinyh@iae.ac.cn; helloandwelcome@163.com*), Sun, C. (*Shenyang Agriculture University, China; sunchao19841229@163.com*), Piao, Z. (*Research Institute of Changbaishan, China; piao_1777@sina.com*), Han, X. (*Chinese Academy of Sciences*, *China; xghan@ibcas.ac.cn*).

The objective of this study was to assess the influence of roads with different intensity of road utilization and road pavement on the distribution of soil pH and soil organic matter(SOM) on roadsides in Changbai Mt. Nature Reserve. Soil samples were collected within 50 m of roads that went through four different types of forest—Korean pine-broadleaved forest (KPF), coniferous forest (CF), dark coniferous forest (DCF), and *Betula ermanii* forest (BF)—on the north slope area of the nature reserve; the differences in these indexes caused by the distances to the road edge were also comparatively studied. Results showed that the soil pH and the SOM on both sides of the roads through the KPF, the CF, DCF, and BF varied greatly. Overall, SOM and soil pH within 10 m from the road perimeter were affected by more human activities and changed more significantly than those with farther distances from the road edge. Soils sampled from regions adjacent to roads with greater traffic flow but subjected to less human activities changed insignificantly, whereas SOM and soil pH at the road's edge with concrete pavement changed significantly in the Changbai Mt. Nature Reserve.

Effect of environmental pollutions on mangrove forests in Nayband National Marine Park. Kouhgardi, E., Shakerdargah, E., Akbarzadeh, M. (*Islamic Azad University, Iran; kouhgardi@yahoo.com; Elaheshakerdargah@gmail.com; Mehrdad.ak@gmail.com*).

The mangrove ecosystem is a complex of various inter-related elements in the land sea interface zone that is linked with other natural systems of the coastal region such as corals, sea grass, coastal fisheries, and beach vegetation. It is a very productive ecosystem sustaining various forms of life. Its waters are nursery grounds for fish, crustaceans, and mollusks, and also provide habitat for a wide range of aquatic life; while the land supports a rich and diverse flora and fauna. Pollutions may affect all these characteristics. Prolongation of critical conditions in the Persian Gulf has endangered its aquatic ecosystem. Water purification equipment, refineries, wastewater emitted by onshore installations (especially petrochemical plants), urban sewage, population density, and extensive oil operations of Arab states are factors contaminating Persian Gulf waters. Population density has been the major cause of pollution and environmental degradation. Pollution may cause the mortality of mangrove forests by affecting roots, leaves, and soil of the area. This study showed high correlation between industrial pollution and mangrove health and increase of population, coupled with economic growth, inevitably caused by the use of mangrove lands for various purposes such as construction of roads, ports and harbors, industries, and urbanization.

Roles of invasive plant species in affecting climate change mitigation in Indonesia. Lembasi, M. (*International Forestry Students' Association, Indonesia; lembasi.metia@gmail.com*).

Indonesia is endowed with rich biological diversity in tropical forests. Because tropical forests contain 40% of the world's carbon stores, their conservation is critical to global carbon balance, and they should also be maintained as a sustainable productive system for future generations. Tropical forests in developing countries are considered as the main sink for anthropogenic C accumulation in the atmosphere and, as such, important for climate change mitigation. Like most of developing countries, one of the roles of Indonesia's government is to improve tropical forest management to optimize for greenhouse gas mitigation. To date, several management schemes have been implemented to this end, such as (savannah) controlled burning and savanna rehabilitation through weed eradication. However, some obstacles have emerged when forest management is practiced, because of excessive disturbance, with subsequent invasion of Acacia. One of them is invasive plants species that threaten the efforts because they drive the change in biodiversity and ecosystems. Invasive Acacia species have an impact on ecosystem balance: they decrease the environmental carrying capacity and disrupt patterns of behavior and distribution of forest animals. These conditions can endanger ecosystem balance. To solve this problem, specific forest conservation and rehabilitation activities need to be conducted.

Interacting effects of defoliation and soil chemistry on sugar maple health following a forest tent caterpillar outbreak in the northeastern USA. Pitel, N.E. (*The State University of New York, USA; nepitel@syr.edu*), Wood, D.M. (*Burns and McDonnell, USA; dmwood@burnsmcd.com*), Wilmot, S.H. (*Vermont Department of Forests, Parks and Recreation, USA; sandy.wilmot@state.vt.us*), Allen, D., Yanai, R.D. (*The State University of New York, USA; dcallen@syr.edu; rdyanai@syr.edu*).

Defoliation is a significant stressor of forest stands and may incite decline diseases of sugar maple (*Acer saccharum*: Marsh). The recent outbreak (2002–2007) of forest tent caterpillar (*Malacosoma disstria* Hübner) in the northeastern United States offered the opportunity to assess the interacting effects of defoliation and site conditions on sugar maple health. We measured 51 stands in

New York and Vermont in summer 2007. Dieback (P = 0.07) and mortality (P = 0.04) were both worse in stands defoliated by forest tent caterpillar. Low growing-season soil moisture during the outbreak, indicated by Palmer's Z-index; cool mean temperature during the outbreak; and concave microrelief were also important predictors of forest damage. In 2008, we found the highest mortality in sites with the greatest crown dieback in 2007. In 2009, soil samples were collected from 34 of the previously studied sites. Mortality was highest on sites with low soil calcium, consistent with previous research on sugar maple decline in the Allegheny Plateau. We present the results of our multiple regression equations for stand dieback and mortality in tables that can be used by forest managers to evaluate the vulnerability of their sugar maple stands to decline after defoliation.

Changing environmental conditions and gall rust disease development on *Falcataria moluccana* in Southeast Asia. Rahayu, S. (*Gadjah Mada University, Indonesia; tatarahayu@yahoo.com*), Su See, L. (*Forest Research Institute of Malaysia, Malaysia*).

Gall rust disease of *Falcataria moluccana* (batai, sengon) caused by *Uromycladium tepperianum* is definitely serious and devastating, damaging and killing seedlings in nurseries and trees in the plantation, with resulting significant losses of trees. The aims of this research were to evaluate gall rust disease incidence and to ascertain the environmental factors influencing gall rust disease development in Southeast Asia. Gall rust disease was monitored for 3 years in a forest plantation in Malaysia and Indonesia. Ten permanent plots with at least 100 trees in each plot were set up for monitoring at each location. The results showed that forest opening, topography, and fog were found to be major factors; while pruning, thinning, and clear-cutting were intermediate factors; and age of trees and altitude were minor factors. More open forest sites, flat topography, absence of fog, pruning, thinning, clear cutting activities, maturity, and lower altitude were significant local site conditions that reduced gall rust disease incidence and severity. Relative humidity and wind speed were two meteorological factors significantly related to gall rust disease incidence. High relative humidity and slower wind speed at the site were favourable for gall rust disease development.

Drought and forest insects: interacting stressors on forest ecosystem health. Seybold, S.J., Grulke, N.E. (*U.S. Forest Service, USA; sjseybold@gmail.com; ngrulke@fs.fed.us*), Graves, A.D. (*University of California/Davis, USA; adgraves@ucdavis.edu*), Coleman, T.W. (*U.S. Forest Service, USA; twcoleman@fs.fed.us*).

The history of the interaction of drought and forest insect population biology will be briefly reviewed in the context of ecosystem health. Results will be presented from research on two phloem-feeding insects in California whose impact on forest trees may be exacerbated by drought stress on the host. In a coniferous example, the Jeffrey pine beetle, *Dendroctonus jeffreyi*, colonizes the main stem of Jeffrey pine, *Pinus jeffreyi*, in xeric mountain ranges throughout California. In a hardwood example, the invasive goldspotted oak borer, *Agrilus coxalis*, is the primary pest of the main stem and larger branches of various oaks, *Quercus* spp., in southern California. In both systems, physiologically defined drought stress of the hosts suggests that local precipitation deficit or drought indices alone may not predict the predisposition of trees to insect attack. We hypothesize a unifying mechanism by which drought-stressed trees are successfully colonized by phloem-feeding insects. The mechanism relates tree biochemistry at various levels of drought stress to resin/sap production and exudation pressure, and, ultimately, to the colonization success of phloem-feeding insects. As climate change is expected to increase the frequency, severity, and duration of droughts in California, understanding this mechanism will help land managers plan for the future.

Pest insects and their natural enemies: does more diverse forest mean more natural enemies? Välimäki, S. (*University of Helsinki, Finland, sanna.valimaki@helsinki.fi*), Sääksjärvi, I.E., Jussila, R. (*University of Turku, Finland, ileesa@utu.fi; reijo.jussila@utu.fi*), Li, J. (*Beijing Forestry University, China, yanzilisan_123@126.com*), Heliövaara, K. (*University of Helsinki, Finland, kari.heliovaara@helsinki.fi*).

Millions of hectares of forests in northern China have been attacked by the Siberian moth, *Dendrolimus superans* Butler (Lepidoptera: Lasiocampidae), which is one of the most destructive native defoliators of *Larix* spp. in China. Siberian moth outbreaks are usually followed by the outbreaks of wood-boring insects (e.g., bark beetles, longhorn beetles) due to a great number of weakened trees. Parasitoid wasps of the Ichneumonidae subfamilies Rhyssinae, Pimplinae, and Xoridinae parasitize wood-boring insects. In our study the aim is to find whether the relationship between the wood-borers and their parasitoids varies between differently treated forests. We compare man-made forests that have and have not been treated with broad-spectrum pesticides targeted against Siberian moth. Semi-natural forests that have avoided the outbreaks are used as control. The data were collected in summer 2007 and 2008 using 36 window traps. We presume that the overall Ichneumonid species richness is highest in the semi-natural forest. These results can be utilized in the local forestry as information of the effects of such biotic stressors. In the long run, parasitoids could be used in biological pest control. Results concerning the relationship between different habitats, the number of wood-borers, and Ichneumonid species richness will be presented.

Posters

Genetic and eco-physiological responses of black spruce (*Picea mariana*) to global climate change conditions. Kim, J.H. (*University of New Brunswick, Canada; q1a5v@unb.ca*), Major, J.E., Malcolm, J. (*Natural Resources Canada, Canada; jmajor@nrcan-rncan.gc.ca; jmalcolm@nrcan.gc.ca*), Rajora, O.P. (*University of New Brunswick, Canada: Om.Rajora@unb.ca*).

Global climate change conditions (elevated CO_2 and atmospheric temperatures) are subjecting forests, especially boreal and temperate forests, to significant abiotic stresses, such as drought. This can affect health, productivity, and fitness of forests. Therefore, it is imperative to understand genetic and eco-physiological responses of forest trees to global climate change. We are addressing this aspect in black spruce (*Picea mariana*)—a transcontinental, ecologically and economically important tree species of the North American boreal forest. Our objective was to determine gene expression and physiological responses and their inter-relationships in black spruce to elevated CO_2, drought, and co-stressed conditions. Clones of four different black spruce genotypes were treated with ambient CO_2, elevated CO_2, drought, and their combined co-stressed conditions. Needle and branch tissues were individually collected at regular intervals for transcript (gene expression) analysis. Photosynthetic rate and stomatal conductance were measured simultaneously. Hundreds of transcripts (genes) showed differential expression (no expression, up-regulation, or down-regulation) in response to elevated CO_2, drought, and their combined conditions. Responses to each treatment at the gene

expression and physiological levels were correlated well among different genotypes. We will present these results, which contribute significantly to our understanding of tree's responses to global climate change.

Growth response of saplings of *Quercus dentata* to environment gradient treaments. Lee, S.K., You, Y.H. (*Kongju National University, Republic of Korea; osk1982@kongju.ac.kr; youeco21@kongju.ac.kr*).

Quercus dentata is a major tree in dry habitat such as limestone area in Korea. In order to characterize the ecological traits of *Q. dentata*, we treated saplings of *Q. dentata* under major environment factors such as light (L), soil moisture (M) and nutrient (N) with each of four gradient levels (gradient 1 is the lowest and gradient 4 the highest) for 5 months in a glass house. Then we measured and analyzed the growth difference. In the nutrient gradient, above-ground, below-ground, and plant biomass and leaf weight were the highest at N3 and the lowest at N1, N2, and N4. In the light gradient, above-ground biomass was the highest at L3 and L4 and the lowest at L2. Below biomass was the highest at L3 and L4 and the lowest at L1. Plant biomass and leaf weight were the highest at L3 and L4 and the lowest L1 and L2. In the moisture gradient, all measured items were not significantly affected by gradient. From these results, growth of *Q. dentata* was more affected by nutrient and light environment than by moisture environment.

Northern trees are exposed to increasing oxidative stress. Oksanen, E. (*Joensuun yliopisto, Finland; elina.oksanen@joensuu.fi*).

Northern forests are encountering new threats due to continuously increasing load of oxidative stress, e.g., rising tropospheric ozone levels, and simultaneous climate warming, which is more intense in northern latitudes compared to global means. The proportion of deciduous trees species, e.g., *Betula* and *Populus* spp., is expected to increase in northern forests with climate warming. Unfortunately, we have growing evidence that the vitality and carbon sink strength of birch and aspen trees are weakened under chronic ozone stress. In this paper we present negative correlations of the main growth responses of Finnish birch (*Betula pendula, B. pubescens*) and aspen species *Populus tremula* and *P. tremuloides* × *P. tremula*) with ozone exposure. Data are derived from 23 different laboratory, open-top chamber, and free-air fumigation experiments. Our results indicate that these species are sensitive to increasing ozone concentrations and that the roots are the most vulnerable targets. These growth reductions were accompanied by increased visible foliar injuries, carbon allocation towards defensive compounds, reduced carbohydrate contents of leaves, impaired photosynthesis processes, disturbances in stomatal function, and earlier senescence. We also present results from a co-exposure of birch and aspen genotypes to ozone and increasing temperature using our novel open-field facility.

Comparison of foliar chlorophyll contents and leaf anatomical structures according to air pollution level using urban planted *Salix pseudolasiogyne* H. Lev. and *Ailanthus altissima* (Mill.) Swingle. Park, J.W., Lee, D.K., Park, G.E. (*Seoul National University, Republic of Korea; jwpark1016@gmail.com; leedk@snu.ac.kr; hellogracia@gmail.com*).

The objective of this study was to compare tree foliar chlorophyll contents, leaf stomata size, and density of *Salix pseudolasiogyne* H. Lev. and *Ailanthus altissima* (Mill.) Swingle. grown in different levels of air pollution in Seoul, Korea. Three leaves were collected from 2–5 trees at each study site; and chlorophyll contents, stomata density, and size (longitudinal length) were measured from August to October 2007. The differences in sampled leaves among the study sites were determined by ANOVA and Duncan's multiple range test. Both *S. pseudolasiogyne* and *A. altissima* showed no difference in leaf chlorophyll contents among the sites in August, but leaf chlorophyll content of *S. pseudolasiogyne* was higher in the "more polluted site" than in the "less polluted site" in September. Leaves from the "more polluted site" showed smaller stomata size both in abaxial and adaxial sides of *S. pseudolasiogyne* and on the abaxial side of *A. altissima*. Foliar stomata density of *A. altissima* (both sides) was lower in the "more polluted site." Therefore, it seems that reduction in stomata size and density lessens the flow of air pollutants through the stomata, which results in an increase in chlorophyll contents, endowing these two species' resistance to air pollution.

Effects of seed size on germination rate, growth rate, and survival rate of four oak species. Shin, J.H., You, Y.H. (*Kongju National University, Republic of Korea; forinyou@kongju.ac.kr; youeco21@kongjua.ac.kr*).

In order to know the effect of seed size on germination, survival, and growth, we measured the germination, survival, and growth rates of four oak species with different acorn sizes. The germinations rate was high in small and medium acorn size of *Quercus aliena* and *Q. serrata*, high in medium and large acorn sizes of *Q. variabilis*, and high in small and large ones of Q. *acutissima*. The growth rate of oaks was high in medium and large acorns of *Q. acutissima* and *Q. variabilis*. During winter season, the survival rate was high in medium acorns of *Q. acutissima*, high in medium and large acorn size of *Q. aliena*, and very low in all the acorn sizes of *Q. variabilis* and *Q. serrata*. From these results, we can conclude that germination rate, growth rate, and survival rate of oaks were dependent on acorn size, and *Q. acutissima* and *Q. aliena* were tolerant among four oak species against cold. Thus *Q. acutissima* and *Q. aliena* expect to distribute in higher altitudes and more northwards parts.

Effect of calcium chloride ($CaCl_2$) on photosynthesis and chlorophyll fluorescence of *Platanus occidentalis*. Sung, J.H., Je, S.M., Cho, J.H., Kim, Y.G (*Korea Forest Research Institute, Republic of Korea; JHS033@forest.go.kr; Jesmi@uos.ac.kr; cjh544@forest.go.kr; youngkul@forest.go.kr*).

Deicing salt is used to melt snow and ice on the road for traffic safety during the winter season, which accumulates in roadside vegetation and induces visible injuries. The damage may be accelerated when deicing salt is used inn early spring, during leaf onset. To understand the mechanisms, we irrigated solutions of 0.5%, 1.0%, and 3.0% $CaCl_2$ concentration in a rhizosphere of *P. occidentalis* (3-year-old) twice prior to leaf bud. Treatments delayed of leaf onset and retarded leaf expansion, especially 3.0% $CaCl_2$ concentration. Physiological traits in mature leaves were negatively responded by $CaCl_2$-treated plants. Treatments reduced total chlorophyll contents, photosynthetic rate, stomatal conductance, transpiration, quantum yield, and increased dark respiration and light compensation point compared with control. F_V/F_M (quantum yield of PSII), NPQ (non-photochemical quenching) were not different between control and treatments of $CaCl_2$ at 80 days after treatments. $CaCl_2$ treatment of 1.0% and 3.0% reduced root diameter by 36% and 66% compared with control respectively. Water transport resistance by increasing CaCl2 concentration in the soil caused stomatal closure, leading to an increase of stomatal limitation of photosynthesis with damage of the photosynthetic apparatus. Eventually, it reduced the root diameter growth.

G-04 The growing threat of Australian insect pests to world eucalyptus plantation forestry

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Downwind from the source: 150 years of insect pests of eucalypts in New Zealand. Berndt, L.A., Withers, T. M., Bain, J. (*Scion/New Zealand Forest Research Institute, New Zealand; lisa.berndt@scionresearch.com; toni.withers@scionresearch.com; john.bain@scionresearch.com*).

Australian insects have been arriving in New Zealand for approximately 150 years, increasingly affecting the value of eucalypts as plantation and amenity trees in that country. New Zealand lies 1,800 km downwind to the east of Australia, and trade and travel are frequent between the countries, creating a high biosecurity risk. Eucalypts are not native to New Zealand, and early plantings enjoyed relative freedom from insect pests. However the rate of establishment of new arrivals from Australia increased steadily during the 20th century. At the peak of invasions in the 1990s, one new eucalypt specialist established every 17 months. There are now 31 specialist eucalypt insects in New Zealand, about a third of which have caused serious damage. Biological control against eucalypt insects started in 1905 and has been extremely successful, with four out of five targeted species under full control. A number of self-established species have also provided control. Over time, various eucalypt species have gone out of favour with growers as new pests discover this resource. With a new era in carbon and bioenergy forestry on the horizon, fast growing eucalypts are gaining favour, potentially opening a new resource to Australian pests in New Zealand.

Insect pests of eucalypt plantations in Australia: the next wave? Lawson, S.A., Nahrung, H.F., Wylie, F.R. (*Department of Employment, Economic Development and Innovation, Australia; simon.lawson@deedi.qld.gov.au; helen.nahrung@deedi.qld.gov.au; ross.wylie@deedi.qld.gov.au*).

Over the past century, several endemic Australian eucalypt insects have established around the world as serious pests. Some, such as the cerambycid beetle *Phoracantha semipunctata*, have invaded almost all eucalypt-growing regions of the world (with the notable exception of Asia), while others such as the gum leaf skeletoniser, *Uraba lugens*, have been one-off introductions restricted to a particular country or region. Nearly all these insects were not significant pests in Australian natural forest or plantations prior to their establishment overseas. Moreover, the most serious recent overseas introductions have been insects that were previously unrecorded in Australia or were poorly known, rare, and of limited distribution (*Leptocybe invasa* and *Thaumastocoris peregrinus*). However, none of the most common and damaging pests of eucalypt plantations in Australia, such as the chrysomelid leaf beetles *Paropsisterna bimaculata, P. agricola*, and *Paropsis atomaria*; the autumn gum moth, *Mnesampela privata*; or stem borers such as *Endoxyla cinerea*, *Phoracantha solida*, and *P. acanthocera* have established overseas. We examine reasons why these more serious pests have not yet become pests on eucalypts overseas, and examine whether historical trends of establishment and pathway analysis can be used to predict future movements of eucalypt-invasive insects worldwide.

Rapid invasion of non-native *Eucalyptus* plantations by *Thaumastocoris peregrinus*. Nadel, R.L., Wingfield, M.J. (*University of Pretoria, South Africa; Ryan.Nadel@fabi.up.ac.za; Mike.Wingfield@fabi.up.ac.za*), Scholes, M.C. (*University of the Witwatersrand, South Africa; Mary.Scholes@wits.ac.za*), Lawson, S.A. (*Queensland Primary Industries and Fisheries, Australia; Simon.Lawson@deedi.qld.gov.au*), Noack, A.E. (*University of Sydney, Australia; a.noack@usyd.edu.au*), Neser, S.; Slippers, B. (*University of Pretoria, South Africa; nesers@arc.agric.za; Bernard.Slippers@fabi.up.ac.za*).

Thaumastocoris peregrinus was described in 2006, although originally misidentified as *T. australicus*, both in its native Australia as well as in South Africa and Argentina where it is an introduced pest. *Thaumastocoris* spp. gained prominence when outbreaks occurred in urban centres of Sydney, Australia, in 2002. First reports of *T. peregrinus* in South Africa and South America occurred in 2003 and 2005 respectively. Two years after initial interception in South Africa, the insect had infested all commercial *Eucalyptus* forestry estates (± 496,000 ha) including 26 *Eucalyptus* spp., and it had begun spreading northwards in Africa. Similar rapid spread and a wide host range were also recorded in South America. Molecular genetic studies have shown that *T. peregrinus* invasions in South Africa have been caused by two independent introductions, together with a separate introduction into South America, probably all from urban centres in Australia. Control of *T. peregrinus* is challenging because populations increase rapidly due to favourable environmental conditions, uniformly distributed hosts, and the absence of natural enemies. Biological control and potentially including the egg parasitoid *Cleruchoides noackae*, appears to be the only long-term sustainable means for *T. peregrinus* control.

Global patterns of Australian eucalypt insect movement. Paine, T. (*University of California, USA; timothy.paine@ucr.edu*).

Eucalyptus are grown in many parts of the world and these regions have also accumulated insects from Australia. The international pattern of introductions provides a contrast to the pattern observed in California. There are 25 species of herbivores that have been introduced from Australia to various parts of the world. A total of 17 pest species are found in California; 10 of those are shared with at least one other geographic region, and 7 are found only in California. However, 6 of the shared species were first recorded from California. The remaining 4 (2 wood borers and 2 leaf beetles) were very early introductions into South Africa, and 3 are now distributed throughout all the *Eucalyptus* growing regions. There are 8 species found in other parts of the world but not in California; 5 of those are seed galling hymenoptera and probably moved in infested seed lots as plantations of *Eucalyptus* are expanded worldwide (e.g., *Moona spermophaga*). Seven of the species found outside California were first detected after the period of greatest invasive activity in California had past. Of the 7 species found only in California, 5 are psyllids that require living plant material to support nymphal survival.

The Eucalyptus snout beetle: new perspectives on an old scourge. Slippers, B., Hurley, B.P., Bouwer, M., Rohwer, E., Chungu, D., Jolanda, D., Wingfield, M.J., Garnas, J. (*University of Pretoria, South Africa; bernard.slippers@fabi.up.ac.za; brett.hurley@fabi.up.ac.za; marc.bouwer@fabi.up.ac.za; egmont.rohwer@up.ac.za; donald.chungu@fabi.up.ac.za; jolanda.roux@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za; jeff.garnas@fabi.up.ac.za*).

Gonipterus scuttelatus was one of the first invasive pests to be recorded on *Eucalyptus* in plantations outside the native range of these trees. This pest has spread to virtually every country where *Eucalyptus* spp. are grown, often having great impact on forestry industries. Classical biological control using a mymarid parasitoid (*Anaphes nitens*) is often cited as a textbook example of successful biological control, though recent outbreaks in South Africa have called this into question. We are applying a variety of tools to understand the spatially variable irruptive behavior of *G. scutellatus* and *A. nitens* in South Africa and beyond. Preliminary results of molecular (COI) diversity suggest the existence of three cryptic species within introduced populations, where a single species was previously assumed to occur. In contrast, sequence diversity for *A. nitens* showed little diversity, suggesting a possible mismatch between the control agent and target hosts. In addition, assays of antennal responses to *Eucalyptus* leaf volatiles indicate differential host attraction among common plantation species, suggesting a role for host preference influencing tree susceptibility. Results of these studies are enhancing our understanding of *G. scutellatus* and will contribute to more effective control strategies for this important plantation pest.

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Susceptibility of *Eucalyptus* species to the attack of *Ophelimus maskelli* in four arboreta in Tunisia. Dhahris, S., Benjamaa, M.L., Khouja, M.L. (*Université 7 Novembre de Carthage, Tunisia; dhahri.samir@iresa.agrinet.tn; benjamaa.lahbib@iresa.agrinet.tn; khouja.medlarbi@iresa.agrinet.tn*).

The *Eucalyptus* gall wasp *Ophelimus maskelli* (Hymenoptera: Eulophidae) has been present in Tunisia since 2006. This insect attacks several *Eucalyptus* species. This work presents differences in the susceptibility to the attack of *O. maskelli* and the level of infestation of several *Eucalyptus* species. Our study was carried out on 50 species of *Eucalyptus* planted since the 1960s in four arboretums belonging to the humid and subhumid bioclimates. The species *E. camaldulensis*, *E. tereticornis*, *E. rudis*, *E. viminali,s* and *E. diversicolor* are attacked in the arboretums with humid and subhumid bioclimates. However, the species *E. robusta*, *E. grandis*, *E. resinefera*, *E. botryoides*, *E. alba*, *E. globulus*, *E. gomphocephala*, *E. cinerea*, *E. maideni*, *E. pellita*, and *E. saligna* are attacked in the arboretums with humid bioclimate; and the species *E. kirtoniana* and *E. bicostata* are attacked in the arboretums with subhumid bioclimate. In the humid bioclimate the infestation level–based on the percentage of infested leaves on the tree–is higher on *E. rudis*, *E. globulus*, *E. tereticornis*, *E. Camaldulensis*, and *E. robusta* but lower on *E. globuus*, *E. grandi,s* and *E. viminalis*, whereas in the subhumid bioclimate the infestation level on the *Eucalyptus* species attacked is low.

Monitoring the bronze bug, *Thaumastocoris peregrinus* (Heteroptera: Thaumastocoridae): effect of trap placing. Martínez Crosa, G. (*Instituto Nacional de Investigación Agropecuaria, Uruguay; gmartinez@tb.inia.org.uy*), González, A. (*Montes del Plata, Uruguay; alejandro.gonzalez@montesdelplata.com.uy*), Simeto, S., Balmelli, G. (*Instituto Nacional de Investigación Agropecuaria, Uruguay; ssimeto@tb.inia.org.uy; gbalmelli@tb.inia.org.uy*).

The bronze bug is an important Australian pest of *Eucalyptus* plantations. The objective of this work was to assess the performance of traps placed in different parts of the tree and stand as part of a *T. peregrinus* monitoring network. Yellow sticky cards (10.0 cm × 12.5 cm) were placed at 1.8 m on the trunk (one in the centre, one at the edge of the stand) and another one between rows in 34 sampling points. Each trap was replaced every 20 days for a year. Traps were also placed near the trunk at 1.8 m, 5.0 m, and 10.0 m in a mixed stand of *Eucalyptus globulus*, *E. grandis*, and *E. tereticornis*, and were replaced every 15 days for 2 months. Traps on the trunk captured more individuals than those between rows but there were differences between the edge and the centre of the stand. Traps placed at 10 m captured a greater number of individuals, which could be related to the higher number of available leaves in the crown. For monitoring purposes it is important to record the average height of the trees and crown. Additional research is required in order to understand population distribution inside stands.

G-05 Synergy in forest threats: symbiotic interactions and invasives

Organizer: Kier Klepzig, *U.S. Forest Service, USA, kklepzig@fs.fed.us.*

Phytopathogenic fungi associated with the cypress bark beetle *Phloeosinus bicolor* P. (Coleoptera; Scolytinae) and their virulence for *Cupressus sempervien*s L. Belhabib, R. (Université Tunis El Manar, Tunisia), Turco, E. (University of Florence, Italy), Yart, A. (Université d'Orléans, France), Ben Jamaa, M.L. (Université 7 Novembre de Carthage, Tunisia), Nouira, S. (Université Tunis El Manar, Tunisia), Lieutier, F. (Université d'Orléans, France).

In Tunisia, *Cupressus sempervirens*, the only native species of the genus *Cupressus*, is widely used as windbreak. However, the bark beetle *Phloeosinus bicolor* caused serious threat to this tree. In the present work, we identified various fungi associated with the insect on *C. sempervirens*, and evaluated their frequency of associations. The most frequent species were *Pestalotia funerea*, *Gleocladium roseum*, *Ascherzonia kawakamii*, and *Chaetomium spirale*. The frequency of association of *G. roseum* was the highest one but was very variable (7 to 93%) depending on insect developmental stages, while that of *P. funerea*, *A. kawakamii*, and *C. spirale* was low (0 to 17%). The ability of these fungal species to stimulate the phloem reactions and to grow into the phloem was assessed 3 weeks after inoculating 3–4-year old trees. *P. funerea* and *A. Kawakami*i induced the most extended phloem reaction zones and fungal growth (7–7.4 mm; 47–47.3 mm), and *C. spirale* the lowest ones (3–5; 11–35 mm). For all inoculations, the phloem reaction zone was lower than fungal growth, possibly because of the age of the inoculated trees. The percentage of damaged sapwood was low and differs among fungal species. *P. funerea* caused the highest damage (10%).

Toward a national early warning system for forest disturbances using remotely sensed land surface phenology. Hargrove, W.W. (*U.S. Forest Service, USA; hnw@geobabble.org*), Spruce, J.P. (*SSAI/NASA Stennis, USA; Joseph.P.Spruce@nasa.gov*), Hoffman, F.M. (*Oak Ridge National Laboratory, USA; forrest@climate.ornl.gov*).

We are using a statistical clustering method for delineating homogeneous ecoregions as a basis for identifying forest disturbances through time over large areas, up to national and global extents. Such changes can be shown relative to past conditions, or can be forecasts of future climatic change. This quantitative ecoregion approach can be used to predict destinations for populations that are forced to move as their habitat shifts, and can also predict the susceptibility of new locations to invasive species. EFETAC and our sister western center WWETAC, along with our NASA Stennis and ORNL collaborators, are designing a new national-scale early warning system for forest threats, called FIRST. Envisioned as a change detection system, FIRST will identify all land surface changes at the MODIS scale, and then will try to discriminate normal, expected seasonal changes from locations having unusual behavior that may represent forest disturbances. As a start, we have developed new national data sets every 16 days from 2002 through 2008, based on land surface phenology, or timing of leaf-out in the spring and brown-down in the fall. Changes in such phenological maps (http://data.forestthreats.org/phenology) will be shown to contain important information about vegetation health status across the United States.

Symbiosis in forest pestilence. Hofstetter, R.H. (*Northern Arizona University, USA; Rich.Hofstetter@nau.edu*), Ayres, M.P. (*Dartmouth College, USA; matt.ayres@dartmouth.edu*), Klepzig, K.D. (*U.S. Forest Service, USA; kklepzig@fs.fed.us*), Marino, P.A. (*Dartmouth College, USA; Paul.A.Marino.04@Alum.Dartmouth.ORG*), Lombardero, M.J. (*Universidad de Santiago, Spain; mariajosefa.lombardero@usc.es*).

Insects and pathogens are major disturbance agents of forests throughout the world. Many cases of forest pestilence are an emergent property of symbiotic associations among plant enemies. Organisms involved in symbioses gain advantages from the association that can lead to plant host range expansion, virulence, and increased fecundity, longevity, and dispersal. Additionally, symbioses that involve biotic vectors favor the evolutionary retention of virulence and can produce positive evolutionary feedbacks that amplify pestilence by promoting aggressiveness. To understand and manage this class of pestilence we must understand the community interactions among these symbiotic complexes. Some examples of pestilence from symbiosis include bark beetle outbreaks such as the mountain pine beetle and Ophiostomatoid fungi and Dutch elm disease, which includes *Scolytus* beetles and *Ophiostoma* fungi. Other examples include oak wilt disease, which comprises *Ceratocystis* fungi and nitidulid beetles; pine wilt from the symbiosis of pinewood nematodes and *Monochamus* beetles; and pitch canker, which comprises spittlebugs and *Fusarium*. Cases of plant pestilence are expected to increase with changes in climate, plant stress, and movement of organisms across borders.

Symbiotic dynamics: pathogens, pests, and biological control. Hurley, B.P. (*University of Pretoria, South Africa; brett.hurley@fabi.up.ac.za*), Klepzig, K. (*U.S. Forest Service, USA; kklepzig@fs.fed.us*), Wingfield, M.J., Slippers, B. (*University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za; bernard.slippers@fabi.up.ac.za*).

The relationship between the woodwasp, *Sirex noctilio*, and the fungus, *Amylostereum areolatum*, offers an intriguing case of how environment and genotype can influence the success of a symbiotic relationship. This is both directly and through its influence on natural enemies. *A. areolatum* is essential for the survival of both *S. noctilio* larvae and the parasitic nematode *Deladenus siricidicola*. This nematode has been used widely for biological control of *S. noctilio* in the southern hemisphere, where *S. noctilio* is an alien invasive. It has been shown that the strain of *A. areolatum* in South Africa is different to the Australian laboratory strain on which the nematode is reared before release. The growth rate of the South African strain is significantly slower, but this does not appear to negatively affect the wasp. It could, however, influence the survival of the nematode, possibly explaining the poor performance of the nematode in South Africa. Furthermore, blue-stain fungi, such as *Diplodia pinea* and *Ophiostoma ips* in the introduced environment also outcompete *A. areolatum*. Our recent studies on the interaction between different *A. areolatum* strains and blue-stain fungi highlight the importance of understanding the multiplicity of factors influencing symbiotic relationships.

Ecology of invasive exotic Asian ambrosia beetles and their symbiotic fungi. Kajimura, H., Ito, M., Kawasaki, Y., Mizuno, T. (*Nagoya University, Japan; kajimura@agr.nagoya-u.ac.jp; ito.masa@agr.nagoya-u.ac.jp; kawasaki.yuuki@h.mbox.nagoya-u.ac.jp; t.mizuno2002@amail.plala.or.jp*), Lakatos, F. (*University of West-Hungary, Hungary; flakatos@emk.nyme.hu*).

Beetles belonging to the subfamily Scolytinae are commonly transported through human activities, and as a result many species have become established in exotic localities throughout the world. These include many ambrosia beetles, which feed on the symbiotic fungi that they cultivated onto the walls of their gallery system. Thus, the fungi have been also introduced into the new habitat. The invaders of beetles and fungi often have been shown to be serious pests and pathogens. Information on their ecology in native habitat is needed to understand about origins of invasiveness. Here we present ecological traits of Asian ambrosia beetles, especially several species of the subtribe Xyleborina, which includes *Xylosandrus* and *Xyleborus*, etc., exotic to the U.S. and/or Europe, and their fungi in the Japanese field populations. To obtain comparative data from experimental populations, we developed a better rearing system, using semi-artificial diets with different ingredients and structures. We also present the features of genetic structure and genetic diversity of the beetles, including their intracellular bacterium, *Wolbachia*, based on phylogeographic analysis.

Mediation of plant pest interactions by microbes. Klepzig, K.D. (*U.S. Forest Service, USA; kklepzig@fs.fed.us*), Adams, A.S., Handelsman, J., Raffa, K.F. (*University of Wisconsin-Madison, USA; asadams@entomology.wisc.edu; joh@bact.wisc.edu; raffa@entomology.wisc.edu*).

Insects show a vast array of symbiotic relationships with a wide diversity of microorganisms. These relationships may confer a variety of benefits to the host (macrosymbiont), such as direct or indirect nutrition and improved development and reproduction. Benefits to the microsymbiont (including a broad range of fungi, bacteria, mites, nematodes, etc.) often include transport, protection from antagonists, and protection from environmental extremes. Symbiotic relationships may be mutualistic, commensal,

competitive, or parasitic. In many cases, individual relationships may include both beneficial and detrimental effects to each partner during various phases of their life histories or as environmental conditions change. The outcomes of insect-microbial interactions are often strongly mediated by other symbionts and by features of the external and internal environment. For many systems, our understanding of symbiotic relationships will advance most rapidly where context dependency and multipartite membership are integrated into existing conceptual frameworks. The contribution of entomological studies to overall symbiosis theory will be greatest where preoccupation with strict definitions and boundaries is minimized, and integration of emerging techniques is maximized. We highlight symbiotic relations involving bark beetles to illustrate examples of the above trends.

Evolution of symbiotic associations between pests and symbionts. Six, D.L., Ott, E. (*University of Montana; USA; diana.six@cfc.umt.edu; eric.ottt@grizmail.umt.edu*).

Mutualisms allow organisms to avoid competition and to exploit marginal environments and resources. It is participation in mutualisms that has allowed many pests as well as ecosystem engineers to become so successful. Here we focus on ectosymbioses among bark and ambrosia beetles and fungi. These involve some of the most important forest pests, as well as species that are critical players in forest succession and nutrient cycling. Both strategies are multiply derived, with ambrosia beetles evolving at least seven times out of tribes containing bark beetles. The fungi associated with scolytine beetles also exhibit patterns of convergence and divergence. The paraphyletic nature of bark and ambrosia feeding strategies and the fact that the fungi associated with both bark and ambrosia beetles are derived from the same groups of fungi indicate the need for studying these symbioses under one common framework. Phylogeny, degree/type of dependence on partners, mode of transmission, effects of the abiotic environment, exposure to new symbionts via exotic introductions, and interactions among symbionts or with other members of the biotic community, all play roles in determining the composition and fidelity of these associations. We are using a phylogenetic approach to investigate stability and flexibility in these symbioses.

G-06 Alien invasive pathogens: threats to forest ecosystem integrity and services

Organizers: Steve Woodward, *University of Aberdeen, UK, s.woodward@abdn.ac.uk*; Ned Klopfenstein, *U.S. Forest Service, USA, nklopfenstein@fs.fed.us.*

Defining what is acceptable biosecurity risk: how wide is the USDA's line in the sand? Bigsby, H. (*Lincoln University, New Zealand; bigsbyh@lincoln.ac.nz*).

For many years, APHIS-USDA has carried out phytosanitary risk assessments using a qualitative risk assessment framework. The risk assessment framework looks at risk of introduction and consequence of introduction by assessing a number of factors using high, medium, and low rankings, and then combining these rankings to obtain an overall measure of risk. This is then used as the basis for recommending phytosanitary measures. While this is an objective risk assessment process, there is no particular mechanism for assessing how consistent the phytosanitary recommendations are in terms of meeting a particular risk-reduction goal. This paper presents a model for quantifying quarantine-related phytosanitary measures by combining the two basic components of pest risk assessment, probability of establishment and economic effects, into a single management framework, Iso-Risk. The Iso-Risk framework provides a systematic and objective basis for defining and measuring acceptable risk, and for justifying quarantine actions relative to acceptable risk. The Iso-Risk framework is applied to a database of APHIS-USDA phytosanitary risk assessments to examine their consistency. The results show that the APHIS-USDA risk assessment system produces assessments that are not consistent across a range of intermediate values for consequence or likelihood of occurrence.

Association of *Phytophthora cinnamomi* with white oak decline in southern Ohio. Bonello, P., Nagle, A.M. (*Ohio State University, USA; bonello.2@osu.edu; nagle.26@osu.edu*), Long, R.P. (*U.S. Forest Service, USA; rlong@fs.fed.us*), Madden, L.V. (*Ohio State University, USA; madden.1@osu.edu*).

A recent decline syndrome and widespread mortality of many mature white oaks (WO) (*Quercus alba* L.) in southern Ohio have raised ecological and timber management concerns. In 2008 and 2009, we quantified *Phytophthora cinnamomi* inoculum densities in two healthy and two declining WO stands and assessed the role of three potential environmental drivers of the decline: soil moisture, topography, and soil texture. We also quantified effects of *P. cinnamomi* inoculum and periodic flooding on root health of 1-year-old potted WOs grown in native soil mixes in the greenhouse. Significantly higher *P. cinnamomi* propagule densities were found in declining stands in both years but they were not associated with variability in soil moisture. Soil moisture and topography also did not affect inoculum patterns within field sites. There was a positive, exponential relationship between overall *P. cinnamomi* inoculum levels and soil moisture on a seasonal scale in 2008 but not in 2009. Sites with greater soil clay content experienced greater decline. In the greenhouse, root systems of WOs were significantly damaged by inoculation of the soil with *P. cinnamomi*. Taken together, these studies provide circumstantial evidence that *P. cinnamomi* contributes to WO decline in southern Ohio forests.

Guava rust (*Puccinia psidii*): a potential threat to important Myrtaceae in the Pacific. Cannon, P.G. (*U.S. Forest Service, USA; pcannon@fs.fed.us*), Neves, R. (*Universidade Federal de Vicosa, Brazil; rnevesg@yahoo.com.br*), Kim, M.S. (*Kookhim University, Republic of Korea; mkim@kookhim.ac.kr*), Klopfenstein, N. (*U.S. Forest Service, USA; nklopfenstein@fs.fed.us*), Alfenas, A.C. (*Universidade Federal de Vicosa, Brazil; aalfenas@ufv.br*).

Puccinia psidii (guava rust) can cause a rust disease of many species of Myrtaceous trees. It was first found in Brazil and Paraguay in the late 1800s. Subsequently, it has been detected in several Caribbean Islands, Mexico, Florida (USA), and California (USA). In 2005, this rust pathogen was found in Hawaii (USA). Although this rust has become widespread in Hawaii, molecular diagnostics indicate that the rust possesses limited genetic diversity, so far. This introduced strain has caused high mortality of the widely invasive rose-apple (*Syzygium jambos*) plants that had become established in Hawaii. Currently, it has had

only minimal impact on the native ohia tree (*Metrosideros polymorpha*), which constitutes 80% of the native forest vegetation in Hawaii. Studies are underway to determine if more aggressive races of this rust exist. An extensive collection of *P, psidii* germplasm has been made in Brazil and it is currently being analyzed for genetic diversity. After genetic characterization is complete, diverse rust genotypes will be used to examine their pathogenicity to ohia tree seedlings grown in Brazil. Genetic and pathogenicity studies of guava rust are of interest to tropical and sub-tropical regions of the Pacific where Myrtaceous tree species are prevalent.

Host defense responses of *Pinus merkusii* seedling upon infection by *Fusarium subglutinans.* Djoyobisono, H., Widyastuti, S. (*Faculty of Forestry, Gadjah Mada University, Indonesia; harjono@gmail.com; smwidyastuti@yahoo.com*)

Pinus merkusii is an important tree species native to Indonesia and several other Asian countries. The wood is very valuable for construction, flooring, and boat building. The resin is used in paints and for various medicinal purposes. Large-scale plantations have been set up in Sumatra and Java. As a consequence, continued supply of seedlings is essential. However, seedlings in nurseries are easily affected by damping-off diseases caused by *Fusarium*. In this study, *F. subglutinans* was identified as the main causal agent of the disease in a central nursery at Pekalongan, Central Java. The detailed infection process of *F. subglutinans* on *P. merkusii* seedling was examined. On the other hand, upon infection by the fungus, *P. merkusii* seedlings reacted by expressing an array of defense responses. Cytological observations were performed to identify the role of accumulation of callose, lignin, and phenolic compounds as well as hypersensitive responses. In addition, the potential use of *Trichoderma* as biocontrol agent was also studied and analyzed. Information obtained from this research will be used to develop a strategy of integrated disease management.

Predicting potential invasiveness of *Armillaria solidipes,* a root pathogen of diverse forest trees. Kim, M.S. (*Kookmin University, Republic of Korea; mkim@kookmin.ac.kr*), Hanna, J.W., Klopfenstein, N.B. (*U.S. Forest Service, USA; jhanna@fs.fed.us; nklopfenstein@fs.fed.us*).

Armillaria solidipes (= *A. ostoyae*) is a root pathogen that causes large losses in growth and productivity of diverse forest trees throughout its circumboreal distribution. However, this species appears genetically variable with distinct ecological behavior in different geographic regions. In North America, *A. solidipes* exists in drier habitats and causes more disease on hardwoods within the Colorado Plateau in comparison with the northwestern USA. In China, *A. solidipes* causes severe root disease on *Larix* spp. which are rarely impacted by this pathogen in North America. Surprisingly, *A. solidipes* has not been found in south-central Idaho, USA, even though suitable habitat, susceptible hosts, and other *Armillaria* species are apparently present. These examples indicate that intercontinental and interregional movement of *A. solidipes* could represent an invasive species risk, especially under changing climate regimes. Furthermore, intraspecific and interspecific hybridization could create pathogens with novel ecological behavior, disease activity, and genetic adaptation. A multi-institutional collaboration is underway to assess genetic relationships of *A. solidipes* across the northern hemisphere. These studies, in conjunction with modeling of suitable climate space for phylogenetic groups, will help assess potential invasive risks associated with intercontinental and interregional movement of *A. solidipes*.

Posters

The Cryphonectriaceae: a largely unexplored family of tree pathogens in the Diaporthales. Gryzenhout, M., Wingfield, M.J. (*University of Pretoria, South Africa; marieka.gryzenhout@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za*).

The Cryphonectriaceae include many important tree pathogens, such as the causal agent of chestnut blight *Cryphonectria parasitica*, and the *Eucalyptus* canker pathogens *Chrysoporthe cubensis* and *C. austroafricana*. Other species in the Cryphonectriaceae also have the potential to cause serious disease problems if they are introduced into countries having susceptible hosts. Currently the Cryphonectriaceae accomodates 16 genera, two of which are known only in the anamorph state. These genera were previously known as species of *Cryphonectria* or they represent newly discovered fungi. Some of these genera are monotypic, but distinguishable from related genera by robust morphological characteristics. Furthermore, numerous isolates obtained from disease symptoms or dead wood from various countries and hosts in the tropics and southern hemisphere, do not group with any of the described genera in the Cryphonectriaceae based on DNA sequences. They can, however, not be described because fruiting structures are not available for this purpose. Knowledge that these monotypic genera and undescribed lineages exist in the Cryphonectriaceae shows that the group is largely under-sampled. Surveys for these fungi should clearly continue and their characterization will be important to reduce risks to worldwide forests in the future.

Expanding host and geographic ranges suggest increasing importance for the eucalypt canker pathogen *Holocryphia eucalypti*. Roux, J., Gryzenhout, M., Vermeulen, M. (*University of Pretoria, South Africa; jolanda.roux@fabi.up.ac.za; marieka.gryzenhout@fabi.up.ac.za; marcele.vermeulen@fabi.up.ac.za*), Nakabonge, G. (*Makerere University, Uganda; nakabonge@forest.mak.ac.ug*), Chauque, A. (*Eduardo Mondlane University, Mozambique; chaumz@yahoo.com.br*), Wingfield, M. (*University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za*).

Holocryphia eucalypti (syn. *Cryphonectria eucalypti*), causes a stem canker disease of eucalypts (Myrtales). This pathogen is not considered particularly important, although it can result in the death of susceptible trees, especially where they are subjected to environmental stress. *H. eucalypti* has been known from eucalypts in Australia and South Africa for many years and it was recently reported from non-native *Tibouchina* spp. (Myrtales) in Australia and New Zealand. Recent surveys in Africa have shown that the fungus now occurs on *Eucalyptus grandis* trees in Mozambique, Swaziland, and Uganda, typically resulting in superficial bark cankers on 3–5 year old trees. Population genetic studies and the very limited distribution outside Australia suggest that *H. eucalypti* is native to Australia and more specifically the eastern part of that country. Suprisingly, it has recently been found sporulating on dead bark of native *Metrosideros angustifolia* (Myrtales) trees in the Western Cape Province of South Africa. Its occurrence on *M. angustifolia* suggests a host shift for the pathogen in its introduced environment. Although *H. eucalypti* is a relatively minor pathogen in its native enviroment, the fact that it is able to infect native trees in a new environment is of concern and deserves further study.

Tree mortality and stem growth of *Pinus sylvestris* and colonization of *Tomicus piniperda* after an attack by *Gremmeniella abietina*. Sikström, U., Weslien, J., Jacobson, S., Pettersson, F. (*Skogforsk, Sweden; ulf.sikstrom@skogforsk.se, jan-olov.weslien@skogforsk.se, staffan.jacobson@skogforsk.se, folke.pettersson@skogforsk.se*).

In the year 2000, large forested areas in Sweden, mainly with 30–50-year-old Scots pine (*Pinus sylvestris* L.), were attacked by the fungus *Gremmeniella abietina* (Lagerb.) Morelet. Thirty-five permanent sample plots were established in five stands infested by *G. abietina*, and 23 plots in four reference stands, more or less unaffected by the fungus. During the 5 years following the attack, 41% of the trees and 34% of the basal area died on average in the five infested stands. The aims of this study were to investigate: (i) the relation between *G. abietina*-induced tree crown transparency (CT) and Scots pine tree mortality; (ii) how the stem growth was affected, both of individual trees and at stand level; (iii) the recovery of the CT; and (iv) if the CT-limit of 90% of Scots pine is valid, above which breeding of *Tomicus piniperda* (L.) is possible in the stems. Results on all these issues will be presented. For example, a model for predicting the probability of *P. sylvestris* tree mortality indicates that at a CT-value higher than c. 85% the probability of mortality increase substantially. Suggestions for practical silvicultural implications will be given.

A new genus in the Cryphonectriaceae, pathogenic to *Eucalyptus* and *Syzygium* in Southeast Asia. Zhou, X.D. (*Chinese Academy of Forestry, China; cerc.zhou@gmail.com*), Chen, S.F., Gryzenhout, M., Roux, J. (*University of Pretoria, South Africa; shuaifei.chen@fabi.up.ac.za; marieka.gryzenhout@fabi.up.ac.za; jolanda.roux@fabi.up.ac.za*), Xie, Y.J. (*Chinese Academy of Forestry, China; xieyj@21cn.com*), Wingfield, M. (*University of Pretoria, South Africa; mike.wingfield@fabi.up.ac.za*).

Many species in the Cryphonectriaceae cause canker diseases on trees, including *Eucalyptus* spp. During tree disease surveys in South China, fruiting structures typical of the Cryphonectriaceae were observed on dying stems and branches of *Eucalyptus* and *Syzigium cumini*. Morphological comparisons suggested that the fungus was distinct from the well-known *Chrysoporthe cubensis*, which is also found in China on these trees. In this study, we identified the fungus and considered its pathogenicity on *Eucalyptus* spp. and *S. cumini*. Isolates were characterized based on morphology and comparisons of DNA sequence data. Following glasshouse trials to select virulent isolates, field inoculations were undertaken to screen different commercial *Eucalyptus* clones and *S. cumini* for susceptibility. Phylogenetic analysis showed that the isolates, including several from Indonesia on *S. aromaticum*, reside in a clade separated from *Chrysoporthe* and other related genera. The fungus thus represents a new genus and species in the Cryphonectriaceae. Field inoculations showed that the new species is pathogenic to *Eucalyptus* and *Syzygium* trees. Moreover, there were significant differences between the tested clones and species, providing opportunities to select disease tolerant planting stock in the future.

G-07 Impacts of interacting disturbances on forest health in the boreal zone

Organizer: Douglas McRae *Natural Resources Canada, Canada, dmcrae@nrcan.gc.ca*

Climate change effects on the interaction between forest insect defoliators and fire in the boreal zone: the state of the science. Candau, J-N., Fleming, R.A. (*Natural Resources Canada, Canada, jcandau@nrcan.gc.ca; rfleming@nrcan.gc.ca*).

The dominant types of natural disturbance in Canada's boreal forests are wildfire and outbreaks of insect defoliators. By far the most damaging of these defoliators is the spruce budworm, *Choristoneura fumiferana*. Understandably, its interaction with fire has received more attention than that of any other defoliator. Recently, Lynch and Moorcroft (2008) studied how the closely related western spruce budworm, *Choristoneura occidentalis*, interacts with fire at relatively fine time and space scales. Because they sometimes mis-identified the insect they worked on in their paper (e.g., in the title: ". . .interactions between spruce budworm and fire . . ."), there has been some confusion when their results seemed to contradict earlier work. We compare and contrast these lines of work and bring in some new results to paint a more comprehensive picture of the state of the science. We show that many of the apparent contradictions can be explained by differences in the nature of the data used and by differences in how these two insects affect their host trees. We finish by exploring the evidence of how climate change will likely affect the interaction between forest insect defoliators and fire based on these latest results.

The effects of anthropogenic disturbances on tree diversity, species composition, and productivity in some major temperate forests of Garhwal Himalaya, India. Gairola, S., Sharma, C.M., Ghildiyal, S.K., Suyal, S. (*HNB Garhwal University, India; sumeetgairola@gmail.com; sharmacmin@gmail.com; skghildiyal@gmail.com; sarveshsuyal@gmail.com*).

The impact of anthropogenic disturbances on tree diversity, species composition, and productivity was assessed in seven major temperate forest types of Garhwal Himalaya. Two study areas—Mandal-Chopta (undisturbed) and Chaurangikhal (disturbed)—having similar physiographic and edapho-climate conditions were selected for the study. Most of the undisturbed forest types had higher species richness, diversity, growing stock, stem density, and total basal cover values as compared to disturbed forest types. In disturbed forest types growing stock was lower in higher diameter classes as compared to undisturbed forest types, which is attributed to selective removal of mature trees from the forest. Lower values of TBC in disturbed forests are attributed to loss of productivity mainly due to anthropogenic disturbances. Except for mixed *Pinus roxburghii* and pure *P. roxburghii* forests (being the non-palatable species), all the other forest types showed low density of seedlings and saplings in the disturbed forest types as compared to undisturbed forest types, the likely reason being regeneration loss due to grazing and lopping. The results have revealed that structure and regeneration of the natural forest types of Garhwal Himalaya are severely affected by the anthropogenic disturbances.

Comparative economic efficiency of alternative release treatments in boreal silviculture: a case study of the Vegetation Management Alternative Program (VMAP) in Ontario, Canada. Homagain, K., Shahi, C., Luckai, N., Leitch, M. (*Lakehead University, Canada; khomagai@lakeheadu.ca; cshahi@lakeheadu.ca; nluckai@lakeheadu.ca; mleitch@lakeheadu.ca*), Bell, W. (*Ontario Forest Research Institute, Canada; wayne.bell@ontario.ca*).

To maintain Canada's international economic competitiveness and to meet global demand for Canadian wood products, there has been an increasing awareness in the forest industry to improve forest productivity through intensive silvicultural practices.

Notwithstanding adverse environmental and social concerns, intensive practices including herbicide-led vegetation release treatments have been practiced to achieve major gains in productivity. In Ontario, vegetation management alternative research efforts have been led by the Vegetation Management Alternatives Program (VMAP) since 1991 to ensure that forest management is socially acceptable and consistent with emerging principles of ecosystem management. The program has made substantial progress in developing and refining a number of alternatives to aerial herbicide application, including: manual/mechanical-cutting and ground-applied herbicides. Periodic re-measurement data on crop-tree characteristics of 16-year post-treatment experimental sites from six different areas of Ontario were used to predict future crop responses to different rotation ages using forest vegetation simulator (FVS). Benefit-cost analyses of alternative treatments were conducted using FVS for growth and yield, timber quality, and value of fibre production for each crop-species. Sensitivity analyses of internal rates of return using different discount rates for each treatment and site combinations will help in formulating and comparing different policy scenarios for each crop species.

Effects and feedbacks of natural and anthropogenic structure changes in boreal forest ecosystems. Panferov, O. (*Georg-August University of Goettingen, Germany; opanfyo@gwdg.de*), Junghans, U. (*North-West German Forest Research Centre, Germany; udo.junghans@nw-fva.de*), Knohl, A. (*Georg-August University of Goettingen, Germany; aknohl@gwdg.de*), Olchev, A. (*A.N. Severtsov Institute of Ecology and Evolution, Russian Federation; aoltche@gwdg.de*), Sogachev, A. (*Technical University of Denmark, Denmark; anso@risoe.dtu.dk*), Varlagin, A. (*A.N. Severtsov Institute of Ecology and Evolution, Russian Federation; varlagin@deol.ru*), Vygodskaya, N. (*Jan Kochanowski University, Poland; igon@pochtamt.ru*), Ahrends, B. (*Georg-August University of Goettingen, Germany; bahrend@uni-goettingen.de*).

Wind damage and forest management activities lead to both small-scale and wide area abrupt changes of boreal forest structure. The created gaps and/or reduced stand density trigger energy and water balance changes that increase or decrease the vulnerability of remaining stand to abiotic and biotic damage factors. The sign and degree of vulnerability changes depends not only on strength of a driving climatic factor itself but also on interactions between climatic agents, forest structure, and soils. Correct assessment in each case requires knowledge of these factors and a process-based modelling approach. This study demonstrates the effects and feedbacks of windthrow/forest management on biotic and abiotic risks in European and Russian boreal forests under SRES scenarios A1B/B1. The decision support system "Forest and Climate Change" (Goettingen University) is used for quantitative assessment of the risks for spruce and pine stands. The results of the study indicate that windthrow and forest management destabilize forest stands. However the risk increase in the 21st century is caused not by the increase of wind velocity alone, but by combination of increased air and soil temperature and seasonal redistribution of precipitation; tree anchorage is reduced due to decrease of soil freezing and increase of soil water.

Changes in forest fire danger in northeast China under two climate change scenarios. Tian, X., Shu, L., Zhao, F., Wang, M. (*Chinese Academy of Forestry, China; tianxr@caf.ac.cn; shulf@caf.ac.cn; zhaofj@caf.ac.cn; fire@caf.ac.cn*), McRae, J.D. (*Natural Resources Canada, Canada; Doug.McRae@NRCan.gc.ca*).

Average temperature of northeastern China will increase 2.22 and 2.55 °C under IPCC Special Report on Emissions Scenarios A2 and B2, respectively, in the 2040s (2041–2050 years), which will have an impact on future fire activities. This paper uses PRECIS (Providing Regional Climates for Impacts Studies) regional climate model's outputs to calculate the Canadian Forest Fire Weather Index on the scale of 50 × 50 km and then to interpolate to 1- × 1-km scale. The results show that the PRECIS model had a good ability to simulate temperature and precipitation of the study area for the baseline period (1961–1990). By the 2040s, the mean FWI values of the study area will increase under scenarios A2 and B2. Under scenario B2 the peak fire season will occur in April, which is earlier than May in the baseline period. Potential burned areas will increase only slightly under scenario A2 but will increase 20% under scenario B2 based on changes in the FWI ratio. Days of high, very high, and extreme fire danger classes will add 5 and 18 days under scenarios A2 and B2, respectively. These results suggest adapting to climate change will require improved fuel management and enhanced suppression abilities.

G-08 Invasive alien species: economic and environmental impacts on forest ecosystems

Organizers: David Langor, *Natural Resources Canada, Canada, dlangor@nrcan.gc.ca*; Hayato Masuya, *Forestry and Forest Products Research Institute, Japan, massw@ffpri.affrc.go.jp.*

***Imperata cylindrica*, an invasive alien grass, alters biomass and nitrogen allocation in pine forests of the southern United States.** Jose, S. (*University of Florida, USA; sjose@ufl.edu*).

Imperata cylindrica, a C_4 rhizomatous perennial grass that invades a range of sites, is one of the most troublesome weed species in the world. Several studies have examined control of this species, but few have explored the impacts on ecosystem processes such as biomass production and nutrient cycling. A 3-year study was conducted to compare the impacts of *I. cylindrica* on the productivity and N allocation of young *Pinus taeda* forests. We used three treatments: (1) vegetation free (VF), (2) native competition (NC), and (3) *I. cylindrica* (IC) competition. At the end of the study, only 26% of the IC pine seedlings survived, half of what was observed in NC. The IC seedlings had significantly lower height, root collar diameter, stem volume, and total biomass compared to NC seedlings. We used ^{15}N-labeled fertilizer to examine how invasion would alter the uptake and allocation of N. *I. cylindrica* was significantly more competitive in acquiring applied N than native species. It also retained significantly more N below-ground compared to native species. Thus, in addition to altering biomass allocation patterns, invasion by *I. cylindrica* could also lead to a shift in N pools from above- to below-ground in invaded ecosystems.

Invasive alien plants in the western lower Indian Himalayas: biodiversity threat and management. Kohli, R. K., Batish, D.R., Singh, H.P. (*Panjab University, India; rkkohli45@gmail.com; daizybatish@yahoo.com; hpsingh-01@yahoo.com*), Dogra, K.S. (*Himchal Pradesh University, India; dograks6@yahoo.co.in*).

Invasive alien plants have caused havoc in Indian Himalayas, a biodiversity hot-spot zone, and have posed a major threat to ecology and economy of the Shiwalik Range of the hill state. The major casualty is native biodiversity, especially in forested ecosystems. The dimensions of loss are so serious that it has invited urgent national attention. Evaluation of the impact of invasive alien plants on alpha diversity of terrestrial plants in the state was undertaken on direction by the Ministry of Environment and Forests, New Delhi. The real challenge is to control their spread for meeting the objectives of the CBD and save the local, national, and global ecology from destruction. Their effective biochemical machinery, giving them a competitive edge over the natives, makes these invasives better colonizers. Use of this property assumes a better strategy and potential in weed management. The proposed presentation aims at discussing the impact of three American invasive weeds—*Lantana camara, Parthenium hysterophorus*, and *Ageratum conyzoides*—on plant biodiversity in Lower Himalayan ranges in India. It shall also discuss the urgent need to develop some cost-effective, environmentally safe herbicides in addition to adopting an integrated approach to combat the most serious enviro-economical problem facing mankind.

Estimating the economic impact of alien forest insects in the USA. Liebhold, A. (*U.S. Forest Service, USA; aliebhold@fs.fed.us*), McCullough, D. (*Michigan State University, USA; mccullo6@msu.edu*), Aukema, J. (*The Nature Conservancy, USA; jaukema@tnc.org*), Kovacs, K. (*University of Nevada, USA; kkovacs@cabnr.unr.edu*), Holmes, T., Haight, R., Britton, K. (*U.S. Forest Service, USA; tholmes@fs.fed.*us; *rhaight@fs.fed.us; kbritton@fs.fed.us*), Englin, J. (*University of Nevada, USA; englin@cabnr.unr.edu*), Von Holle, B. (*University of Central Florida, USA; vonholle@mail.ucf.edu*), Leung, B. (*McGill University, Canada; brian.leung2@mcgill.ca*).

Quantifying the impacts and costs of biological invasions is critical to informing trade policy. While non-indigenous forest insect species are known to cause considerable impacts in the United States, a comprehensive analysis of their economic impacts, based on econometric principles, is unfortunately lacking. In this paper, we address this deficiency by describing an analysis of the impacts of all forest insect species on both market and non-market values. The analysis used a comprehensive list of all non-native insect species that divided these species into three guilds: wood borers, sap feeders, and defoliators. Within each guild, we estimated the probability distribution of economic impacts on various economics sectors. These estimates were derived from estimates of the impact of the pest species with greatest impacts within each guild, and then extrapolation to all species. This analysis allows for an estimate of the impact of each new species, and these calculations are useful for evaluating economic trade-offs of various trade policies. Our framework is highly flexible and will be useful across natural resource sectors needing to estimate environmental damages.

Impacts of invasive tree pathogens on forest ecosystems in Japan. Masuya, H., Okabe, K., Kanzaki, N. (*Forestry and Forest Products Research Institute, Japan; massw@ffpri.affrc.go.jp; kimikook@ffpri.affrc.go.jp; nkanzaki@ffpri.affrc.go.jp*).

The global increase in trade of wood has resulted in an increase in invasions by alien tree pathogens in many countries. Japan has been colonized by several damaging tree pathogens, but there is little information about their impacts on forest ecosystems. Here we present some examples of invasive tree pathogens in Japan, predicted pathways, and their impact on Japanese forests. The most conspicuous invasive tree pathogen in Japan is the pine wood nematode. It has now spread over most of Japan. The invasion by the nematode resulted in increases of some pine-infesting beetles, *Monochamus*, *Shirahoshizo*, and *Cryphalus* species. Species compositions of beetle-associated fungi, such as *Ophiostoma* spp., also seem to have changed due to the presence of Japanese pine wilt disease. The known pathway for introduction of pine wood nematode is by means of imported logs. Until the1970s, logs were the main form of imported wood in Japan, but that is no longer the case. Thus, the risk of logs as a pathway for invasive tree pathogens is now less, but the risk of introductions associated with green lumber still is high. Recently we have isolated several *Ophiostoma* species from imported green lumbers, and their potential for invasion requires assessment.

Social costs of invasive plant species in the interior northwestern United States. Wibbenmeyer, M., Venn, T.J. (*University of Montana, USA; matthew.wibbenmeyer@umontana.edu; tyron.venn@umontana.edu*).

Concerns about invasive species have increased substantially because of their escalating threat to the health, integrity, and productivity of natural and agricultural ecosystems. Invasive plants in the United States are responsible for control costs and market damage costs that sum to billions of dollars annually. Although negative impacts on non-market values are likely to be large, to date little research has been performed to estimate these economic losses. The scarcity of non-market damage cost estimates for invasive plants is recognized by policy-makers and economists as a major limitation of most existing invasive plant management decision-support tools. This paper will present findings from a choice modeling non-market valuation survey that estimates the marginal social costs of invasive plants in the forested interior northwestern United States. At the time of abstract submission, we do not have specific results to report; however, marginal social costs of invasive plants are being estimated with regard to degradation of water quality, wildlife habitat, and recreation opportunities. This study is part of a larger project that is developing a weed management decision support tool that can spatially and temporally allocate weed management treatments to minimize total damage cost, including non-market damages.

Posters

Exotic plantation species in hill forest ecosystems of Bangladesh: a threat to native biodiversity. Hossain, M.K. (*Chittagong University, Bangladesh; mkhossain2009@gmail.com*)

The natural hill forests of Bangladesh were generally uneven-aged and multistoried with the valuable tropical species of *Dipterocarpus turbinatus, D. alatus, D. costatus, Swintonia floribunda, Aphanamaxis polystachya, Artocarpus chaplasha, Tetrameles nudiflora, Daubanga grandifolia*, *Pterygota alata*, etc. The understorey is a tangle of shrubs, creepers, climbers, ferns, and orchids. The species were adapted to the hill ecosystems after a long successional process, but the exotic plantation species are becoming a major threat to natural ecosystems and their species. The deliberate preferences of economically important species (*Tectona grandis, Swietenia macrophylla*) through clear-felling followed by artificial regeneration eroded some of the native species and the genetic resources abruptly. Recent preferences of fast-growing species (*Eucalyptus camaldulensis, Acacia*

mangium, and *A. auriculiformis*) in plantation programs also encourages invasion by the pioneer colonizing species. Of these, the *A. auriculiformis* is dominating in all the plantation programs and growing well in all sorts of degraded lands. The paper highlights the preferences of exotic trees in plantation programs and possible threats of the exotics to native biodiversity of the hill forest ecosystems of the country.

Invasion and allelopathic effects of *Mikania cordata* in plantation forests of Bangladesh. Hossain, M. K., Anowar, S. (*Chittagong University, Bangladesh; mkhossain2009@gmail.com; anowar@yahoo.com*).

The spread and invasion of *Mikania cordata* in the plantation forests of Bangladesh is a serious concern due to its vigorous creeping and climbing habits. The health of young forest plantations is severely damaged by this noxious weed. The growth of the invasive weed species (*M. cordata*) is very fast and engulfs the young seedlings and saplings within 2–3 weeks in the rainy season and attains a height of more than 10 meters at maturity. The invasion of the weed significantly reduces the growth and yield of plantation forests of the country. The study was conducted in the laboratory of the Institute and showed that water soluble allelochemicals of *M. cordata* inhibits the germination and initial growth performance of both the selected agricultural (*Oryza sativa, Triticum aestivum, Vigna sinensis, Abelmoschus esculantus, and Amaranthus tricolor*) and forest crops (*Acacia auriculiformis, Albizia procera*, and *Paraserianthes falcataria*) in the nursery. To date the only control measure is the mechanical one, which increases plantation establishment costs significantly. Forest managers are looking for an alternative control measure of this noxious weed.

The dispersal and plant community characteristics of *Magnolia obovata* in urban forests. Kim, Y.H., Oh, C.H. (*Dongguk University, Republic of Korea; woodskyh@dreamwiz.com; ecology@dongguk.edu*).

The distribution and flow of naturalized plants have increased due to influence of human intervention, climate change, and urban heat islands. Among these, problems harmful to humans and ecosystems have occurred. The study of naturalized plants generally focuses on herbs from Korea. But recently, as the influence of naturalized plants on trees is spread, the study on this is needed. This study attempted to find out plant community structure, dispersal range and characteristics, and distribution of *Magnolia obovata* naturalized plants on trees, and its dispersal in urban forests. Survey results show that it was planted 30 years ago and spread in the study area. It has a characteristic appearance of interlayer in the plant community, being more shade-tolerant than other trees and faster than other trees in growth, and seeds are dispersed by gravity and by animals. The importance value between native plants and *M. obovata* had a negative relation in the plant ecosystem. Therefore, it would be necessary to manage the plants. For future research, studies of the germination percentage of natural forests, soil environment suitable for breeding, and seed biology, such as the use of animals in the field study, of *M. obovata* are needed.

Biodiversity loss due to tropical American weeds in Indian urban forests. Kohli, R.K., Singh, H.P., Batish, D.R. (*Panjab University, India; rkkohli45@gmail.com; hpsingh_01@yahoo.com; daizybatish@yahoo.com*).

Being rich in plant diversity, India has 3 of the 34 biodiversity hotspot zones. However, during the past few decades, due to various anthropogenic reasons including introduction of fast-growing exotic species or invasion of fast colonizing weeds, the native flora of the state is under severe threat of depletion. The urban landscape, though rich in vegetation, presents an unending kingdom of exotics at the cost of native plants. Absence of natural predators and allelopathic properties of some of these exotics play an important role in their invasiveness. This presentation deals with successful invasion by tropical American weeds in India. It shall discuss the distribution, density, and various ecological and biological characteristics of the weed favouring its fast spread in the state, with a view to understand its interference potential vis-à-vis its invasiveness (apart from the reasons of success): mechanism of invasion, colonization, and establishment of these invaders. The efforts of the government and public participation in dealing with the problem and relative management success shall also be discussed. Value addition to these invasives has opened new field of management practices.

G-09 Advances in forest pest surveillance and monitoring

Organizers: Zhen Zhang, *Chinese Academy of Forestry, China, zhangzhen@caf.ac.cn*; Steven Seybold, *U.S. Forest Service, USA, sseybold@fs.fed.us*; Jon Sweeney, *Natural Resources Canada, Canada, jsweeney@nrcan.gc.ca*

Monitoring forest insects in pest control and in conservation biology programs. Anderbrant, O. (*Lund University, Sweden; olle.anderbrant@ekol.lu.se*).

Following the isolation and identification of the first pheromone 50 years ago, the potential of pheromones and other chemical signals in plant and forest protection soon became clear. Today, various semiochemical-based methods are used for managing a wide range of insect pest species, including forest pests. Although the pheromones of a large number of forest insects are known, only relatively few are used regularly on a large scale. Some reasons for this are: (1) it is often difficult to obtain consistent and reliable relationships between trap catch and damage or economic losses, and (2) there is limited economic incentive for preventive forest protection when insects affect slow-growing, mainly northern, forest trees. However, future challenges such as climate change, human population increase, and preservation of biodiversity present new perspectives for monitoring programs. Baited traps can track not only pest insects, but also rare species. Examples that illustrate this new role of monitoring programs will be presented.

Relating bark beetle trap catch with beetle populations within trees and across stands. Hofstetter, R.W. (*Northern Arizona University, USA; rich.hofstetter@nau.edu*), Hayes, C., McMillin, J., Fettig, C.J. (*U.S. Forest Service, USA; cjhayes@fs.fed.us; jmcmillin@fs.fed.us; cfettig@fs.fed.us*), Ayres, M.P. (*Dartmouth College, USA; matt.ayres@dartmouth.edu*).

Bark beetles are found throughout the world, and the ecological and economic impact of beetle-caused tree mortality surpasses all other disturbances including fire and wind. Bark beetle abundances can vary greatly across regions and years and sometimes reach numbers in the billions within forests, such as observed recently in British Columbia, Canada and Colorado, USA. Quantifying bark beetle abundance can be difficult, and the relationship of trap captures to real abundances across spatial scales is not well-understood. Using various studies across multiple species, geographic ranges, and scales, we attempt to quantify the relationships between trap catches and beetle population densities and tree damage. Our results focus on the western pine beetle, *Dendroctonus brevicomis*, in western North America and the southern pine beetle, *D. frontalis*, in central and southern North America. We discuss whether monitoring pine bark beetle populations with pheromone-baited funnel traps or sticky traps is an effective means of predicting levels of beetle-caused tree mortality and how trap-catch data can be scaled up from local to landscape and regional levels.

Detection of alien insect pests and diseases on European and North American woody plants in Siberia. Kirichenko, N.I. (*V.N. Sukachev Institute of Forests, Russian Federation; nkirichenko@yahoo.com*), Péré, C. (*CABI Europe-Switzerland, Switzerland; c.pere@cabi.org*), Tomoshevich, M.A. (*Central Siberian Botanical Garden, Russian Federation; arysa9@mail.ru*), Baranchikov, Yu.N. (*V.N. Sukachev Institute of Forests, Russian Federation; baranchikov_yuri@yahoo.com*), Kenis, M. (*CABI Europe-Switzerland, Switzerland; m.kenis@cabi.org*).

We surveyed Siberian arboreta to identify poorly known pests and diseases that, if introduced into Europe and North America, may represent a danger for native woody plant species. The observations were carried out in the biggest Siberian cities: Novosibirsk, Krasnoyarsk, and Tomsk in 2008–2009. When damage was noticed on alien species, congeneric plants found at the same site were also inspected for comparison. About 70 woody plant species from Aceraceae (*Acer*), Betulaceae (*Alnus, Betula*), Caprifoliaceae (*Lonicera, Viburnum*), Fabaceae (*Caragana*), Rosaceae (*Rosa, Malus, Prunus, Crataegus*), Salicaceae (*Populus*), Tliliaceae (*Tilia*), and Ulmaceae (*Ulmus*), etc. were inspected. We found several highly damaging arthropod pests and pathogens on alien trees and shrubs. The majority of insect species belong to Hemiptera, mainly aphids, and Lepidoptera. The level of damage by external defoliators was similar on alien trees and native congeners in Siberia. In contrast, damage by leaf mining insects as well as their taxonomic diversity was significantly less on European and North American trees than on native Siberian plants. More than 60 pathogen species were detected on Eurasian, European, and North American woody plant species in Siberia. Within micromyceta, the species causing mildew were the most abundant on alien trees.

DNA barcode construction for Korean forest insect pests based on the Insect Mitochondrial Genome Database (IMGD). Lee, W.H., Park, J.S. (*Seoul National University, Republic of Korea; won9@snu.ac.kr; starflr@snu.ac.kr*), Choi, W.I., Jung, C.S. (*Korea Forest Research Institute, Republic of Korea; wchoi@forest.go.kr; csjung@forest.go.kr*), Lee, Y.H., Lee, S.H. (*Seoul National University, Republic of Korea; younglee@snu.ac.kr; seung@snu.ac.kr*).

DNA 'barcoding' has potential applications in insect pest monitoring and quarantine, and large numbers of DNA sequences for insect species identification have been reported in recent years. However, the exact number of relevant *COI* sequences in public databases such as NCBI (http://www.ncbi.nlm.nih.gov/) is not readily available. The insect mitochondrial genome database (IMGD; http://www.imgd.org) contains 164 completely sequenced mitochondrial genomes and 159,035 partially sequenced mitochondrial gene entries originated from 33,199 hexapod species; it makes it possible to check whether or not DNA sequences have been previously reported for certain insect species. In this study, we applied the IMGD to establish baseline data before constructing a DNA barcode system for Korean forest pest insects. Retrieving data from the IMGD, we recognized that DNA sequences were already available for 73 of 259 species recognized as forest pest insects in Korea. Most of the 73 species with DNA sequences are common pests worldwide, but the remaining 186 species are endemic to the Eastern Palearctic region. Based on these data, we are proceeding to construct a Korean Forest Insect Pest DNA barcode database.

Early detection of non-native bark beetles in the United States with pheromones and host volatiles. Rabaglia, R.J. (*U.S. Forest Service, USA; brabaglia@fs.fed.us*).

Native bark and ambrosia beetles are among the greatest threats to the heath of the natural and urban forests of the United States. The introduction and establishment of non-native species can severely impact the vitality and integrity of forest ecosystems. Since 1980, the number of non-native bark and ambrosia beetles established in the United States has doubled. The early detection, diagnosis, and response to non-native species have been identified as the most effective strategy for managing these invasive pests. In 2001, the USDA Forest Service initiated an early detection and rapid response project for non-native bark beetles. This project has identified a list of 10 high-risk target species that are threats to North American forests. Traps baited with either species-specific pheromones or generally attractive host volatiles are used in forested areas around high risk sites across the country. This project has detected seven species new to North America and has collected data on the response of native and non-native species to the semiochemicals. The responses of these species to the baited traps of the national program will be summarized in this presentation.

Detection of low-density invasive populations of the Mediterranean pine engraver, *Orthotomicus erosus*, in California with pheromone-baited traps. Seybold, S.J. (*U.S. Forest Service, USA; sjseybold@gmail.com*), Liu, D.-G. (*University of California-Davis, USA; dgliu@ucdavis.edu*), Venette, R.C. (*U.S. Forest Service, USA; rvenette@fs.fed.us*), Flint, M.L. (*University of California-Davis, USA; mlflint@ucdavis.edu*), Munson, A.S., Bulaon, B.M., Jorgensen, C.L. (*U.S. Forest Service, USA; smunson@fs.fed.us; bbulaon@fs.fed.us; cljorgensen@fs.fed.us*).

The Mediterranean pine engraver, *Orthotomicus erosus* (Wollaston) (MPE), is a non-native species that was first detected in North America in 2004. The invasive population is located in the southern Central Valley of California. In 2007 and 2008, mark-recapture trials with pheromone-baited flight traps were conducted in open agricultural fields to determine the intrinsic dispersal capacity of MPE for predicting population spread. Most recaptured beetles moved ≤500 m downwind in 20–60 min, but a few individuals moved 4 to 10 km in <24 hr. From these data, a distance-decay model predicted that approximately 40% of the population would move ≤500 m and approximately 98% would move <5.5 km. In 2009, transects of pheromone-baited funnel traps were placed in California, Idaho, and Utah, with an inter-trap distance of 10 km (chosen based on the mark-recapture trials).

The results suggest that MPE is not present in Idaho and Utah, and is still confined primarily to the southern Central Valley of California. However, this population appears to be expanding into the southern Sierra Nevada mountains near Sequoia National Park; a second, high-density population was detected in the Antelope Valley and appears to be expanding into the Angeles National Forest of southern California.

Occurrence and distribution of invasive forest insect pests in Korea after 2000. Shin, S.C, Choi, K.S., Choi, W.I. (*Korea Forest Research Institute, Republic of Korea; shinsc99@forest.go.kr; choiks99@forest.go.kr; wchoi@forest.go.kr*).

Insect pests are among the most destructive agents affecting forests and shade trees. Rising temperatures will induce frequent invasion of exotic forest insect pests. Exotic forest insect pests introduced to Korea after 2000 include the locust gall midge, *Obolodiplosis robiniae* and the fulgorid *Lycorma delicatula*. Locust gall midge was first found in 2002 and was already widespread, occurring almost country-wide; its host plant is black locust, *Robinia pseudo-acacia*. In 2009, *Platygaster robiniae*, a gregarious koinobiont endoparasitoid of the locust gall midge, was found in Korea with parasitism rates of greater than 50%. Damage by the locust gall midge was probably decreased due to the parasitoid. *Lycorma delicatula* was first discovered in Seoul and Kyunggi Province in 2006. Its favored host is tree of heaven, *Ailanthus altissima*, but it also attacks Japanese coral, *Viburnum awabuki* and Chinese elm, *Ulmus parvifolia*. Distribution and abundance of *L. delicatula* have increased exponentially since its discovery in Korea, suggesting that native natural enemies have had little negative impact on the pest populations. In 2009, *L. delicatula* had spread over 2/3 of Korea. Considering its favorable hosts, *A. altissim*, and grape vine, are distributed throughout Korea, *L. delicatula* has potential to invade the whole country.

Sex pheromone for monitoring flight periods and population densities of the pine sawfly, *Diprion jingyuanensis* Xiao et Zhang (Hym.: Diprionidae). Wang, H.B., Zhang, Z. (*Chinese Academy of Forestry, P. R. China; wanghb@caf.ac.cn; zhangzhen@caf.ac.cn*), Chen, G.F. (*General Station of Forest Pest Control, China; guofachen@sina.com*), Olle Anderbrant, O. (*Lund University, Sweden; olle.anderbrant@ekol.lu.se*), Hedenström, E., Högberg, H. E. (*Mid Sweden University, Sweden; hans- Erik.Hedenstrom@miun.se; erik.hogberg@miun.se*).

The pine sawfly, *Diprion jingyuanensis* Xiao et Zhang, is a serious pest of Chinese pine, *Pinus tabulaeformis* Carr., in northern China. We used synthetic pheromone to monitor the flight period and evaluate pheromone-baited traps as a possible tool for estimating and predicting population densities. The pheromone bait was a four-isomer (*threo*) mixture containing the active isomer (1*S*,2*R*,6*R*)-1,2,6-trimethyldodecyl propionate. The first flight peak of *D. jingyuanensis* occurred in mid-June during each year of a 3-year study (1997–1999); in 1997 and 1998 a second flight peak was recorded in mid-July. The flight period was similar for populations located at low- and high-elevation sites. Temperature was the main weather factor affecting trap catches. Diurnal flight activity began at 9:00, peaked at 13:00, and lasted until 20:00. Our results suggest that it will be important to standardize the trapping protocol in population monitoring studies. By using traps baited with 2 mg of pheromone, it is possible to detect sawfly occurrence at very low population densities. We found strong significant positive correlations between trap catch and relative population density (measured as percentage of attack on 100 randomly sampled trees), which underscores the promise of large-scale use of pheromone-based monitoring for *D. jingyuanensis*.

Semiochemical-based monitoring of an invasive species, red turpentine beetle (*Dendroctonus valens*). Zhang, Z., Wang, H.B., Liu, S.C., Sun, Y.M., Kong, X.B (*Chinese Academy of Forestry, China; zhangzhen@caf.ac.cn; wanghb@caf.ac.cn; suicunliu@163.com; yongmingsun72@yahoo.com.cn; xbkong@sina.com.cn*).

The red turpentine beetle (RTB), *Dendroctonus valens* LeConte, originally distributed in North and Central America, was introduced into China in the early 1980s. Since 1998, it has been a major mortality factor for *Pinus tabulaeformis* Carr. Field tests of the flight behavior verified that multiple funnel traps baited with the monoterpene (*S*)-(+)-3-carene can be used for monitoring RTB. RTB was trapped at sites even when the population could not be detected in the host. Monitoring over several years indicated that the RTB flight period ranged from late April to late August. Flight maxima occurred once in mid-May or twice in mid-May and mid-August. Damage and population levels of RTB were measured and we demonstrated that these attributes were correlated with trap catches. When the trap catch was below 20 beetles per trap, the number of pitch tubes ranged from 0 to 2 per 100 trees. Above this level management measures should be taken. A GIS-based management system was developed to manage the monitoring data and make population prediction. The techniques are used throughout the distribution of RTB in China.

G-10 Trends in wood and bark borer invasions and effects of policy

Organizers: Eckehard Brockerhoff, *Scion-New Zealand Forest Research Institute, New Zealand, eckehard.brockerhoff@scionresearch.com*; Robert Haack, *U.S. Forest Service, USA, rhaack@fs.fed.us.*

International policies, standards, and programmes to reduce wood and bark borer invasions Allen, E.A. (*Natural Resources Canada, Canada; eallen@nrcan.gc.ca*), Haack, R. (*U.S. Forest Service, USA; rhaack@fs.fed.us*), Brockerhoff, E. (*Scion/New Zealand Forest Research Institute, New Zealand; Eckehard.Brockerhoff@scionresearch.com*).

The international trade of wood commodities including wood packaging is well-recognized as a pathway for the movement of unwanted forest pests. For many years individual countries have attempted to reduce the influx of pests and the negative impacts on forests through the implementation of plant health import regulations. Member countries of the International Plant Protection Convention (IPPC) have published international standards aimed at providing guidance for the development of national plant health regulations (e.g., ISPM No. 15) with the goal of attaining harmonized regulatory approaches. In addition to regulatory standards, internationally recognized diagnostic methods and phytosanitary treatments to kill, inactivate, or remove forest pests are

being pursued. Challenges to this process include issues such as: defining adequate levels of treatment efficacy, identifying pest organisms for treatment testing, and finding effective methodologies that are technologically attainable by both developed and developing countries. International standards and protocols need to be based on sound scientific principles. Analysis of forest quarantine issues is carried out by the IPPC-Technical Panel on Forest Quarantine, which is assisted by the International Forestry Quarantine Research Group (IFQRG) to undertake data syntheses and research.

Using border interception records to estimate borer arrival rates and effects of phytosanitary policy. Brockerhoff, E.G., Bain, J. (*Scion/New Zealand Forest Research Institute, New Zealand; eckehard.brockerhoff@scionresearch.com; john.bain@scionresearch.com*), Cavey, J.F. (*Animal and Plant Health Inspection Service (APHIS), USA; joseph.f.cavey@aphis.usda.gov*), Haack, R.A. (*U.S. Forest Service, USA; rhaack@fs.fed.us*), Kimberley, M. (*Scion/New Zealand Forest Research Institute, New Zealand; mark.kimberley@scionresearch.com*), Liebhold, A.M. (*U.S. Forest Service, USA; aliebhold@fs.fed.us*).

Knowledge about pest arrival rates is an important prerequisite to understanding invasion risks and the benefits of phytosanitary policy regulating high-risk pathways. Border interception records and the results of detailed surveys are the best information sources available to gain insights about actual arrival rates. We used border interception data from the United States and New Zealand from shipments originating from all over the world as a proxy for relative arrival rates of bark beetles and longhorned beetles. These groups include the majority of high-impact borer species that have become successful invaders. Using interception data going back to 1950 and establishment records we modelled the relationship between interceptions and establishments. This enabled us to evaluate several efficacy scenarios of phytosanitary policy aimed at reducing invasions of borers transported with solid wood packaging materials. The results indicate that the success of phytosanitary policy varies among species depending on their arrival rate, in a non-linear fashion. The effects will be greatest for less frequently arriving species while for the most frequent arrivals, reductions in arrival rate will result in less pronounced reductions in establishment, unless a phytosanitary policy is highly effective. This approach is useful for cost-benefit analyses of phytosanitary policy measures.

Risks of bio-invasion through import of wood and adoption of phytosanitary measures in India. Devi, R. (*Institute of Wood Science and Technology, India; okremadevi@icfre.org*).

As a measure to reduce the pressure on forests, the Government of India has imposed a complete ban on felling of trees, but the import policy has been liberalized and the liberalized trade of wood imports has a great potential to increase bio-invasion. About 119 timber species are being imported currently from Myanmar, Indonesia, Malaysia, Nigeria, Australia, and African countries. The information on intruders arriving in India through imported wood and wood products is scanty. No authentic data were available on the fungi that invaded through imported wood. A survey was conducted in different ports (Mangalore, Tuticorin, Mumbai, Kandla, Kolkata, and Andaman and Nicobar Islands) during 2003–04 to study invasion of insects and fungi through import of wood and wood products. Some 926 insects belonging to 55 species under 17 families, and 22 types of fungi (from 13 genera), were collected from different species of wooden logs. Most of the species are new introductions to India and one ant, *Acanthomyrmex* spp., belongs to a new genus identified for the first time from India. The present paper deals with the bio-invasive risks associated with import of wood and wood products into India and the current status of SPS measures are discussed.

Borer invasions in North America: Buprestidae, Cerambycidae, and Siricidae. Haack, R.A. (*U.S. Forest Service, USA; rhaack@fs.fed.us*).

The world's forests are threatened by exotic forest insects and diseases. Wood packaging material (WPM) used in international trade, such as pallets and crating, is an important pathway for the worldwide spread of bark- and wood-infesting insects, especially borers. In North America (i.e., the continental United States and Canada), numerous exotic borers have been discovered in recent decades, including species of jewel beetles (Buprestidae), longhorned beetles (Cerambycidae), and woodwasps (Siricidae). Information will be presented on arrival rates of these exotic borers in North America, the states and provinces where they were first discovered, the likely means of their arrival, likely countries of origin, tree species at risk, current pest status, regulatory actions taken to control their spread, and eradication efforts. Case studies on the Asian longhorned beetle (*Anoplophora glabripennis*), brown spruce longhorned beetle (*Tetropium fuscum*), emerald ash borer (*Agrilus planipennis*), and sirex woodwasp (*Sirex noctilio*) will be presented. International efforts to reduce live pests in WPM, such as ISPM No. 15, will be discussed. In addition, given that firewood poses a risk for human-assisted movement of exotic borers, information will be provided on U.S. efforts to regulate firewood movement and treatment.

Xylophagous insects' succession and tree fitness: two novel viewpoints on insect occurrences from living tree to wood detritus. Iwata, R. (*Nihon University, Japan; iwata@brs.nihon-u.ac.jp*).

Wood is formed at cambial region and is occasionally attacked by primary subcortical borers. If the tree dies or is felled, dead wood mass emerges, and organisms immediately begin to attack and decompose it. If it is retained as construction or working material, it has a long lifetime, but if abandoned, it is immediately subjected to the decomposition by organisms. Wood detritus, as produced by wood decomposition process, is further subjected to the decomposition by soil organisms. These processes, considered together, give a succession scheme of xylophagous insects. Special references are given to Cerambycidae (longhorn beetles) and Isoptera (termites) as representative xylophagous insect groups, occuring at almost all the phases. Also, in so far as the interactions between the xylophagous insects and living trees are concerned, the tree's interest from the viewpoint of "fitness" (as an ecological term) should be considered, as opposed to the economic interest. This leads to that several important primary borer pest species do little harm to the host tree, as their attacks do not affect the host tree's fitness, but cause economic loss of wood only. These two novel viewpoints may contribute to the strategies of controlling borers and their invasion.

Introduced and exported bark and ambrosia beetles in North and South America. Rabaglia, R. J. (*U.S. Forest Service, USA; brabaglia@fs.fed.us*).

The movement of bark- and wood-boring insects into and out of North and South America has been occurring for more than 100 years. In 1977, Steve Wood documented the movement of bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae)

up to that time. In the past 30 years, there have been an increasing number of these beetles established in the Americas, as well as American species becoming established elsewhere. Several of these species have caused damage to urban and rural forests. Historically, *Scolytus multistriatus*, vectoring the fungus that causes Dutch elm disease, has caused extensive tree mortality across the Untied States. The recent establishment and mortality of trees caused by *Xyleborus glabratus* and its fungal associate in the southeastern United States has increased awareness and concern about these species. This presentation will discuss the species that have been introduced and exported from North and South America; document the increasing numbers of species being introduced and established; and discuss impacts, patterns, and commonalities with these establishments. In addition, information will be presented on national surveys being conducted in the United States to detect new exotic borers.

Current trends in introduction of exotic tree-infesting borers in Europe. Roques, A. (*INRA, France; alain.roques@orleans.inra.fr*).

A total of 65 alien insect species are presently observed in Europe to develop as xylophages on woody plants and untreated wood. Coleopterans account for more than 80% of species with long-horned beetles (Cerambycidae), followed by bark and ambrosia beetles (Scolytidae), as the major groups. Along with globalization, the rate of arrival of new xylophagous species in Europe exponentially increased from 0.2 /yr during the first half of the 20th century to 0.8/yr during the period 1975–2000, to reach 1.1/yr during 2000–2008. Asia turned to be the main supplier of introduced species beyond North America, whereas a few species came from South America (e.g., poplar ambrosia beetle) and Australasia (eucalyptus borers). Most species were never intercepted at the European borders by phytosanitary services, but some other frequently intercepted species never established. At present, the trade of ornamentals, including bonsais, contributes more to introductions than does the timber trade. Most introduced xylophages are polyphagous and switched on European trees but about a quarter of the species develop only on their original, exotic host also planted in Europe. In most cases, the species spread is still limited in Europe, with a larger presence on trees planted in man-made habitats than in forests.

Wood borers invasion and their management in China. Sun, J. (*Chinese Academy of Sciences, China; sunjh@ioz.ac.cn*).

With trade globalization, invasive forest pests are becoming an ever increasing challenge facing us. China is no exception in this aspect. In fact, we are one of the most impacted countries by invasive species, with 50 of the 100 most invasive species by IUCN. General forest invasive species information will be overviewed briefly in this presentation, followed by more details on invasive wood borers reported in China, such as *Denroctonus valens* LeConte, *Rhynchophorus ferrugieus* (Olivier), *Quadrastichus erythrinae* Kim, etc., with their likely origin countries, damage they caused, current pest status, and management measures taken. Emphasis will also be given on policy effects caused by those invasions and subsequent internal phytosanitary policy impacts on controlling further spread of those invasive species. In addition, a case study on red turpentine beetle, *D. valens* LeConte, will be presented as well, to illustrate the importance of international collaboration in combating forest invasive species. Another case study on pine wood nematode will also be included as it is a major concern in Asian countries and more so for Europe now; recent progress on its detection and control will be discussed.

Demonstrating the benefits of phytosanitary regulations: the case of ISPM 15 for the United States. Turner, J.A. (*New Zealand Forest Research Institute., New Zealand; james.turner@scionresearch.com*), Springborn, M. (*University of California-Davis, USA; mspringborn@ucdavis.edu*), Britton, K. (*U.S. Forest Service, USA; kbritton01@fs.fed.us*), Brockerhoff, E. (*New Zealand Forest Research Institute., New Zealand; eckehard.brockerhoff@scionresearch.com*), Cavey, J.F., Garrett, L.J. (*Animal and Plant Health Inspection Service (APHIS), USA; joseph.f.cavey@aphis.usda.gov; lynn.j.garrett@aphis.usda.gov*), Haack, R.A. (*U.S. Forest Service, USA; rhaack@fs.fed.us*), Lowenstein, F. (*The Nature Conservancy, USA; flowenstein@tnc.org*), Marasas, C. (*Animal and Plant Health Inspection Service (APHIS), USA; carissa.marasas@aphis.usda.gov*), Nuding, A. (*University of California-Santa Barbara, USA; nuding@nceas.ucsb.edu*).

Economic evaluation of phytosanitary regulations to reduce risk from invasive forest pests has been hampered by the absence of an adequate analytic framework supported by pertinent data. Lack of an analytic framework makes it difficult to determine potential ecological and economic benefits of proposed regulations and weigh these benefits against possible trade costs. A framework incorporating ecological and economic components of trade and invasive pests was developed to assess averted pest damages and lost gains from trade by linking phytosanitary regulations to changes in pest infestation, arrival, and establishment rates and subsequent impact. This framework was used to analyse the benefits and costs to the United States of implementing the phytosanitary regulation ISPM No. 15 in 2006 to reduce the incidence of bark- and wood-infesting insects (e.g., Cerambycidae and Scolytidae) in wood packaging material associated with imports. Trade and pest interception data were analyzed to assess the extent to which ISPM No. 15 led to a reduction in live pests. The consequent averted damages are compared to the trade costs of the regulation. Applications of this approach to support decision making around ISPM No. 15 and other phytosanitary policies to reduce risks from invasive forest pests will be discussed.

Posters

Identification of stem borer and damage characteristics in Melina (*Gmelina arborea*) plantations. Triyogo, A., Sumardi, Trisyono, Y.A. (*Gadjah Mada University, Indonesia; triyogo99@ugm.ac.id*).

Gmelina arborea is one of the important trees for forest plantation. It is used for pulp, paper, and plywood. Considering that *G. arborea* is an exotic species, it may be considered to be at high risk for pest and disease infestations. This research was aimed to study the biological characteristics, attack pattern, and distribution of stem borers. Studies were conducted in PT. Sumalindo (East Kalimantan). The sampling plot was 20 × 20 m^2, and the plants were stratified based on the plant age. Observations were directed to determine the species of stem borers and the damage they caused. *Xyleutes ceramica* and *Acalolepta rusticatrix* were documented attacking *G. arborea*, with their damage intensity of 13% and 54.8%. These insects attacked 22% and 64.4% of the plant plantation.

G-11 Molecular ecological and evolutionary perspectives on changing populations of forest insects and their symbionts

Organizer: Bernard Slippers, *University of Pretoria-FABI, South Africa, bernard.slippers@fabi.up.ac.za.*

Insect vector of pinewood nematode carries many *Wolbachia* genes on an autosome. Aikawa, T. (*Forestry and Forest Product Research Institute, Japan; taikawa@ffpri.affrc.go.jp*), Anbutsu, H. (*National Institute of Advanced Industrial Science and Technology, Japan; h-anbutsu@aist.go.jp*), Nikoh, N. (*The Open University of Japan, Japan; nikoh@u-air.ac.jp*), Kikuchi, T. (*Forestry and Forest Product Research Institute, Japan; kikuchit@ffpri.affrc.go.jp*), Shibata, F. (*Ehime University, Japan; fukashishibata@hotmail.com*), Fukatsu, T. (*National Institute of Advanced Industrial Science and Technology, Japan; t-fukatsu@aist.go.jp*).

The longicorn beetle *Monochamus alternatus* is notorious as vector of the pinewood nematode *Bursaphelenchus xylophilus*, which causes the pine wilt disease. In Japan and other Asian countries, the disease is responsible for loss of millions of pine trees annually, making the beetle a most important forestry pest. In an attempt to seek for symbiont-mediated control strategies for the insect, we surveyed *Wolbachia* infections in natural populations of *M. alternatus*. Certainly *Wolbachia* genes were detected, but, unexpectedly, they were inherited biparentally, exhibiting a typical Mendelian inheritance. The *Wolbachia* gene titers in homozygotic positive insects (++) were nearly twice as high as those in heterozygotic positive insects (+–). Exhaustive PCR surveys revealed that approximately 14% *Wolbachia* genes were detected from the insect. Fluorescent *in-situ* hybridization confirmed the location of the *Wolbachia* genes on an autosome. On the basis of these results, we conclude that a large *Wolbachia* genomic region has been transferred to and located on an autosome of *M. alternatus*. The discovery of massive gene transfer from *Wolbachia* to *M. alternatus* would provide further insights into the evolution and fate of laterally transferred endosymbiont genes in multicellular host organisms.

The fungus garden microbiome of leaf-cutter ants. Currie, C.R., Suen, G. (*University of Wisconsin-Madison, USA; Currie@bact.wisc.edu; gsuen@wisc.edu*).

For ca. 50 million years, fungus-growing ants (Formicidae: Attini)have been farming fungus for food. The culmination of fungus-growing in ants is the leaf-cutters, which use fresh leaf substrate to cultivate their mutualistic fungus (Basidiomycota: Agaricales). Through various methods, including 454 metagenomic sequencing, we are investigating the microbial communities in the fungus garden of the leaf-cutting ant Atta colombica. We first demonstrate that lignocellulose is degraded by measuring cellulose content of leaf-material as it passes through the garden. Then, though 16S rDNA sequence analysis and community metagenomics, we find that the microbial community is dominated by bacteria that belong to the Enterobacteriacea. Using these data, we performed directed culturing to obtain representative isolates of these microbes, and perform functional assays and genome sequencing that confirm their putative roles within the garden. Through these diverse approaches, including metgenomics and whole genome sequencing, we provide evidence that leaf-cutter ants employ a diverse community of microbial symbionts to aid in the deconstruction of plant biomass, likely facilitating their dominate role as herbivores in New World tropical forest ecosystems.

Genetic diversity and source of the invasive *Eucalyptus* pest, *Thaumastocoris peregrinus*, and its potential biological control agent, *Cleruchoides noackae*. Nadel, R.L., Wingfield, M.J. (*University of Pretoria, South Africa; Ryan.Nadel@fabi.up.ac.za; Mike.Wingfield@fabi.up.ac.za*), Scholes, M.C. (*University of the Witwatersrand, South Africa; Mary.Scholes@wits.ac.za*), Lawson, S.A. (*Queensland Primary Industries and Fisheries, Australia; Simon.Lawson@deedi.qld.gov.au*), Noack, A.E. (*University of Sydney, Australia; a.noack@usyd.edu.au*), Neser, S. (*University of Pretoria, South Africa; nesers@arc.agric.za*), Wilcken, C.F. (*Sao Paulo State University, Brazil; cwilcken@fca.unesp.br*), Bouvet, J.P. (*INTA, Argentina; jbouvet@correo.inta.gov.ar*), Slippers, B. (*University of Pretoria, South Africa; Bernard.Slippers@fabi.up.ac.za*).

Cleruchoides noackae is a potential biological control agent for *Thaumastocoris peregrinus*, a pest of non-native *Eucalyptus* plantations in South Africa and South America. Specimens representing native populations of *T. peregrinus* and *C. noackae* were collected from Southeast Queensland, Sydney, and Perth in Australia, as well as non-native populations in South Africa and South America. The CO I mitochondrial DNA (mtDNA) diversity was established for all populations and these revealed two cryptic *Thaumastocoris* species, in addition to *T. peregrinus* in the native populations. The CO I mtDNA sequence data revealed 8 unique haplotypes in *T. peregrinus* populations, compared to 24 haplotypes in corresponding *C. noackae* populations. The distribution of CO I haplotypes for *T. peregrinus* was not geographically structured in native populations. Furthermore, the data suggest that there have been two introductions of the pest into South Africa, and an independent introduction into South America, most likely from urban centres in Australia. The CO I haplotypes for *C. noackae* populations in Southeast Queensland and Sydney resided in two distinct clusters, indicating low gene flow between populations. The Perth population of *C. noackae* represented four haplotypes, two of which were shared with those occurring in Sydney, suggesting a possible introduction into Perth.

Diversity, symbiosis and control: A molecular case study of *Sirex noctilio*, *Amylostereum areolatum* and *Deladenus siricidicola*. Slippers, B., Hurley, B.P., Van der Nest, M., Mlonyeni, O.X., Boissin, E., Wingfield B.D., Wingfield M.J. (*University of Pretoria, South Africa; bernard.slippers@fabi.up.ac.za; brett.hurley@fabi.up.ac.za; magriet.vdnest@fabi.up.ac.za; osmond.mlonyeni@fabi.up.ac.za; emilie.boissin@fabi.up.ac.za; brenda.wingfield@fabi.up.ac.za; mike.wingfield@fabi.up.ac.za*).

Sirex noctilio (woodwasp), *Amylostereum areolatum* (basidiomycete fungus), and *Deladenus siricidicola* (nematode) exist in an obligate symbiosis. The woodwasp and fungus have a mutualistic relationship where the wasp mainly derives nutritional benefits from the fungus, which in turn acquires protection and a mode of dispersal. In two distinct parts of its life-cycle, the nematode feeds on the fungus and later parasitizes the wasp. The wasp and fungus have been introduced into new environments where they are invasive on various *Pinus* spp. In these non-native plantations, the wasp/fungus mutualists have caused killed large numbers of

trees. The introduction of the parasitic nematode has been used to provide control in such situations, and has been successful in many, but not all environments. Molecular data from microsatellite markers and single nucleotide sequence polymorphisms have revealed that the populations of all three organisms have gone through severe bottlenecks during the processes of unintentional and intentional introductions. The genetically uniform populations result in two complications; a potential mismatch of co-evolved genotypes and a lowered potential to adapt to changing environments. Understanding the genetic diversity and interactions of these organisms has not only revealed the history of their introductions, but has also contributed to optimizing control efforts.

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Colonization dynamics of Japanese populations of *Xylosandrus germanus* (Curculionidae: Scolytinae) based on mitochondrial DNA sequencing. Masaaki, I., Hisashi, K. (*Nagoya University, Japan; ito.masaaki@a.mbox.nagoya-u.ac.jp; kajimura@agr.nagoya-u.ac.jp*).

We examined the genetic structure of populations of an ambrosia beetle, *Xylosandrus germanus* (Curculionidae: Scolytinae), to understand its colonization dynamics. We collected specimens from 18 sites in Japan and studied the genetic structure of these populations using portions of the mitochondrial cytochrome oxidase I gene (*COI*). A phylogenetic analysis revealed three distinct lineages (clades A, B, and C) within *X. germanus*. Clade A contained 34 haplotypes from all the 18 populations; clade B contained 11 haplotypes from 5 populations of northern and eastern Japan and one western population; and clade C contained only a single haplotype from two northern populations. In the analysis of molecular variance, genetic variation was detected between populations in Hokkaido and most populations in the other three main islands. Between these two groups of populations, all the values of the coefficient of gene differentiation were significantly larger than zero, except for a few combinations. Nested clade phylogeographic analysis showed that restricted gene flow with isolation by distance was inferred for most clades with significant geographical association. Our results suggest that the gene flow of *X. germanus* has been interrupted between Hokkaido and Honshu in northern Japan after the last glacial maximum.

Genetic analysis of central European cockchafer species. Mészáros, B., Lakatos, F. (*University of West-Hungary, Hungary, m.baalint@gmail.com; flakatos@emk.nyme.hu*), Stauffer, Ch. (*University of Natural Resources and Applied Life Sciences, Austria, christian.stauffer@boku.ac.at*), Arthofer, W. (*University of Innsbruck, Austria, wolfgang.arthofer@uibk.ac.at*).

Cockchafers are widespread pest species throughout central Europe. Economically important species include the European cockchafer (*Melolontha melolontha* Linnaeus), the large cockchafer (*Melolontha pectoralis* Germar), and the forest cockchafer (*Melolontha hippocastani* Fabricius). The European cockchafer is divided into seven tribes in the Carpathian basin. The four Alpine tribes have a 4-year life cycle while three lowland tribes complete their life cycle in 3 years and inhabit lowland areas of Hungary. In the present work we investigated the genetic differences among the three species and the three lowland tribes. We compared a 1,188 bp fragments of the cytochrome oxidase (COI) gene of the mitochondrial DNA (mtDNA) from 44 *M. melolontha*, 6 *M. hippocastani*, and 11 *M. pectoralis* individuals from Hungary and Austria. A sequence divergence of 12.3% was found between *M. melolontha* and *M. hippocastani*; 13.0% between *M. hippocastani* and *M. pectoralis*; and 5.1% between *M. melolontha* and *M. pectoralis*. A 0.25% difference was found within *M. melolontha* populations. No subdivision into lineages representing the three tribes was found; however, some geographical patterns were observed.

G-12 Oak decline in the world

Organizers: Naoto Kamata, *University of Tokyo, Japan, kamatan@uf.a.u-tokyo.ac.jp*; Kazuyoshi Futai, *Kyoto University, Japan, futai@kais.kyoto-u.ac.jp.*

Sudden oak death in California: linking biology and disease management. Garbelotto, M. (*University of California-Berkeley, USA;matteog@berkeley.edu*), Rizzo, D.M. (*University of California-Davis, USA; dmrizzo@ucdavis.edu*), Menteermeyer, R. (*University of North Carolina, USA; rkmeente@uncc.edu*).

Sudden oak death (SOD) was first described in California in the mid-1990s and its causal agent, *Phytophthora ramorum*, was discovered less than 10 years ago. The biology of the pathogen and its epidemiology are briefly discussed, with an emphasis on how they are directly contributing to formulate viable and effective management and regulatory prescriptions. A strong educational effort is currently underway to help local communities implement these management options, and to compare projected disease impacts on coastal oak woodlands in the presence and in the absence of active disease management. Strong evidence indicates the causal agent is exotic and that it was introduced multiple times in North America through the sale of infected ornamental plants. The SOD epidemic thus provides one of the best examples of how forest health is at risk because of collateral effects of economic activities often totally unrelated to forestry and forest uses. It also provides a vivid example of how modern technologies can be used to better our understanding of the epidemiology of the disease and of how basic and applied research are inextricably intertwined and both needed to formulate practical disease management guidelines.

Oak (*Quercus*) decline around the world: a review. Gottschalk, K.W., Long, R.P., Wargo, P.M. (*U.S. Forest Service, USA; kgottschalk@fs.fed.us; rlong@fs.fed.us; pwargo@fs.fed.us*).

Oak decline is ubiquitous, occurring everywhere oak forests grow in the northern hemisphere. Because of the large number and diversity of oak species and the large range of sites and conditions where oak forests grow, many oak species experience decline, although some species seem to be affected more than others. A review of the world literature on oak decline will be presented. Several models of oak decline will be summarized. Using the decline disease spiral model of Manion (1991), predisposing factors, inciting factors, and contributing factors will be elucidated for these oak decline events. The relationship between the various decline stages will be used to compare and contrast oak decline around the various regions of the world. Common predisposing factors include soil and stand factors, genetics, age, and pollution. Common inciting factors include defoliating

insects and diseases, frost, drought, and mechanical damage. Common contributing factors include opportunistic insects and diseases. Despite the wide variety of species and sites, the oak decline process, symptoms, and associated organisms are surprisingly similar. Recent developments in oak decline include the introduction of non-native invasive species. Some of these species fit into this traditional oak decline model but others act in a more direct fashion.

Occurrence and severity of *Ceratocystis fagacearum*-caused oak wilt in the United States. Juzwik, J. (*U.S. Forest Service, USA; jjuzwik@fs.fed.us*).

Oak wilt attributed to the fungus *Ceratocystis fagacearum* causes rapid crown wilt in red oak species, resulting in tree death within 1 year. Most live oaks and many white oak species either die within several years or exhibit extensive crown dieback following infection. Oak wilt is only known to exist in the United States, where it is found in the central and eastern regions. Expansion of the disease range before 1951 is likely due to disease recognition rather than spread. Expansion in the past 30 years has been uncommon and unpredictable. Despite wide disease distribution, oak wilt severity ranges from low to high within regions and within some affected states. Although impact has been hard to quantify, oak wilt remains at epidemic levels in urban and rural forests of central Texas and portions of Michigan, Minnesota, and Wisconsin. In a number of states, oak wilt is primarily of concern in urban forests. Epidemics in Texas have been exacerbated by dominance of live oaks in affected ecosystems due to the common root systems associated with the natural, clonal reproduction characteristic of the species. The abundance of red oak species is also important in development of epidemics in Texas and Midwestern states.

Oak decline caused by ambrosia beetle/*Raffaelea* complex in Japan and Korea. Kamata, N. (*University of Tokyo, Japan; kamatan@uf.a.u-tokyo.ac.jp*), Kim, K-H. (*Korea Forest Research Institute, Korea; kyung624@forest.go.kr*).

In Japan, mass mortality of Fagaceae trees related to *Platypus quercivorus* have been reported since the 1930s and have been epidemic and expanding in range since the late 1980s. It was proved that this mortality was caused by the fungus *Raffalea quercivora* carried by the ambrosia beetle *P. quercivorus*, which was recorded from Japan, Taiwan, Indonesia, and India. However, no incidences of the disease have been reported in countries other than Japan. Tree mortality by this disease is highest for *Quercus crispula* followed by *Q. serrata*, and mortality of evergreen species is relatively low. On the other hand, in Korea, incidences of similar symptoms suddenly emerged in 2004 and have expanded in range much more rapidly than in Japan. In Korea, the vector insect is *P. koryoensis* and the pathogen was identified as a new species and described as *Raffaelea quercus-mongolicae*. Tree mortality is highest for *Q. mongolica* followed by *Q. serrata*. It is interesting that similar symptoms are threatening oaks both in Japan and Korea although their species (plant-pathogen-insect) differ. Similarities and dissimilarities in oak wilt diseases in the two countries will be summarized. Recent progress of research on control tactics and on allelochemicals will also be presented.

Microorganisms associated with oak wilt diseases in Korea. Kim, S.H., Suh, D.Y. (*Dankook University, Republic of Korea; piceae@dankook.ac.kr; seozom@naver.com*), Kim, K.H. (*Korea Forest Research Institute, Republic of Korea; kyung624@forest.go.kr*).

Oak wilt disease mediated by the infestation of an ambrosia beetle, *Platypus koryoensis*, has been threatening forest health in Korea. A *Raffaelea* fungus vectored by the beetle is considered to be the casual agent of the disease. However, the mechanism of oak tree death has not been clearly elucidated yet. In an effort to find if there are other microbiological elements that are associated with the beetle, we investigated cultivable microorganisms from oak trees infested by *P. koryoensis. P. koryoensis*-infested *Quercus mongolica* trees grown at five different locations in Korea were sampled at different seasons from 2007 to 2009. Bacteria, yeast, and filamentous fungi were isolated from egg galleries of *P. koryoensis* formed inside the sampled oak wood. They were also isolated from larvae and adult beetles of *P. koryoensis* caught in the sampled wood. Sixteen species of bacteria belonging to 11 genera, 8 species of yeast belonging to 6 genera, and 10 species of fungi belonging to 12 genera were identified. *Serratia* and *Raoultella* were major bacterial genera. *Pichia guilliermondii* was the common species in yeast. In fungi, *Raffaelea* spp. was also commonly isolated. The physiological and biochemical properties of the isolated microorganisms are presented.

Research on oak decline disease in Spain. Sanchez, G. (*Direcccion General de Medio Natural y Política Forestal, Spain; gsanchez@mma.es*), Tuset, J.J., Hinarejos, C., Mira, J.L. (*Instituto Valenciano de Investigationes Agrarias (IVIA), Spain; jjtuset@ivia.es; chinare@ivia.es; jlmira@ivia.es*), Prieto, M. (*Direcccion General de Medio Natural y Política Forestal, Spain; mprieto@mma.es*).

Holm oak and cork oak are *Quercus* species affected by oak decline ("seca" in Spanish) in Spain. *Phytophthora cinnamomi* is the soil fungus associated with this disease. Since 1991 this fungus has been isolated from feeder roots of both oak species and is considered the main cause of oak decline. Disease symptoms have been obtained by inoculating mycelium and zoospores of *P. cinnamomi* both in adult trees in the field and in seedlings (2 years old) in the greenhouse. Studies on disease dynamics—zoospore production, influence of cations and anions in fungal development, influence of soil moisture, host-pathogen interaction, and zoospore infection—have been carried out over the past 15 years in both laboratory and greenhouse. To achieve disease control, in 2001 an experimental plot was established in an area heavily contaminated by *P. cinnamomi* where six Mediterranean *Quercus* species were planted. Seven years after planting, all seedlings from species susceptible to the fungus were treated by soil application with aluminum phosphate, mefenoxam, *Myrothecium* liquid extract, and phosphorous acid. These treatments will be continued for another 5 or 6 years. At the same time, a monitoring control was designed to determine the behavior of treated trees under these controlled conditions.

Goldspotted oak borer: a surprising primary mortality agent on oaks in southern California. Seybold, S.J., Coleman, T.W. (*U.S. Forest Service, USA; sjseybold@gmail.com; twcoleman@fs.fed.us*).

A new threat to oaks in California was identified in June 2008 following years of misdiagnosis. The goldspotted oak borer (GSOB), *Agrilus coxalis* Waterhouse (Coleoptera: Buprestidae), is aggressively attacking and killing three species of oaks in San Diego County. About 17,000 coast live oaks (*Quercus agrifolia*), California black oaks (*Q. kelloggii*), and canyon live oaks

(*Q. chrysolepis*) have died in a 1,200-km^2 area centered on the Descanso Ranger District, Cleveland National Forest, and Cuyamaca Rancho State Park. Oak mortality has been continuous for the past 6 years and occurs on all land ownerships. Since GSOB is native to southeastern Arizona, Guatemala, and Mexico, and the indigenous population has never been associated with tree injury or mortality, we hypothesize that the elevated oak mortality in southern California has occurred because of an absence of evolved host resistance in native oaks and/or an absence of natural enemies found in GSOB's native range. The native distributions of California hosts of GSOB extend north through most of the state, along the coastal foothills and the Sierra Nevada. Thus, this new pest to oaks has the potential to cause a more widespread decline of oaks in more northerly regions in California, and perhaps beyond.

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Damage grade of Mongolian oak on the basis of entry hole number formed by *Platypus koryoensis* (Coleoptera: Platypodidae). Choi, K.S., Choi, W.I., Lee, J.S. (*Korea Forest Research Institute, Republic of Korea; choiks99@forest.go.kr; wchoi@forest.go.kr; jscrown@nate.com*).

An ambrosia beetle, *Platypus koryoensis*, is known to be a major vector of Korean oak wilt disease (KOW) in Mongolian oak and is considered a serious forest health threat. We assessed Mongolian oak damage by ambrosia beetles on the basis of entry hole density and location within the trunk. We randomly selected 240 Mongolian oak trees from Mt. Uamsan and 60 oak trees from Mt. Gyebangsan and measured degree of damage to an individual tree, DBH, and entry hole density per 148- × 210-mm^2 sample area on lower trunk (surface) and upper trunk (100 cm above surface) in both upslope and downslope tree sides. Degree of damage was divided into 3 classes: healthy trees, trees damaged by ambrosia beetles, and trees killed by KOW). As degree of damage to Mongolian oak increased, the number of entry holes increased regardless of their locations. Ambrosia beetles preferred to attack the lower trunk on the downslope side. In addition, average DBH of oak trees increased with increase in degree of damage, suggesting ambrosia beetle preferred to attack older trees. Entry hole densities of lower and upper trunk on the downslope side were principal components to explain the degree of damage on Mongolian oak.

What are the trends for oak (*Quercus* spp.) species in the forests of Iran? Ghanbari, S., Sefidi, K. (*University of Tehran, Iran; ghanbarisajad@gmail.com; kiomarssefidi@gmail.com*).

Oak species (*Quercus* spp.) are among the main species of Iranian forests and are considered the dominant species in Zagros and Arasbaran forests. About 70 percent of these two important forests and 7% of the Hyrcanian zone are composed of oak with an area of approximately 3,738,000 hectares. During recent decades, the oak forest area has decreased from 10 million hectares in 1950 to 3.7 million hectares in 2004. Constant reduction of the forest species is a serious danger for biodiversity and sustainable forest management (SFM). Therefore, this study examines the past trend of oak species and ways to prevent its destruction. This research was conducted using both published literature and direct observations. Results showed that 11 pest and disease species—as well as abundant socio-economic factors such as use of oak fuelwood, livestock feeding, soil erosion due to high animal density, and insufficient seed trees for regeneration—play a vital role in oak destruction. To prevent the destruction of oak and other species requires consideration of socio-economic problems and dependence of local people on the forest, improvement of agriculture and animal husbandry methods, replacement of fuelwood with fossil fuel, and development of agroforestry systems.

Selection of antagonistic basidiomycetes strains against *Raffaelea quercus-mongolicae* causing oak wilt in Korea. Jeon, S. M., Ka, K.H., Kim, K.H. (*Korea Forest Research Institute, Republic of Korea; labsky@hanmail.net; kasymbio@forest.go.kr; kyung624@forest.go.kr*).

This study was conducted to determine a method for using oak trees infected by the pathogen causing oak wilt. One hundred fifty-eight strains of basidiomycetes were screened for their antagonistic activity against *Raffaelea quercus-mongolicae* by pairing cultures on potato dextrose agar (PDA) medium. Twenty-nine strains (18.3%) of the tested mushrooms showed strong antagonistic activity against *R. quercus-mongolicae*, whereas no activity was observed in the remaining 33 strains (20.8%). The former included not only commercially important mushrooms such as *Lentinula edodes* and *Phellinus linteus*, but also other mushroom strains (*Fomitopsis pinicola, Ganoderma neo-japonicum, Laetiporus sulphureus var. miniatus*, *Piptoporus betulinus*, *Pycnoporus coccineus*, *Trametes vesicolor*, and *Wolfiporia coccos*). The antagonistic activity in most of these strains was increased with increase in culture time; for example, one strain of *L. edodes* significantly inhibited the mycelial growth of *R. quercus-mongolicae* and the PDA medium was covered with mycelial cells of *L. edodes* by 82, 98, and 100%, respectively, after 7, 14, and 30 days. From the results, it is strongly suggested that basidiomycetes can inhibit the fungal pathogen causing oak wilt, so that these selected mushrooms can be cultivated on the infected oak trees.

Altered anatomical features of *Quercus rubra* following propiconazole treatment and implications for oak wilt suppression. Juzwik, J. (*U.S. Forest Service, USA; jjuzwik@fs.fed.us*), Blaedow, R.A. (*North Carolina Division of Forest Resources, USA; ryan.blaedow@ncdenr.gov*), Chaney, W. (*Purdue University, USA; chaneyw@purdue.edu*).

The systemic fungicide propiconazole (PPZL) is used for oak wilt management in the United States. It is not known whether the beneficial effect of prophylactic treatment in northern red oaks is due to direct inhibition of the pathogen (*Ceratocystis fagacearum*) growth *in-vivo* and/or plant growth regulation that enhances the tree's defenses against the fungus. In a histological study, annual growth increments and included xylem features formed in the year prior (year-1) to intravascular infusion of PPZL were compared to those in the same branch samples 1 or more years after treatment. Significant differences were then compared to changes in control trees. Significant decreases in widths of annual growth increment, both earlywood and latewood, were observed in treated trees 1 to 3 years post-treatment compared to year-1. These decreases differed from the control trees only in the first year following treatment. The size of xylem vessels were significantly reduced in PPZL trees 1 and 3 years after treatment compared to year-1 and controls. The numbers of vessels/cm^2 in the earlywood was also reduced following treatment compared to year-1 and controls. In summary, PPZL alters growth in treated red oaks. These changes may contribute to observed disease suppression.

The gypsy moth in North America: current status of an alien oak defoliator. Liebhold, A. (*U.S. Forest Service, USA; aliebhold@fs.fed.us*).

The gypsy moth was introduced to North America in 1868 or 1869 and has slowly been expanding its range. In regions where this insect has become established, massive defoliation outbreak episodes recur with some degree of periodicity. In mesic oak stands, gypsy moth populations are characterized by oscillations with a ca. 9–10 year period, while in drier oak stands, populations exhibit a ca. 5-year period. The fungal pathogen, *Entomophaga maimaiga*, appeared in North American populations about 15 years ago, after which regional outbreak levels had generally decreased to the point that there was considerable speculation that large outbreaks were a thing of the past. However, in 2006, a large outbreak occurred in the mid-Atlantic region and intensified in 2007 and 2008 before collapsing in 2009. Considerable gypsy moth defoliation occurs in populated areas of the northeastern USA, and there is often public demand for aerial suppression. The entire situation is very reminiscent of outbreaks that were experienced in the early 1980s and 1990s. Evidence indicates that the collapse of gypsy moth populations in 2009 was associated with epizootics of *E. maimaiga*, but it is not clear how or whether this agent has affected the long-term outbreak dynamics of gypsy moth.

Biology of an ambrosia beetle, *Platypus koryoensis* (Coleoptera: Platypodidae), a vector of Korean oak wilt disease (KOW). Won, D.S. (*Kangwon National University, Republic of Korea; dsw470@kangwon.ac.kr*), Choi, W.I. (*Korea Forest Research Institute, Republic of Korea; wchoi@forest.go.kr*), Kim, J.K. (*Kangwon National University, Republic of Korea; jongkuk@kangwon.ac.kr*), Kim, K.H. (*Korea Forest Research Institute, Republic of Korea; kyung624@forest.go.kr*).

Korean oak wilt disease (KOW) was first reported in 2004 to cause serious impacts on an oak species, *Quercus mongolica*, which is one of the dominant trees in Korean forests. A native ambrosia beetle, *Platypus koryoensis*, is a vector of *Raffaelea* spp. known to cause KOW. To control KOW, it is necessary to control the density of ambrosia beetles. However, information on the ambrosia beetle is limited in Korea. This study was conducted to elucidate basic life history information of the ambrosia beetle through field and laboratory observations at a study site in Kangwon province. The ambrosia beetle had one generation per year. Flight period of the adults ranged from late May to late August and the peak period is mid-June. During the early period of flight, the sex ratio of the ambrosia beetle was male-biased and then changed to be equal between female and male. A pair of female and male beetles constructed a gallery in the trunk of a tree. Eggs laid by the female hatch and larvae develop from the first instar to late instars or even pupate to adults. They over-wintered as the 5th instar larvae or as adults, and over-wintered larvae pupated in April.

G-13 Atmospheric deposition and climate change impacts on forests

Organizers: He Shang, *Chinese Academy of Forestry, China, shanghechina@126.com*; Andrzej Bytnerowicz, *U.S. Forest Service, USA, abytnerowicz@fs.fed.us.*

Using changes in the composition of plant communities to estimate critical loads of nitrogen deposition under changing climate and land use. Belyazid, S. (*BCC, Sweden; salim@belyazid.com*), Sverdrup, H. (*Lund University, Sweden; harald.sverdrup@chemeng.lth.se*), Kurz, D. (*Geo-science, Switzerland; geo-science@bluewin.ch*).

Critical loads (CLs) of nitrogen (N) deposition to terrestrial ecosystems are currently estimated with two methods: (1) the empirical CLs are fixed ecosystem-specific values that are derived directly from empirical evidence of vegetation changes in response to N load; and (2) dynamically derived CLs are based on a ceiling for nutrient N concentrations in soil water. Both methods have had successes in setting critical limits on N deposition, but also showed limitations. Expected changes in climate and land use in coming decades and centuries put into question the stability of the assumptions underlying the classical CLs methods. With the help of the existing dynamic models for biogeochemistry and plant community composition, a method has been tested for linking N deposition to changes in plant communities and directly estimating CLs. The analysis of multiple driver effects shows that climate change and nitrogen deposition have comparable effects in magnitude on chemical and biological indicators, and that the effects of climate change are aggravated by the accumulated N within the ecosystems. It was possible to derive CLs of N deposition, but estimated ecosystem recovery as measured with plant community composition is subject to long delays.

Wet nitrogen deposition into typical forest ecosystems in China. Enzai, D. (*Peking University, China; duez@pku.edu.cn*).

Nitrogen (N) deposition has been identified as an essential factor impacting the ecological processes in forest ecosystems. Anthropogenic N emissions to the atmosphere have been increasing dramatically since the 1980s and have significantly contributed to N deposition in China. However, the magnitude and potential ecological impacts of N deposition are not well-documented in most typical forest ecosystems in China. This review synthesizes published papers to display the rate and concentration characteristics of wet N deposition as well as the interactive effects on canopy in approximately 20 forest ecosystems from boreal to tropical areas. Since most existing individual-site measurements were of limited duration, and usually without uniform measurement methods, the establishment of a long-term monitoring network of nitrogen deposition in typical forests in China to evaluate the status of nitrogen deposition is recommended. Manipulated experiments and predictive modeling should be carried out to find out how different types of forest ecosystems in China might be affected by nitrogen deposition on regional and national scales. Scientific N-regulating strategies and effective tools for forest management are useful to optimize beneficial roles and minimize negative impacts of nitrogen deposition on forest systems.

Sulfur content change in soil and needles/leaves in Kaz Dag˘ları forests. Ozel, N., Akkas, E., Akbin, G., Oner, H., Sayman, M. (*Ege Forestry Research Institute, Turkey; nihalo@rocketmail.com; emin_akkas@yahoo.com; giyasa@yahoo.com; hhnd1971@yahoo.com; mhsaymanqyahoo.com*).

Monitoring of forest ecosystems and their health has gained importance in recent decades. In the 1970s, with occurrences of mass dieback of forests due to air pollution and acid rains in Europe, monitoring activities aimed at detecting effects of air pollution on forest ecosystems were initiated, since extended to complete monitoring of forest ecosystems. Thermal power plants have been considered major sources of air pollution. The Kaz Mountains, at the intersection of Aegean and Marmara Regions, which have different climates, are among the most important forest areas in Turkey. Just after a decision to establish the 18 Mart Çan Thermal Power Plant, it was noticed that air drift and wind direction might move air pollution from the power plant with potential effects on the Kaz Mountains. Therefore monitoring activities were initiated with support of the Electricity Company. Through 2002–2008, samples were collected twice a year from 21 plots for soil, 18 plots for foliage, and 2 creeks for water, and analyzed for sulfur contamination. No significant differences in S soil concentrations were detected between various localities; however, significant differences among years occurred. Significant effects of site location and year of collection were detected for S concentrations in foliar samples.

Acid deposition and its effects in China. Shang H., Yao, B., Chen, Z., Hu, X.Y. (*Chinese Academy of Forestry, China; shanghechina@126.com; acmn21@126.com; chenzhan0508@126.com; studentmizhou@126.com*).

Acid rain emerged as a grave environmental problem in China in the late 1970s. South China has become the third largest acid rain zone following Europe and North America. Three decades of sustained economic growth has been accompanied by increased energy demand, greater coal combustion, and larger emissions of air pollutants, such as nitrogen (N) and sulfur (S) oxides. Widespread acid rain is observed in southern and southwestern China, where annual pH in precipitation is as low as 4.1 in some urban areas, and total sulfur deposition has been estimated to be about 10 g S m^{-2} $year^{-1}$ in heavily exposed areas. In addition, N oxides and ammonia are emitted from agriculture, power production, and rapidly increasing numbers of vehicles. Considerable deposition of pollutants also occurs in pristine forested regions. Adverse effects on forests have been reported for relatively small areas near large cities. Studies indicate that acidification of soil and soil water has occurred in recent decades, probably causing elevated concentrations of toxic aluminum in soil water. Since large, regional surveys have not been carried out, there are large uncertainties about effects on a regional level. Such information is necessary before effective countermeasures can be developed.

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Effect of nitrogen application on nitrous oxide emissions from a brown forest soil in northern Japan. Kim, Y.S., Imori, M., Watanabe, M., Koike, T. (*Hokkaido University, Japan; soilys@for.agr.hokudai.ac.jp; masakazu@for.agr.hokudai.ac.jp; nab0602@for.agr.hokudai.ac.jp; tkoike@for.agr.hokudai.ac.jp*).

Nitrogen (N) deposition has the potential to change below-ground nutrient dynamics and thereby can alter the soil-atmosphere exchange of nitrous oxide (N_2O), which is one of the major greenhouse gases. To investigate changes in soil N_2O flux following the N application, N input was initiated at the onset of our experiment, and included two treatments with four replications, a zero N control (0 N) and 5 g N m^{-2} $year^{-1}$ (5 N), in brown forest soil in the experimental nursery during two growing seasons. The N was added as an ammonium nitrate (NH_4NO_3) solution distributed on four occasions during each growing season. Measurements of N_2O fluxes took place on 10 occasions with a bimonthly schedule during the growing seasons. Collected N_2O concentrations were determined by a gas chromatograph (GC-14B, Shimadzu and Kyoto) equipped with an electron capture detector. Soil N_2O fluxes at both study sites were the highest in mid-July in each season. In the 5 N-treatment, increased levels of soil N_2O fluxes were observed. Our results indicate that short-term increased N availability may have an effect on processes linked to N_2O dynamics in the soil.

G-14 Ecology and management of pine wood nematode in the face of climate change

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Morphological and molecular biological identification of *Bursaphelenchus* (Nematoda: Aphelenchoididae) distributed in Korea. Han, H., Han, B.Y., Chung Y.J., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea; hrhan@forest.go.kr; h7531@nate.com; yjchung@forest.go.kr; Shinsc99@forest.go.kr*).

Pine wood nematode (PWN), *Bursaphelenchus xylophilus*, is a causative organism of pine wilt disease (PWD) in most pine trees. PWD was first introduced to Korea in 1988; however, the damage has dramatically increased since 2000. Fifteen isolates of *B. xylophilus*, 2 isolates of *B. mucronatus*, and 6 unidentified *Bursaphelenchus* spp. were collected from different geographical locations and hosts in Korea. The nematode isolates were characterized by both ITS and D2D3 rDNA sequence analysis. ITS and D2D3 regions were amplified by PCR and followed by cloning and sequence. As a result, all the sequences of ITS and D2D3 from various *B. xyophilus* isolates were identical without any intraspecific variation. However, 2 genotypes of *B. mucronatus* were found, of which one from *P. thunbergii* was East Asian type and the other one from *P. koraiensis* was European type. Six unknown species of *Bursaphelenchus* were also identified by both morphological characteristics and ITS and D2D3 sequence analysis. They were determined as *B. thailandae, B. hylobianum, B. lini, B. tusciae, B. pinophilus, B. doui*, and *B. yongensis*. ITS-RFLP phenotype was also proposed to discriminate different species and genotypes.

Hazard map for pine wilt disease in Kyoto City, Japan. Ikeda, T. (*Kyoto Prefectural University, Japan; tikeda@kpu.ac.jp*), Naoe, S. (*Kyoto University, Japan; shoji-n@ecology.kyoto-u.ac.jp*).

The ancient capital of Kyoto has been designated a UNESCO World Heritage site and has many good aesthetic landscapes. Pine forest, *Pinus densiflora*, is the integral component of such a landscape. However, most of pine forest has disappeared due to pine wilt disease. We addressed the degree of pine death and showed the hazard map for pine wilt disease at Kyoto City, which is very

useful to draw up the control programs and to predict the spread of wilt damage due to global warming. Elevation was an accurate index to predict pine mortality. Mortality decreased at the elevation of 500 m and above. Most World Heritage sites are located at the elevations below 500 m. Pine mortality was lower on the ridge of mountain than on the slope. There was no clear difference in pine mortality among the cardinal points. Hazard map for pine wilt disease as the threshold elevation of 500 m in Kyoto City was made based on data of elevation. Because most pine forests in Kyoto City needing protection for landscape conservation were at elevations below 500 m, control programs should be carried out thoroughly in the pine forests.

Preventative silvicultural control could stop pine wilt disease. Kwon, T.S., Shin J.H., Lim J.H., Kim Y.K. (*Korea Forest Research Institute, Republic of Korea; insectcom@korea.kr; kecology@korea.kr; limjh@korea.kr; youngkul@forest.go.kr*).

Pine wilt disease (PWD) represents a major threat to forest ecosystems worldwide. Although we now have a better understanding of the disease itself, we still have not succeeded in devising effective control measures for PWD. Here, after several years of field studies, we report the preventative silvicultural control of PWD. In our field experiments, silvicultural control using preventative clear-cutting and the manual removal of logs was implemented in 16 districts that had newly PWD-infected stands between 2005 and 2007. We found that preventative clear-cutting of neighboring asymptomatic pine trees (within a 10- to 50-m radius of wilt trees) and the removal of felled logs or branches could suppress the spread of PWD. As a result of silvicultural control, we succeeded in suppressing PWD in 11 of the 16 districts investigated. In contrast, during the 21 years of conventional control (chemical treatment of wilt pine trees), successful control was achieved in only one district among the 34 districts in Korea that had experienced PWD epidemics. We are convinced that our results will be of considerable interest to those engaged in the very difficult battle against the spread of PWD around the world.

Chemical ecology and management potential for the pine sawyer *Monochamus galloprovincialis*, vector of pine wood nematode in Europe. Pajares, J., Álvarez, G., Ibeas, F. (*University of Valladolid, Spain; jpajares@pvs.uva.es; gonzalbaz@gmail.com; fibeas@pvs.uva.es*), Gallego, D. (*University of Murcia, Spain; dgallego@um.es*), Sánchez, G. (*Ministerio de Medio Ambiente, y Medio Rural y Marino, Spain; gsanchez@ma.es*), Hall, D. (*University of Greenwich, UK; D.R.Hall@greenwich.ac.uk*).

The introduction and spread of pine wood nematode *Bursaphelechus xylophilus* in Portugal poses a serious threat to European pine forests, and efficient tools for managing this disease are strongly demanded. Monitoring and control of pine sawyer *Monochamus galloprovincialis*, the known vector of the pathogen in Europe, are among the strategies for fighting pine wilt disease. Results on the chemical ecology of this beetle are presented. *M. galloprovincialis* is attracted to host compounds and to bark beetle semiochemicals. It was determined that an optimal kairomonal blend consisted of α-pinene, ipsenol, and methyl-buthenol. *M. galloprovincialis* females were attracted to males in olfactometer bioassays; analysis of volatiles revealed the presence of a male-emitted compound. Identification and synthesis led to demonstrate antennal detection and attractive response in the field, stronger by females but also by males. Releasing the pheromone together with the kairomone resulted in a very high attraction of males and females. Such kairomone-pheromone bait has a high potential for use in the integrated control of the pine sawyer in Europe. VCR recording and mating bioassays demonstrated male mate recognition through the licking of female cuticle. Comparison cuticular profiles showed differences between sexes, and identification of a contact sex pheromone is currently underway.

Phytochemical based strategies for pine wood nematode (*Bursaphelenchus xylophilus*) control. Park, I.K., Kim, J.H., Kim, E.A., Park, H.M., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea; parkik1@forest.go.kr; junheon@gmail.com; kea7013@smu.ac.kr; pham83@naver.com; shinsc99@forest.go.kr*).

Pine wood nematode, *Bursaphelenchus xylophilus*, has caused pine wilt disease worldwide including Japan, South Korea, China, Taiwan, and Portugal. This disease was first reported in Gumjung Mt., Busan city in 1988, and has spread to several areas of the Korean peninsula. The damaged area was about 6,851 ha and total infected trees were about 81,000 in 2008. Most damaged trees are red pine tree (*Pinus densiflora*) and black pine tree (*P. thunbergii*). *Pinus* species are predominant tree species in Korean forests and are very susceptible to the pine wood nematode; ecological and economic damage is substantial. Control of this disease is primarily by fumigation of disease-infected trees with metham-sodium; aerial application of synthetic pesticide against *Monochamus alternatus*, the insect vector of this disease; or injection of nematicides. However, there are environmental and human health concerns with conventional pesticides. To avoid environmental pollution and health problems, there is a need to search for naturally occurring toxicants in plants. In this study, we investigated the nematicial activity of phytochemicals to find potential alternatives to currently used pine wood nematode control agents or as model compounds for the development of chemically synthesized derivatives with enhanced activity or environmental friendliness.

Studies on mass-rearing techniques of *Dastarcus helophoroides* (Fairmaire) (Coleoptera: Bothrideridae) in Guangdong, China. Qian, M.H., Xiong, L.N., Huang, H.H., Fan, J.X., Huang, Y.H., Wu, H.W. (*Guangdong Academy of Forestry, China; susanqian842@hotmail.com; gdfri@sti.gd.cn*).

Dastarcus helophoroides (Fairmaire) (Coleoptera: Bothrideridae) is a parasitoid of the pine sawyer, *Monochamus alternatus* Hope, which is the primary vector of the most destructive pest pinewood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) in China. In this study, we investigated indoor mass-rearing methods for *D. helophoroides*. There were two reproductive peaks in indoor breeding *D. helophoroide* adults, with eggs emerging in spring and fall respectively. Adding larvae of *M. alternatus* into pine blocks with grooves shortened the pre-oviposition period and increased the fecundity of *D. helophoroide*s. The average egg-adult survival rate of *D. helophoroide*s reared on narcotized natural host lavae of *M. alternatus* was 90.0%, whereas it was above 20.0% reared on the substitute host mealworm *Tenebrio moliter*. These parasitic beetle adults succesfully laid eggs, and their average mortality rate was lower than 5.00%, when they fed on an artificial diet which was made from dried egg yolk powder, dried yeast powder, cane sugar, pine wood powder, benzoic acid, agar, powder I, and distilled water. Our results show that indoor mass-production of *D. helophoroides* is feasible when larvae are reared on its natural host *M. alternatus* and the substitute host *T. moliter*, and adults fed on artificial diet.

Biological control of pine wilt disease by applying an endoparasitic fungus of pinewood nematode, *Esteya vermicola.* Sung, C.K., Wang, C.Y., Fang, Z.M., Wang, Z., Lee, C.H. (*Chungnam National University, Republic of Korea; kchsung@cnu.ac.kr; wyyunnan@yahoo.com.cn; microfang@cnu.ac.kr; wangzhen979@hotmail.com; lchstj@hanmail.net*).

Biological control is an environment-friendly alternative strategy to control pine wilt disease through the use of natural enemies. An endoparasitic fungus of pinewood nematode (PWN), *Esteya vermicola*, was isolated from South Korea and exhibited high infection activity. Infective conidia of this fungus are lunate, adhesive, and can attach to nematodal cuticles, causing subsequent infections. All the tested PWNs were killed and colonized by *E. vermicola* within just 2–3 days *in-vitro*. The effect of *E. vermicola* to protect pine trees from wilt disease was investigated and evaluated both in greenhouse and field during the past 2 years. When 4-year-old *Pinus densiflora* were treated with *E. vermicola* 1 month before PWN infection, the survival rate of pine seedlings reached 67–81%. Moreover, infected nematodes and hyphae of *E. vermicola* were observed in wood slices. On mountain, 15–20-year-old *P. densiflora* and *P. thunbergii* were selected and treated with *E. vermicola* 3 months before PWN infection. According to the results, 60–80% tested pine trees survived pine wilt disease. Therefore, *E. vermicola* has great potential as biological control agent to reduce prevalence of pine wilt disease. Further studies about evaluation of its application and formulation as a commercial nematocide have been positively underway.

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Relationship between the development of xylem embolism observed by a compact MRI and the distribution of pinewood nematode in pine stem. Akami, A. (*University of Tokyo, Japan; aaai09a@nenv.k.u-tokyo.ac.jp*), Umebayashi, T. (*Forestry and Forest Products Research Institute, Japan; t_umebayashi@hotmail.com*), Fukuda, K. (*University of Tokyo, Japan; fukuda@k.u-tokyo.ac.jp*).

Pine wilt disease caused by the pinewood nematode (*Bursaphelenchus xylophilus*) is one of the most serious tree diseases in the north temperate zone, known to induce xylem embolism to death in infected pines. Previous studies have shown that a number of nematodes grow stagnant around infection site at the early stage of this disease symptom, and they rapidly multiply throughout the tree at the late stage. It has not been fully understood whether the distribution of nematode corresponds to the development of xylem embolism or not, since it was hardly able to simultaneously monitor both the development of xylem embolism in the stem and the nematode distribution. In this study, we nondestructively monitored 3-dimensional development of xylem embolisms with multi-cross-sectional slices taken by a compact MRI in the 1-year-old main stem of 24 inoculated Japanese black pines of 3 years old. Nematode density in the stem segments at various stages of xylem embolism development was determined by the Baerman method. Our results clarified that even the pace of the xylem embolism development varied among trees; the nematode distribution and population density in the stem showed strong correlation with the development of xylem embolisms.

Predicting emergence patterns of the insect vector *Mocochamus alternates* of pine wood nematode in Korea. Bae, M.J. (*Kyung Hee University, Republic of Korea*), Chung, Y.J. (*Korea Forest Research Institute, Republic of Korea*), Park, Y.S. (*Kyung Hee University, Republic of Korea; parkys@khu.ac.kr*).

The main vector insect of the pine wilt disease (PWD) caused by the pine wood nematode, *Bursaphelenchus xylophilus*, is a pine sawyer beetle, *Monochamus alternates*. The vector insect is distributed mostly in the southern part of Korea. Control of PWD is mainly focused on killing the vectors before their emergence from host trees, by burning infested trees. Furthermore, after their emergence, an aerial spay is applied to kill the vectors. Therefore, it is important to predict the emergence time and patterns of the vectors at different local areas for effective control of the disease. In this study, we aimed to predict the emergent time of the pine sawyer beetles, using the developmental threshold temperature degree day as 13.2º C to calculate the emergent time and the daily temperature data measured at 448 sites in 2008. The local temperature was estimated using an ordinary Kriging method in GIS, and used as independent variable in a multiple linear regression model for the prediction of emergence patterns. Our developed model showed high prediction power for the effective cumulative temperature for initial emergence date, 30%, 50%, 70%, and 100% of cumulative emergence ratio.

Comparative studies on the pathogenicity and inhabitation of the '*xylophilus* group' nematodes in the genus *Bursaphelenchus* distributed in pine forests in Korea. Cheon, H.M., Moon, Y.S., Huh, H.S., Lee, S.K., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; mayjun@forest.go.kr; moonils@forest.go.kr; hyesoon80@korea.com; leesk77@forest.go.kr; pnch@forest.go.kr*).

Since pine wilt disease was first reported in 1988, this disease has become a serious threat to pine forests in Korea. An additional infested area, new host trees, and a new insect vector of this disease have occurred continuously, possibly as a result of climate change and transportation of woods. Because of these findings, the importance of biological study of *Bursaphelenchus* species has been re-evaluated worldwide. Therefore, we conducted a study to determine the species of *Bursaphelenchus* associated with pine trees, and their biological characteristics, such as pathogenicity, geographic locations, host tree species, and insect vectors in pine forests in Korea. *Bursaphelenchus* species, in particular the members of "the *xylophilus* group." were isolated from several wilted pine trees in different provinces and insect vectors. To understand the role of the *xylophilus* group species in these wilting cases, the pathogenicity of the *xylophilus* group species on 5-year-old seedlings of the three pine species most widespread in Korea was investigated under greenhouse conditions. *B. xylophilus* proved to be highly virulent, followed by the European type of *B. mucronatus*, whereas the Asian type of that was nonpathogenic. Other physiological and molecular characters of the nematodes will be discussed.

Flight experiment of *Monochamus alternatus* and *M. saltuarius* (Coleoptera: Cerambycidae) adults in pine forest. Chung, Y. J., Koh, S.H., Hong, J.I., Kim, D.S. (*Korea Forest Research Institute, Korea; yjchung@forest.go.kr; shkoh@forest.go.kr; sndp1980@hanmail.net; skimds@forest.go.kr*).

The pinewood nematode, *Bursaphelenchus xylophilus*, causative agent of pine wilt, is vectored by cerambycid beetles of genus *Monochamus*. Among them, *M. alternatus* and *M. satuarius* are thought to be the most important vectors in Korea. To prevent

spread of damage, and to enhance effectiveness of monitoring and pine wilt disease control, we need information about the flight behavior of *M. alternatus* and *M. saltuarius*. Flight behavior of newly-emerged adult insect vectors was observed in pine forest located in Seoul and Jinju. Of newly emerged *M. alternatus* adults that did not undertake maturation feeding, 96% of tested individuals succeeded their flight; initial flight distance was 18.0 ± 2.7 m. Of *M. alternatus* individuals that did undertake maturation feeding after emergence, 89% succeeded their flight; initial flight distance was 15.0 ± 2.4 m. Of *M. saltuarius* that did not undertake maturation feeding, 69% succeeded their flight; that the initial flight distance was 2.5 ± 0.5 m. Of *M. saltuarius* individuals that did undertake maturation feeding, 78% succeeded their flight with initial flight distance of 2.1 ± 0.8 m. Results suggest that *M. alternatus* flies to nearby host trees via comparatively long-distance initial flights, and *M. saltuarius* moves to host trees mostly by walking after a short-distance initial flight.

Habitation behavior of *Monochamus alternatus*, vector of pine wood nematodes, on thinning products in forests damaged by pine wilt disease. Jeon, K.S., Kim, J. B. (*Korea Forest Research Institute, Republic of Korea; jeonks@forest.go.kr; jbkim99@forest.go.kr*).

We studied the relationship between the time of thinning and product type of tended red pine forest and the habitation of *Monochamus alternatus*, a vector for pine wood nematode, in 2008. Thinning was controlled by timing (March, June, September, December); by area (675 m^2); and by the type of thinning product (patch, row, leaving) per area 225 m^2. Study area is at Jinju-experiment forest (area 1,700 m^2). Regarding type of thinning products: (a) number of larvae entrance holes (241.3/100 m^2) were distributed thus: patch 119.1 (49.4%), row 68.4(28.4%), leaving 53.8(22.3%); (b) number of insect emergence holes (112.9/100 m^2) were distributed thus: patch 54.2 (48.0%), row 41.3(36.6%), leaving, 17.3(15.4%). With regard to timing of thinning period: (a) number of larvae entrance holes (241.3/100 m^2) were distributed thus: patch June-211.6 (87.7%), March-23.6 (9.8%), December-5.3 (2.2%), September-0.9 (0.4%); (b) number of insect emergence holes (112.9/100 m^2) were distributed thus: June-97.8 (86.6%), March-15.1 (13.4%), September–December-0.0(0.0%). As a result of this study, *Monochamus alternatus* vector habitation was controlled most (in the case of no treatment) by leaving products after thinning; also, thinning timing effects were regulated best when thinning was done during September and December.

Geographical distribution and cold hardiness of *Monochanus alternatus* and *M. saltuarius* in Korea. Jung, C.S., Kim, J.H., Koh, S. H., Chung, Y.J., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea, csjung@forest.go.kr; wlcjstk81@hanmail.net; shkoh@forest.go.kr; yjchung@forest.go.kr; shinsc99@forest.go.kr*).

Monochamus alternatus and *M. saltuarius* were reported as the vectors of *Bursaphelenchus xylophilus*, pine wood nematode in Korea. They have occupied their own geographical distribution: *M. saltuarius* in southern part and *M. alternatus* in mid-northern part of the Korean peninsula. We measured the supercooling point (SCP) of 2 species (laboratory-reared population) by each developmental stage. The SCPs of 2nd, 3rd, 4th, and 5th instar larvae of *M. saltuarius* were –7.68 ± 0.19 ºC, –7.02 ± 0.69 ºC, –3.70 ± 0.62 ºC, –4.93 ± 1.34 ºC, respectively. On the other hand, the SCPs of 3rd, 4th, 5th instar larvae and pupae of *M. alternatus* were –4.46 ± 1.12º, –5.94 ± 1.33º, –7.83 ± 1.44º, and –9.53 ± 1.78 ºC, respectively. The pupae of *M. alternatus* and 2nd instar larvae of *M. saltuarius* had the lowest SCP; the highest SCP was recorded in 2nd and 4th instar larvae, each. The SCP of *M. alternatus* gradually decreased by developmental stage. However, there were no apparent correlations between the SCPs and developmental stage in *M. saltuarius*, contrary to assumptions that regional beetle distribution may be associated with adaptation capacity to low temperature represented by SCP as well as their growth temperature. However, the samples tested were not collect from fields, so we are preparing additional experiments with both nationwide and indoor-reared population.

Effects of damage intensities on soil respiration rates in pine wilt disease stands. Kim, C.S., Jeong, J.S. (*Jinju National University, Republic of Korea; ckim@jinju.ac.kr; jy668@nate.com*), Lee, K.S. (*Korea Forest Research Institute, Republic of Korea; beldel660@forest.go.kr*).

Although pine wilt disease caused by pine wood nematode, *Bursaphelenchus xylophilus*, has become the most serious threat to Korean pine ecosystems, little is known about the underlying relationships between soil respiration rates and the incidence of pine wilt disease. This study was conducted to measure soil respiration rates on three severely (SVD), moderately (MDD), and slightly damaged (SLD) pine stands in adjacent, natural red pine stands in Jinju, Korea, where an area is severely damaged by pine wilt disease. Mean soil water content during the study period was significantly higher in SVD (19.1%) than in MDD (16.0%) and SLD (16.1%) plots because of decreased transpiration loss. Mean soil temperature was not changed among damage intensities because of seasonal fluctuation of soil temperature among treatments. Mean soil respiration rates were higher for MDD (0.60 g CO_2 m^{-2} h^{-1}) and SLD (0.54 g CO_2 m^{-2} h^{-1}) than for SVD (0.47 g CO_2 m^{-2} h^{-1}) plots. This study suggests that decreased soil respiration in SVD plots could be attributed to reduced root respiration by selective tree cutting of infected tree in SVD plots.

Density of pine wood nematodes, *Bursaphelenchus xylophilus*, in *Monochamus alternatus* (Coleoptera: Cerambycidae) adults from dead pine trees in the forest. Kim, D.S., Lee, S.M., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; skimds@forest.go.kr; leesm99@forest.go.kr; pnch@forest.go.kr*), Park, C.G. (*Gyeongsang National University, Republic of Korea; parkcg@gnu.ac.kr*).

Number of pine wood nematodes (PWNs), *Bursaphelenchus xylophilus*, escaped from *Monochamus alternatus* adults emerged from two different types of pine logs was checked. For type A, healthy pine trees from forest were cut into logs, and *M. alternatus* adults that emerged from dead pine trees due to PWN infection were put in screen cages together with the logs. For type B, dead pine trees due to PWN infection were cut into logs, and we let naturally occurring *M. alternatus* lay eggs on the logs in pine forest. *M. alternatus* emerged from the two log types were checked in the next year as to how many PWNs they were harboring in their bodies. Number of nematodes per *M. alternatus* adult were 11,315.4 ± 6,672.5 and 21,415.3 ± 5,296.0 in type A and B logs, respectively. Of the 23 and 28 beetles that emerged from types A and B respectively, 5 and 14 beetles harboured more than 5,000 PWNs per beetle. The 29.7% and 24.8% of total PWNs in host body escaped from hosts during the whole host life span, and 80.7% and 76.2% of these PWNs escaped within 3 weeks after adult emergence from their host body in type A and B logs, respectively.

Two new environmentally friendly control methods to control vectors emerged from the dead trees infected by pine wood nematode. Kim, J.B., Lee, S.K., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; jbkim99@forest.go.kr; leesk77@forest. go.kr; pnch@forest.go.kr*).

Pine wood nematode is transferred to other trees by vectors. A typical controlling method against vectors in Korea is fumigation of the infected dead trees by *Bursaphelenchus xylophilus* using 25% metam-sodium. However, this method is harmful to the environment because of chemical contamination and plastic waste in the mountain afterward. To reduce this environmental problem, two new environmentally friendly control methods were developed. The first one is covering the infected tree with the polyethylene net for controlling vector (PNCV), in which 22 polyethylene filaments are woven into a net. A field test of the PNCV was carried out for 3 years and it was confirmed that vectors could not cut polyethylene filaments and not escape out of the PNCV, so they finally die because they could not eat fresh young twigs after emerging. The other one is using the automatic bark remover (ABR). The ABR is a newly designed debarking device that is equipped on top of a chainsaw engine allowing ease and rapid debarking of infected trees at the controlling field. Debarking of freshly-dead trees can eliminate an egg-laying and hatching place of vectors that is between the wood and bark.

Pyochelin isolated from *Burkholderia arboris* KRICT3 carried by pine wood nematode, *Bursaphelenchus xylophilis,* shows phytotoxic activity to pine callus. Kim, J.-C., Le Dang, Q., Son, S.W., Choi, Y.H., Choi, G.J., Jang, K.S., Park, M.S. (*Korea Research Institute of Chemical Technology, Republic of Korea; kjinc@krict.re.kr; quangldang@yahoo.com; sonmonkey@nate.com; yhchoi@krict.re.kr; kjchoi@krict.re.kr; ksjang@krict.re.kr; ms1014@hanmail.net*), Lim, C.H. (*Chungnam National University, Republic of Korea; chlim@cnu.ac.kr*).

Pine wilt disease is a very complex disease and has been reported to be caused by pine wood nematode, *Bursaphelenchus xylophilus* and its accompanying bacteria. The phytotoxin-producing bacteria have been reported to be involved in the development of pine wilt disease. In this study, we tried to characterize phytotoxins produced by *Burkholderia arboris* KRICT3, which was carried by the pine wood nematode. It produced phytotoxic compounds in the pine seedling assay, and the ethyl acetate (EtOAc) layer of fermentation broth of the strain displayed phytotoxic activity on pine callus of *Pinus densiflora*. One active compound was isolated from the EtOAc layer by repeated Sephadex LH-20 column chromatography and preparative TLC. The chemical structure was determined to be siderophore pyochelin (a mixture of two interconvertible diastereoisomers pyochelin I and II) by UV, ESI-MS, and NMR spectral data. Pyochelin caused a killing effect on viability of pine callus, but it was not active to barley leaves in the leaf-wounding assay. In addition, pyochelin showed potent growth inhibitory activity against various fungal pathogens. The results suggested that pyochelin may play a role in the wilting process in pine wilt disease.

Development of overwintering larvae and emergence of *Monochamus saltuarius* (Coleoptera: Cerambycidae). Koh, S.H., Hong, J.I., Jung, C.S., Chung, Y.J. (*Korea Forest Research Institute, Republic of Korea; shkoh@forest.go.kr; sndp1980@hanmail.net; csjung@forest.go.kr; yjchung@forest.go.kr*).

The effects of temperature condition on the development and emergence of insect vectors is essential information. Logs of Korean white pine, *Pinus koraiensis*, in which larva of pine sawyer, *Monochamus saltuarius* entered in the field and overwintered, were put into an incubator with temperature conditions of 20, 25, 30, and 35 °C. We recorded the number of newly-emerged adults daily, and then investigated the number of live and dead *M. saltuarius* in pupal chambers by dissecting the logs. Emergence of adults was observed in the field net cage located in Seoul from 2007 to 2009. Results of investigation on the developmental time taken by the larvae of *M. saltuarius* to emerge as adults showed that it decreased from 23.3 days to 11.9 days according to increasing of temperature from 20 °C to 30 °C. Survival rate of the overwintering larvae of *M. saltuarius* to emerge as adults decreased by 0.91, 0.90, and 0.83 respectively when temperature condition increased up to 20, 25, and 30 °C. Emergence of *M. saltuarius* adults began in early May and was completed during late May.

Characterization of GHF5 cellulose gene of the sawyer *Monochamus saltuarius.* Kwon, H.M. (*Kangwon National University, Republic of Korea; cocuphillip@nata.com*), Chung, Y.J., Shin, S.C., Jung, C.S. (*Korea Forest Research Institute, Republic of Korea; yjchung@forest.go.kr; Shinsc99@forest.go.kr; csjung@forest.go.kr*), Kim, J.K., Park, Y.C. (*Kangwon National University, Republic of Korea; jongkuk@kangwon.co.kr ycpark@kangwon.ac.kr*).

Currently, cellulase(s) became a hot issue both being a candidate to produce environmentally friendly natural resources, and being a target to control wood-feeding insects, such as termites. An endogenous cellulose gene of the sawyer, *Monochamus saltuarius*, known as a vector of the pine wilt disease of *Pinus koraiensisin* in the central part of the Korean peninsula, was cloned and expressed in *Escherichia coli*. The full-length cellulase gene cDNA was found to be 978 bp excluding the poly-A tail. The polypeptide of 326 amino acids was predicted. The *M. saltuarius* cellulase gene had a unique catalytic site, IIYETFNEPT, of glycosyl hydrolase families 5(GHF5). Homology analysis of the deduced polypeptide sequence showed that *M. saltuarius* cellulase had a match of 93.2% with *Apriona germari* cellulase III and 92.9% with *Psacothea hilaris*. Expression of the cellulase by the transformed *E. coli* was conformed on SDS-PAGE.

Cloning and expression of GHF45 cellulose gene of the sawyer, *Monochamus saltuarius.* Kwon, H.M. (*Kangwon National University, Republic of Korea; cocuphillip@nata.com*), Chung, Y.J., Shin, S.C., Jung, C.S. (*Korea Forest Research Institute, Republic of Korea; yjchung@forest.go.kr; Shinsc99@forest.go.kr; csjung@forest.go.kr*), Kim, J.K., Park, Y.C. (*Kangwon National University, Republic of Korea; jongkuk@kangwon.co.kr; ycpark@kangwon.ac.kr*).

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Phaedon cochleariae cellulase. Over-expression of the cellulase, archived by IPTG induction of LB broth culture, was conformed with SDS-PAGE. We failed to confirm the cellulolytic activity of the expressed polypeptide, indicating that the cellulase had more than a simple structure.

Water stress and initial infection route of the nematode in *Bursaphelenchus xylophilus*-inoculated pine trees. Lee, H.Y., Koo, C.D. (*Chungbuk National University, Republic of Korea; hoasis82@hanmail.net; Koocdm@chungbuk.ac.kr*), Sung, J.H., Shin, J.H. (*Korea Forest Research Institute, Republic of Korea; jhs033@forest.go.kr; kecology@forest.go.kr*).

The purpose of this study was to understand water stress development and initial infection route of the nematodes in *Bursaphelenchus xylophilus*-inoculated pine trees. Leaf water potentials of 4-year-old, nematode-inoculated *Pinus densiflora* seedlings were measured with a plant moisture system at predawn. Initial infection routes of the nematode were investigated with scanning electron microscope in the current branches, which were inoculated with the nematode after *Monochamus saltuarius* maturation feeding and in the shoot stem of 20-year-old *P. thunbergii*. Predawn water potentials on the 56th day were –0.71MPa in the infected seedlings, and –0.26MPa in the non-infected seedlings. Leaves of the infected seedlings became yellow, and resin did not exude on the cut basal stem. Maturation feeding by *M. saltuarius* on pine branch bark exposed cortical tissues, resin canals, phloem, cambium, and ray parenchyma cells in xylem and tracheids. Pinewood nematodes were observed in all the above tissues. In 20-year-old pine trees, however, the nematode was present in cortical tissues, resin canal, and pith, but not in tracheids. In conclusion, pinewood nematodes developed water stress in pine seedlings and initially infected cortical tissues and resin canals.

***In-vitro* screening of endophytic fungi from *Pinus* species with nematicidal activity against pine wood nematode, and their application for the prevention of pine wilt disease by trunk injection.** Lee, J.K., Kim, Y.T., Kim, N.K., Shin, K.C. (*Kangwon National University, Republic of Korea; jongklee@kangwon.ac.kr; yongtae00@hanmail.net; kimnamkyu@kangwon.ac.kr; keumchulshin@kangwon.ac.kr*), Kim, S.U. (*Seoul National University, Republic of Korea; sesedad@gmail.com*).

Pine wilt disease (PWD) caused by pine wood nematode (PWN) is a fatal disease of red pines in northeastern Asia. PWN is mycophagous, and feeds fungi during its life cycle. Some 279 fungal strains were isolated from both healthy and infected pines (*Pinus densiflora*, *P. thunbergii*, *P. rigida*, *P. koraiensis*) widely distributed in Korea; strains with high nematicidal activity (NA) against PWN were screened. Twelve fungal strains were selected, and their culture extracts were screened in 96 well microplates at different concentrations. Extracts from 3 strains showed 100% NA at final concentration of 5,000 μ/Mℓ, and these strains were identified as identical species by rDNA ITS sequence analysis. Preventive efficacy of the endophytic fungi was evaluated by injecting mycelial suspension into living stems of 6-year-old red pine seedlings before nematode inoculation. Changes in inoculated seedlings were investigated and compared at 10, 20, 30, and 60 days after nematode inoculation. Pre-treatment with MS of selected fungi showed preventive efficacy. Seedlings treated with other agents and/or nematode showed 90–100% needle browning and were almost dead after 60 days. However, pre-treated seedlings with MS showed 20–45% needle browning. Results suggest that endophytic fungi with high NA could be promising agents for PWD management.

Effectiveness of soil treatment and trunk injection of insecticides on the Japanese pine sawyer. Lee, S.M., Kim, D.S. (*Korea Forest Research Institute, Republic of Korea; leesm99@forest.go.kr; skimds@forest.go.kr*), Lee, D.W. (*Kyungpook National University, whitegrub@knu.ac.kr*), Park, N.C. (*Korea Forest Research Institute, Republic of Korea; pnch@forest.go.kr*), Choo, H.Y. (*Gyeongsang National University, Republic of Korea; hychoo@nongae.gsnu.ac.kr*).

Insecticidal activity was evaluated to establish effective control methods against the pine wilt disease (PWD) vector insect *Monochamus alternatus*, using four trunk injection insecticides and five soil application insecticides. Mortality of *M. alternatus* was 100% at treatment of 5g/host carbosulfan 5.0% GR, thiamethoxam 1.5% GR, and clothianidin 0.5% GR after 30 days in a pot. Imidacloprid 4% SL was highly effective (100% mortality) against *M. alternatus* and no feeding on pine tree occurred when four insecticides were applied through trunk injection at the rate of 0.5 Mℓ per cm DBH at 62 days after treatment, and thiamethoxam 1.5% SL was 76.0% mortality against *M. alternatus* and no feeding on pine tree occurred at 27 days after treatment. Trunk injection of imidacloprid 4% SL and acetamiprid 10% SL at the rate of 0.5 Mℓ per cm DBH was highly effective (100% mortality) against *M. alternatus* and no feeding on pine tree occurred at 41 days after injection in field. The mortality of *M. alternatus* adults, when tested with 1-year-old twig and 2-year-old twig of pine trees injected at a dose of 0.6 Mℓ per cm DBH of a pine tree acetamiprid 10% SL were 80% and 70% respectively.

A study on the possibility of soil infection with pine wood nematode, *Bursaphelenchus xylophilus*, through pine sawdust. Moon, Y.S., Cheon, H.M., Han, H.R., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea; moonils@forest.go.kr; mayjun@forest.go.kr; hrhan@forest.go.kr; shinsc99@forest.go.kr*).

Most of the described species of *Bursaphelenchus* have a phoretic relationship with insects, especially bark beetles and wood borers. The PWN is vectored principally by cerambycid longhorn beetles in the genus *Monochamus*. The infection possibility of adjacent healthy trees from the root of the PWN-infected trees was investigated. Under outdoor conditions in Korea an infection test made on 5-year-old *Pinus thunbergii* showed that PWN brought about high mortality of inoculated pine trees. The test on the spreading of pine wood nematode through pine sawdust was carried out in the greenhouse of Korea in 2006; 13 Japanese black pine (*P. thunbergii*) trees were inoculated with the pine wood nematode (pine sawdust) at the surface soil. Of 13 inoculated trees, 1 died showing browning of the foliage, and 8 showed external symptoms of yellow and wilted leaves, 11 weeks after inoculation. Up to 4 months after inoculation, 11 trees died. The results show that the nematode can go out from the sawdust to cause pine seedling wilt. This phenomenon gives evidence that pine wood nematodes can penetrate immediately from roots or stem base of seedlings.

An aerophotography based system for detecting and on-site locating of damaged trees with discolored foliage. Nakamura, K. (*Forestry and Forest Products Research Institute, Japan; knakam@ffpri.affrc.go.jp*), Takehana, M. (*Kyoritsu Air Service Co. Ltd., Japan; takehana@k-air.co.jp*), Nakakita, O. (*Forestry and Forest Products Research Institute, Japan; nakakita@ffpri.affrc.go.jp*).

A high-performance wide-range surveillance method for detecting damaged trees is needed to locate and track the spreading area of some kinds of forest pests and diseases, e.g. pine wilt disease in Japan. Aerial photography provides with the best solution because of its high-resolution image and adjustability in timing for taking the image. Location of a designated point will be obtained on a photo image when it is ortho-rectified. Use of near infra-red color image will make the foliage discoloration distinct. We organized a procedure of an aerophotography-based detection and on-site locating system for pine wilt-damaged trees, and developed mutually relevant software for managing the damaged trees to be properly treated. Tree information management software is to incorporate the results from photo interpretation for damaged tree detection into digitized photo images, obtain the coordinates of the trees, and compile the data into a file. On-site navigation software working on a PDA with built-in GPS will help to find the designated damaged trees by loading the image and data files created by the management software. The system is readily used for he other forest pests and diseases accompanying foliage discoloration.

A second-generation breeding program for resistance to pine wilt disease in *Pinus thunbergii*. Ohira, M. (*Forestry and Forest Products Research Institute, Japan; sasamine@affrc.go.jp*), Miyahara, F., Mori, Y. (*Fukuoka Prefecture, Japan; miyahara-f1092@pref.fukuoka.lg.jp; miureine@gmail.com*), Masaki, S. (*Saga Prefectural Forestry Experiment Station, Japan; masaki-shiyuuichi@pref.saga.lg.jp*), Yoshimoto, K. (*Nagasaki Agricultural and Forestry Technical Development Center, Japan; kikuo.y@pref.nagasaki.lg.jp*), Yamada, Y. (*Forestry and Fisheries Research Center Forestry Research Institute, Japan; yamada-yasuhiro@pref.oita.lg.jp*), Tagami, T. (*Miyazaki Prefectural Forestry Technology Center, Japan; tagami-toshihiko@pref.miyazaki.lg.jp*), Miyazato, M. (*Kagoshima Prefectural Forest Technology Center, Japan; miyazato@kpfes.ecnet.jp*), Tobase, M. (*Amakusa Forest Owner's Cooperative, Japan; toba-m@afoc.jp*), Shiraishi, S. (*Kyushu University, Japan; sushi@agr.kyushu-u.ac.jp*).

Pinus thunbergii forests in Japan have been seriously damaged by pine wilt disease caused by the pine wood nematode *Bursaphelenchus xylophilus*. To counter this disease, 16 resistant clones (first-generation) were selected from infection sites in a national breeding program by 1984 and the selected clones were used to establish seed orchards. Because *P. thunbergii* is a difficult-to-root species, seedlings obtained from seed orchards have been used for reforestation. Between 2004 and 2008, we conducted a second-generation breeding program in Kyushu region. The purposes of this program are to select of higher resistant genotypes and to propagate the genotypes asexually. In the first phase of this program, 962 individuals survived after 3 times of artificial inoculation of pine wood nematode strains. These individuals were derived from among 19,846 seedlings obtained from the seed orchards. In the second phase, a cutting-propagation system was developed on the basis of management of scion gardens and optimization of rooting conditions. In this system, the rooting ability of the cuttings of the survived individuals was evaluated. Then, 94 clones were selected as the easy-to-root stock plants. We will be able to supply these highly resistant clones within a few years.

Effects on habitation of *Monochamus alternatus* by tending of sapling red pine forest. Park, N.C., Jeon, K.S., Kim, D.S. (*Korea Forest Research Institute, Republic of Korea; pnch@forest.go.kr; jeonks@forest.go.kr; skimds@korea.kr*), Hong, S.C. (*Kyungpook National University, Republic of Korea; schong@knu.ac.kr*).

Cage plots were established in 2009 to find the relationship between combination of tended red pine sapling and the habitation of *Monochamus alternatus*, a vector for pine wood nematode. Red pine saplings tended at different times were successively put into the cage, and then the adult of *Monochamus alternatus* was added in June. Presence or absence of the larvae was determined November. Sapling tendings were done at seven successive times in 2009, mid- and late February, mid- and late March, mid-April, May, and June. Some saplings were also tended in mid-October of 2008, the previous year of this experiment. Larvae were found in all the saplings tended later than mid-March 2009. No larvae were found in saplings tended in mid-October 2008; larvae were found in those tended in February and late March 2009, but they were not found in those tended in mid-October 2008. When the saplings tended in mid-October 2008 and mid- and late February 2009 were put into the cage singly, larvae were found in all the saplings. Results indicated the mixture of the saplings tended at different times affected the habitation of *Monochamus alternatus* differently.

Full-length cloning and characterization of stilbene and chalcone synthase in the seedlings of Japanese red pines inoculated with pinewood nematode. Shin, H., Lee, H., Woo, K.S., Koo, Y.B. (*Korea Forest Research Institute, Republic of Korea; hannashin@forest.go.kr; hslee@forest.go.kr; woo9431@forest.go.kr; ybkoo@forest.go.kr*), Lee, K.J. (*Seoul National University, Republic of Korea; fraxinus@snu.ac.kr*).

From the cDNA libraries constructed from pinewood nematode-inoculated stems of Japanese red pine (*Pinus densiflora* Sieb. et Zucc.), we found 12 ESTs corresponding to stilbene synthase (STS) and chalcone synthase (CHS). For the representative 5 ESTs after clustering, full-length cloning and characterization were conducted. One 1491-bp cDNA clone contained 1176-bp open reading frame (ORF) and was matched to PDSTS2 (*Pinus densiflora* stilbene synthase 2). The others had 1326–1572-bp length and showed high homology to CHS of Japanese red pine or other pine species. The length of ORF matching to CHS was longer than that of STS around 10 to 20-bp, and there was characteristic deletion of 3-bp in the clones matching to CHS. Time-course analysis on the response of pinewood nematode-inoculated Japanese red pine showed that the expression of transcripts encoding STS was induced over two-fold at the earlier time than that of CHS in the symptom development. Moreover, the magnitude of expression was larger in transcripts encoding STS than CHS. Both STS and CHS seem to have important roles as phytoalexins in the response of Japanese red pine to pinewood nematode. More specific interactions between two genes are needed to study.

Direct control measures against the pine wood nematode in Portugal: an approach towards reduced environmental impact. Trindade, M., Cerejeira, M.J. (*Instituto Superior de Agronomia, Portugal; mjtrindade@isa.utl.pt; mcerejeira@isa.utl.pt*).

Since its detection in Portugal in 1999, pine wilt disease, caused by the pine wood nematode (PWN) *Bursaphelenchus xylophilus*, has spread to new regions of the country. Up to now the direct control against PWN has been done mainly by heat treatment (HT), fumigation with methyl bromide (MB), and removal and burning of affected trees. The most recent measures adopted in Portugal related with PWN direct control are presented: (1) MB replacement in fumigation treatments, following the ratification of the Montreal Protocol by the Portuguese Government and the European Union reevaluation of the active substances; (2) heat

treatment control measures—(a) legal requirements in order to certify the control against *B. xylophilus* in softwood sawn timber, pallets and other packages, according to an official document published in 2009; (b) Increase in the number of authorized companies to perform treatments with HT—and (3) selection of nematicides (fumigation and trunk injection treatments) based on reported efficacy against the PWN and inclusion in Annex I of Directive 91/414/EEC. The contribution to a reduced environmental impact of the various measures described above will be discussed.

***Esteya vermicola*, an endoparasitic fungus of pinewood nematode with high infection acticity.** Wang, C.Y., Fang, Z.M., Wang, Z., Lee, C.H., Sung, C.K. (*Chungnam National University, Republic of Korea; wyyunnan@yahoo.com.cn; microfang@cnu.ac.kr; wangzhen979@hotmail.com; lchstj@hanmail.net; kchsung@cnu.ac.kr*).

Pinewood nematode (PWN) is the pathogenic agent of pine wilting disease, which has resulted in big damage to ecosystem and numerous economic losses in forest industry. In order to control pine wilt disease, nematophagous fungi were isolated and screened. In 2006, an endoparasitic fungus of PWN, *Esteya vermicola*, was isolated from South Korea. PWNs were attracted by living mycelia of this rare hyphomycete and adhered by its lunate infective conidia, causing subsequent infections. A new method was developed to confirm that the attractive substances consisted of avolatile exudative compounds and diffusing volatile compounds. Furthermore, PWNs in discs of infected pine seedling, dead blocks of infected pine tree, and 15- and 30-day-infected pine seedlings aslo could be attracted by *E. vermicola*. As to the influence of PWN on *E. vermicola*, both its metabolite and homogenate could stimulate and speed up fungal growth. Two months after inoculation of 10^8 ml^{-1} and 10^6 ml^{-1} conidia suspension of *E. vermicola*, PWN density in pine wilt-killed *Pinus densiflora* logs were decreased by about 79% and 47%, respectively. Accordngly, *E. vermicola* could be used as biological control agent to control wilt disease by decreasing PWN number in woods.

Differences between the influence of susceptible and resistant pine trees to pinewood nematode. Wang, Z., Wang, C.Y., Lee, C.H., Fang, Z.M., Sung, C.K. (*Chungnam National University, Republic of Korea; wangzhen979@hotmail.com; wyyunnan@yahoo.com.cn; lchstj@hanmail.net; microfang@cnu.ac.kr; kchsung@cnu.ac.kr*).

Pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is the causal agent of pine wilt disease (PWD), transmitted by insect vectors—pine sawyer beetles (*Monochamus* spp.), particularly *Monochamus alternatus*, during oviposition or feeding. PWN is found mainly on *Pinus* spp. Although the dead wood of all species of *Pinus* can act as a substrate for PWN development, only a limited number of species are susceptible to attack as living trees and killed by PWD, such as *P. densiflora*, *P. thunbergii*, and *P. koraiensis*. Many other species have been found to be highly resistant to PWD, for example *P. banksiana* and *P. rigida*. However, the reason for resistance is not clear yet. In the present study, *P. densiflora* and *P. rigida* were chosen and compared in their influence on PWN. Their branches were cut from about 10-year-old healthy trees, inoculated with a great deal of PWNs and cultured in water. Two weeks later, PWNs were reisolated from pine branches. Harvested PWNs were used for mRNA chips and labeled with bromodeoxyuridine (BrdU), respectively, to investigate the influence of two pine species on nematodal genes and cell proliferation. Artificially cultured PWNs on *Botrytis cinerea* were used as control and the results provided significant information.

Selection of resistant Japanese black pine trees to pine wilt disease and a breeding strategy toward marker-assisted selection. Watanabe, A., Hirao, T., Iki, T., Isoda, K. (*Forestry and Forest Products Research Institute, Japan; nabeatsu@affrc.go.jp; hiratomo@affrc.go.jp; iki@affrc.go.jp; keiso@affrc.go.jp*).

The pine wood nematode (*Bursaphelenchus xylophilus*) causes considerable damage to Japanese black pine (*Pinus thunbergii*) and Japanese red pine (*P. densiflora*) forest in Japan. Although several nematode-resistant pines have been selected from hard nematode-damaged forest, it is likely that the number of resistant trees is not yet enough to maintain genetic diversity of pine forests in Japan. We selected resistant black pine trees following conventional breeding strategies with modification from the Kanto region mainly in Japan, where no resistant trees have been found. All of about 19,000 seedlings derived from 240 mother trees surviving in seven nematode-damaged forests were tested by artificial inoculation to verify tolerance/resistance to nematode. Of these, we have obtained four resistant individuals, and anticipate that more resistant individuals were screened. In addition to the conventional scheme, we are attempting to find new ways to do marker-assisted selection. For this purpose, we are developing several microsatellite markers to construct a linkage map and estimate genetic diversity among pine forests. Moreover, we are attempting to approach gene expression profiling in defense responses to nematode infection using suppression subtractive hybridization (SSH) or construction of cDNA library. More 50 microsatellite markers and thousands of EST already have been obtained.

Biology of the parasitoid *Dolichomitus nakamurai* of the sawyer *Monochamus saltuarius*. Won, D.S., Kim, J.K., Park, Y.C. (*Kangwon National University, Republic of Korea; dsw470@kangwon.ac.kr; jongkuk@kangwon.ac.kr; ycpark@kangwon.ac.kr*), Koh, S.H., Chung, Y.J. (*Korea Forest Research Institute, Republic of Korea; shkoh@forest.go.kr; yjchung@forest.go.kr*).

The sawyer, *Monochamus saltuarius*, is known as a vector of pine wilt disease of *Pinus koraiensis* in the central part of the Korean peninsula. The parasitoid adult, *Dolichomitus nakamurai*, was frequently observed flying on and around the entrance hole of the sawyer larva, *M. saltuarius*, in the dead trunk and twig of *P. koraiensis* in Chuncheon, Kangwondo, Korea. To find a potent biological control agent against the sawyer, we studied the parasitoid's biology, including development, behavior, rate of parasitism, and so on. The parasitoid was a medium sized ichnumonid wasp and moved very actively between trees. The parasitoid emerged during late march and early May, showing a peak in mid April. The female, given honey in a cage placed in the field, lived for 11 to 19 days. The parasitoid was a solitary ectoparasitoid. Larvae molted three times before making a silk cocoon for the prepupa. The term from larva to prepupa took about 40 days. The over-wintered prepupa became a pupa in March, next year. The emerged adult escaped from the host chamber through the hole made by its mandible. Rate of parasitism was varied from 12.5% to 31%.

Some biological characteristics of the sawyer *Monochamus saltuarius*. Won, D.S, Kim, J.K., Park, Y.C. (*Kangwon National University, Republic of Korea; dsw470@kangwon.ac.kr; jongkuk@kangwon.ac.kr; ycpark@kangwon.ac.kr;*), Chang, S.J. (*Kangwon Forest Research Institute, Republic of Korea; csjun99@korea.kr*), Shin, S C. (*Korea Forest Research Institute, Republic of Korea; shinsc99@forest.go.kr*).

The sawyer, *Monochamus saltuarius*, has been known as a vector of pine wilt disease of *Pinus koraiensis* in the central part of the Korean peninsula, which (particularly in Chuncheon, Kangwondo) was one of the best-known places for production of pine nuts in Korea. Controlling the spread of pine wilt disease was an emergent requisite to ensure benefits to pine tree culturing farmers. To help farmers' needs, some biological characters of the sawyer were checked. The sawyer halted growth as a prepupa in the self-made over-wintering chamber in the pine tree during the winter. And then, the adult emerged during late May and late June, showing a peak in early June. The adult liked feeding on 1–2-year-old twigs and performed mating behaviors during feeding. Fully grown eggs were made after 4–5 days of the emergence. First egg-laying was observed 5–6 days after emergence. Females made oviposition scars to lay eggs inside the bark; males made the scars also. A female made an average of 251 ± 104 of oviposition scars and laid an average of 86 ± 34 eggs. Females and males lived 51 ± 15 and 45 ± 18 days, respectively, at R.T.

Species and emergence patterns of natural enemies against wood-borers in *Pinus koraiensis.* Won, D.S., Kim, J.K., Park, Y.C. (*Kangwon National University, Republic of Korea; dsw470@kangwon.ac.kr; jongkuk@kangwon.ac.kr; ycpark@kangwon.ac.kr*), Koh, S.H., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea; shkoh@forest.go.kr; shinsc99@forest.go.kr*).

In the central part of the Korean Peninsula, the nematode *Bursaphelenchus xylophilus*, which is considered an agent of the pine wilt disease, is transmitted by the vector of sawyer, *Monochamus saltuarius*. Natural enemies against wood-borers of *Pinus koraiensis* were surveyed based on the collection in the field. Total number of natural enemies was 35 species (15 families, 6 orders). Among them, 4 species of the predators, *Trogossita japonica* and *Thanassimus lewisi*, and the parasites, *Dolichomitus nakamurai* and *Perithous* spp., were considered as the most potent control agents of the sawyer. Two species, *Sclerodermus harmandi* and *Spathius* spp., were thought to be generalists. Emergence patterns of some important natural enemies were checked. The adult of *T. japonica* emerged during early April and late June, and showed a peak in early June. The adult emergence of *T. lewisi* was during mid April and late June, showing a peak in late May. *D. nakamurai* emerged during late March and early May, with a peak in mid April. *Perithous* spp. was during early April and early May, with a peak in mid April.

Attraction effects to various conditions of *Pinus koraiensis* against pine sawyer beetle, *Monochamus saltuarius* (Coleoptera: Cerambycidae). Yoon C.M., Kim G.H. (*Chungbuk National University, Republic of Korea; changmann@hanmail.net; khkim@chungbuk.ac.kr*).

Recently, pine sawyer beetle, *Monochamus saltuarius*, has been proved a vector of pinewood nematode, *Bursaphelenchus xylophilus*, in South Korea. This pest causes serious concern because it is widely distributed in middle South Korea and is most likely to spread fast. To understand its ecological behavior, the attraction behavior of pine sawyer beetle was tested in the volatile samples of *Pinus koraiensis* by emitting different host conditions. The olfactory response of the immature (0–3 days old after emergence) adults of *M. saltuarius* preferred volatiles from fresh host condition (fresh twigs, just-cut twigs wrapped with the parafilm), whereas mature (20–30 days old) adults preferred volatiles from 3-day-old stressed hosts (3-day old cut twigs that were artificially damaged by male and female infestations). In the GC and GC/MS analyses, contrary to the samples from the fresh host condition having monoterpene volatiles only, the samples from the 3-day-old stressed hosts were revealed to have more volatiles of oxygenated monoterpenes and sesquiterpenes. The attraction assay of *M. saltuarius* adults to the volatile mixtures of monoterpenes, oxygenated monoterpene, and sesquiterpene appeared to be efficient when the oxygenated monoterpene mixture was necessarily treated with monoterpene mixtures.

G-15 Cork Oak forest degradation causes and sustainable development in western Mediterranean countries

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Key factors of forest biodiversity: the case of cork oak formations in Tunisia. Abid, H. (*Ministry of Agriculture, Tunisia; habibabid2001@yahoo.fr*), Khaldi, A. (*INRGREF, Tunisia; habibabid2001@yahoo.fr*).

Quercus suber is also known as the cork oak. It is a tree that is native to southern Europe and northern Africa and is located around the Mediterranean Sea in Portugal, Spain, France, Italy, Tunisia, Algeria, and Morocco. There are great geographical differences in management of this forest type. The Tunisian environmental features include: (i) five bio-climatic levels going from humid to arid, according to a north-south aridity gradient; and (ii) dense/rich forests (north) to open, low forests (centre), and fragile Saharan formations (south). A specific model of geographic information system (GIS) was developed for the cork oak forest in Tunisia. All the factors are integrated in this GIS, such as topographic and forest maps, aerial photographs, soil, vegetation, hydraulic, topographic, climatic, population, rural village, infrastructure and wildfire management, protected areas, roads, and forest trails. Since 2007, Tunisia has established a national strategy to conserve and develop cork oak forest. Seven thematic studies focused on the following aspects: ecology, silviculture and management, mapping and data analysis, research, socio-economy, political and macroeconomic synthesis, and economical analysis. This means a multidimensional challenge for: cork oak renewal, acceleration of its regeneration, sustainable development, increase of product value, and ensuring sustainability.

Outbreaks dynamics of gypsy moth (*Lymantria dispar* L.) in Tunisia. Ben Jamâa, M.L., Mnara, S. (*Institut National de Recherches en Génie Rural, Eaux et Forêts/INRGREF, Tunisia; benjamaa.lahbib@iresa.agrinet.tn*).

The gypsy moth, *Lymantria dispar* is the most harmful cork oak forest pest in the world. This paper aims to establish the current situation of knowledge of gypsy moth in Tunisia. Since its introduction in 1920, four outbreaks occurred: (1920–1935), (1945–1955), (1966–1977), and (1986–1998). The last latency period starts from 2000 to 2005. A small infestation of the gypsy moth was discovered in 2006 in northwest Tunisia, suggesting that the gypsy moth will start a new outbreak. However, a brutal

decrease of the caterpillar's population was noted in 2008, due to a three factors: quantities and qualities of feeding, natural enemies' activity, and climate conditions. From 2007 to 2008, the number of egg mass per tree decreased from 13 ± 5 to 10 ± 8 and the fecundity of females decreased from 560 to 356. The livings eggs were affected strongly, passing from 60 ± 29% to 34 ± 27%. The percentage of dried eggs increased from 14.53 ± 17% to 40.26 ± 22%. Predator action increased from 22% to 62% and the percentage of egg parasitism by *Oencyrtus kuvanae* is about 19%. The daily maximum temperature reached 41 °C, causing mortality of caterpillars and dried nymphs. The population dynamics of gypsy moth seems to starts a new cycle of outbreaks.

Genetic variation in growth characteristics and decay of different provenances of *Quercus suber* L. in the experimental site Tebaba, northwest Tunisia. Khouja M.L., Hamrouni L., Ben Jamaa M.L., Khaldi A., Nouri, M. (*INRGREF, Tunisia; khouja.medlarbi@iresa.agrinet.tn; hamrounilam@yahoo.fr; benjamaa.lahbib@iresa.agrinet.tn; khalditn@yahoo.fr; nouri.mohamed@iresa.agrinet.tn*), Selmi, H. (*Direction Générale de Forêt, Tunisia; selmi@yahoo.fr*), Franceschini A. (*IPV, Italy; afran@uniss.it*).

The oak cork (*Quercus suber* L.) is an essential component of the Tunisian wet forest. Area occupied by cork oak strongly decreased from 127,000 ha in 1950 to 60,000 ha in 1995. Because of the problems related to environment conditions, senescence, and regeneration difficulty, the genetic base of this species has been considerably reduced, which threatens to endanger population survival and reduce ability to adapt to future environmental changes. To understand the geographical variability of *Q. suber* and generate plants for a genetic improvement program, an assay of 26 provenances (from 6 countries) was conducted at Tebaba (northwest Tunisia) in 1997. Total height, diameter, survival, and plant form were assessed at age 7; results showed differences between provenances and within populations were significant for all characteristics. The present study attempted to select the most efficient provenances that can be adapted in Tunisian ecological conditions. Ten years after the installation of the trial, many symptoms of dryness were recorded on all sources but with varying degrees. Phytopathology analysis performed on twigs, branches, stem, and roots showed the presence of pathogens, some of which appear to be involved in the process of decay. However, no pathogen of soil was detected.

Growth and anatomical responses to different water and light intensities in cork oak (*Quercus suber* L.) seedlings. Kwak, M.J., Woo, S.Y., Seo, S.M. Lee, S.H. (*University of Seoul, Republic of Korea; na8349@yahoo.com; wsy@uos.ac.kr; ssm99110154@hanmail.net; earlymay1004@yahoo.com*).

This study was performed to investigate the effects of water and light intensity on a growth and anatomical aspect of cork oak (*Quercus suber* L.) seedlings from acorns collected from Tabarka (northern Tunisia). The experiments were divided into two treatments: water stress (well-watered: 25–35% water contents, moderate drought stress: 15–20%, and severe drought stress: 7–10%); and light intensity (full sunlight: 100% of full sunlight, moderate sunlight: 65–70% of full sunlight, low sunlight: 20–25% of full sunlight, and extremely low sunlight: 3–4% of full sunlight). Growth varied among water stresses, but this variation was typically smaller than light intensity. Seedlings grown under severe drought stress increased in root growth. In severe drought stress, the ultrastructural features of the abaxial leaf surface were folded and shrunken, and was observed in a higher stomatal frequency, the thicker palisade and spongy parenchyma. The severe drought stress indicated a swelling and disruption of the thylakoid, large starch grains, increased plastoglobuli, and accumulation of the reactive oxygen species (ROS), hydrogen peroxide (H_2O_2). The extremely low sunlight was revealed the higher and broader grana. In conclusion, water and light stress affect the growth and the anatomical development of *Q. suber*, depending on the water and light intensity.

Water relations of cork oak during dry period and reaction of the species to global warming. Nasr, Z. (*National Research Institute of Rural Engineering, Tunisia; safia_44@yahoo.fr*), Woo S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Khaldi A., Zineddine ZM., Rejeb M.N. (*National Research Institute of Rural Engineering, Tunisia; Rejeb. Khaldin@yahoo.fr; Znedmouna@yahoo.fr; nejib@iresa.agrinet.tn*).

Water relations studies could be a key element in the understanding of species reactions to global warming. An experiment was carried out in a cork oak forest, north Tunisia. Leaf transpiration (TR) and stomata conductance (Gs) were taken under various radiation (PAR), vapour deficit (VPD), and (CO_2) concentrations using a Li-COR 6400.-sap flux (SF) was measured on the trunks by Granier sensors. Variations of PAR and VPD appreciably affected the variation of Gs, with a negative relationship. Under high PAR and VPD, Gs take the lowest values.TR was closely related to Gs, and the relationship is linear; when CO_2 is increased from 400 to 800 ppm, Gs is reduced by 25%. This fall implies a reduction of TR, but carbon assimilation increased and we noted a rise of water efficiency. Hourly SF indicated certain variability between trees. Daily SF varied from 10 to 15 L dm^{-2} d^{-1}. The relations with climate parameters are positive, but SF reached a threshold when climatic demand increased. Under dry conditions, oak transpiration seems to be maintained around a critical value in order to ensure optimal carbon assimilation by the means of stomata adjustment.

Stand structure and regeneration of cork oak (*Quercus suber L.)* in northwestern Tunisia. Stiti, B. (*INRGREF, Tunisia; stiti.boutheina@iresa.agrinet.tn*), Park, P.S. (*Seoul National University, Republic of Korea; pspark@snu.ac.kr*), Khaldi, A. (*INRGREF, Tunisia; khaldi.abdelhamid@iresa.agrinet.tn*), Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*), Rejeb, M.N. (*INRGREF, Tunisia; rejeb.nejib@iresa.agrinet.tn*).

Currently, cork oak forests suffer from degradation and a lack of regeneration. This study aimed to assess natural regeneration and stand structure in a in a Tunisian northwestern cork oak forest to investigate its potential maintenance. Cork oak regeneration evaluation was conducted, in 91 plots selected at random, through the assessment of seedlings and tree age distribution examination. This forest showed poor cork oak regeneration potential with a mean seedling height of 6.8 cm. Only 1.7% of the trees were younger than 40 years, indicating that regeneration of cork oak has been very low for the past few decades. The crown widths of individual trees were measured and crown cover was used to describe stand density and individual tree competition to analyze the potential of cork oak seedling growth. The results show a high tree-area ratio (TAR), an elevated crown competition factor (CCF), and an excess of trees to be thinned. The consequence of these factors is crucial competition for light and water that explains the poor cork oak regeneration in this study site.

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Economic instruments for reducing cork oak forest degradation. Daly-Hassen, H. (*INRGREF, Tunisia; dalyhassen.hamed@iresa.agrinet.tn*), Pettenella, D. (*Università di Padova, Italy; davide.pettenella@unipd.it*).

Cork oak forest degradation often results from open access and insufficient enforcement of existing rules established in application of the traditional "command and control" approach for the conservation of Mediterranean forest resources. This paper analyzes appropriate economic instruments among the market-based mechanisms and payment for environmental services that could contribute to a multi-functional forest, reducing cork oak forest degradation. Policy recommendations are derived from three case studies of economic analysis of cork oak forest management where the trade-offs between local income generation and forest conservation were investigated. The first study showed that the financial income generated by household economies is high in Ain Snoussi (Tunisia), in contrast to Jerez (Spain), where significant investment on natural resources conservation induced an income loss. The second confirmed that current use of Tunisian cork oak forest induces high financial benefit for local population, but also high degradation costs, such as losses of cork and forage production, carbon emissions, and erosion. A third study using cost-benefit analysis at Ain Snoussi underlined that financial income would be reduced when sustainable management is carried out.

Favorite shrub species of *Orgyia trigotephras* (Lepidoptera, Lymantriidae), defoliator of cork oak in Tunisia. Ezzine, O. (*INRGREF, Tunisia; olfa.ezzine@gmail.com*), Dahmouni. M (*INSAT, Tunisia; mariem_dahmouni@yahoo.fr*), Ben Jamâa. M.L (*INRGREF, Tunisia; benjamaa.lahbib@iresa.agrinet.tn*), Nouira. S (*Faculté de Science de Tunis, Tunisia; said.nouira@issbat.rnu.tn*).

Among the most defoliating insects shrub of cork oak forests is *Orgyia trigotephras* (Lepidoptera, Lymantriidae). This work aims to identify the favorite species of *O. trigotephras's* caterpillars. We identified mineral compounds—nitrogen (N), calcium (Ca), magnesium (Mg), phosphorus (P), and potassium (K)—and secondary metabolites (flavonols) of 8 species of shrub (*Quercus coccifera*, *Erica multiflora*, *E. arborea*, *Pistacia lentiscus*, *Phillyrea media*, *Cistus crispus*, *Daphne gniduim*, and *Myrtus communis*) from three types of scrub leaves (old leaves not attacked and attacked and newly saddle leaves). There were no differences between types of leaves for mineral compounds and secondary metabolites. However, significant differences were found between shrub species for the two parameters. For mineral compounds, *M. communis* and *P. lentiscus* are the richest species for phosphorus and potassium, respectively, but for secondary metabolites *C. crispus*, *Q. coccifera*, *E. multiflora*, and *P. lentiscus* have the highest concentrations of flavonols. Although, *Ph. media* and *D. gnidium* are the poorer ones. *O. trogotephras's* caterpillars seem to prefer *P. lentiscus*, *C. crispus* and *E. arborea* than the other ones.

Diversity of Lepidopteran defoliators species in cork oak forests of Tunisia. Mannai, Y., Ben Jamâa, M.L., Mnara, S. (*INRGREF, Tunisia; farfallaflora@yahoo.fr; benjamaa.lahbib@iresa.agrinet.tn; mnara.sofiane@iresa.agrinet.tn*), Nouira, S. (*University of Tunis El Manar, Tunisia; said.nouira@issbat.rnu.tn*).

Cork oak is attacked by various Lepidoptera defoliators. This work aims to study the population structure of lepidopteran larvae in two infested northwestern Tunisian cork oak forests: El Jouza (Amdoun) and Bellif (Nefza), where serious defoliations were observed since 2005. Caterpillars were collected from infested branches weekly from March to June 2009. In total, 19 species belonging to 15 families were identified in Bellif and 15 species belonging to 7 families in El Jouza. The Geometridae, Noctuidae, Lymantriidae, Pyralidae, Drepanidae, Gelechiidae and Tortricidae families were found in the two sites with the highest number of collected species. The green leaf roller *T.viridana*, a defoliator insect of oak species considered one of the pests that cause damages in North African forests, is the most abundant species. It represents 96% and 61% in El Jouza and Bellif for the first larval stage and 92.5% and 23% for the last stage, respectively. The following species were more present in both localities: *Lymantria dispar* (4% and 13% in Bellif and El Jouza, respectively) and *Erannis defoliaria* (20% and 2% Bellif and El Jouza, respectively).

Effect of insects on cork-oak acorn viability in a Tunisian forest. Stiti, B., Ben Jamâa M.L., Hadj A., Khaldi A. (*INRGREF, Tunisia; stiti.boutheina@iresa.agrinet.tn; benjamaa.lahbib@iresa.agrinet.tn; ammar_hadj@yahoo.fr; khaldi.abdelhamid@iresa.agrinet.tn*).

This study was carried out to assess phytosanitary quality of cork oak acorns (*Quercus suber* L.) and to discuss the effect of insect damage on germination and seedling regeneration. The acorns were collected from a northwestern forest of Tunisia in February 2009. Analysis of these cork oak seeds, dropped to the forest floor, revealed they were attacked by the weevil *Curculio glanduim* and the moth *Cydia fagiglandana*. The mean percentage of insect-infested acorns was 48%. Indeed, most infested acorns exhibited one larval-exit-hole indicating that only one insect had emerged from each acorn: 31% and 10%, respectively. The remainder of infested acorns (7%) showed various holes. Despite this percentage of damage, germination rate of acorns was 78%. Moreover, viability test showed that the insect attack was observed in embryos for no more than 22% of acorns. We conclude that the effect of seed predation on germination, and then on seedling recruitment, is very low and thus, it does not contribute to explain the poor regeneration of cork oak stand in this Mediterranean ecosystem.

Individual tree variation in acorn production of Northwestern Tunisian cork oaks. Stiti, B., Khaldi A., Hadj A., Rejeb M.N. (*INRGREF, Tunisia; stiti_b@yahoo.fr; khaldi.abdelhamid@iresa.agrinet.tn; ammar_hadj@yahoo.fr; rejeb.nejib@iresa.agrinet.tn*).

Acorns are an important animal food resource and seed source for cork oak regeneration. Most acorn production studies note consistent differences in acorn productivity among individuals, but none clearly demonstrate determinants of productivity, particularly in North Africa. The objective of this study is to examine the range of variability in acorn production among trees sampled in autumn of 2007, throughout a northwestern Tunisian cork oak forest. Using a random sampling procedure, 91 400 m^2 circular plots were selected. The circumference over bark and tree height were measured for all trees in all the plots (2,123 stems). Fifty trees were chosen on the basis of weighted distribution circumference classes. Afterwards, for each tree, acorns were

collected from the canopy and gathered from the ground surrounding the tree. Mean acorn production was estimated to 9 kg per tree. Acorn productivity appeared more correlated to circumference than height. In order to explain tree acorn production, correlations were elaborated using different related parameters, especially, to tree circumference at breast height, height and crown size, and stand density.

G-16 Climate factors and tree susceptibility/resistance to insects and pathogens

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Climate factors and tree resistance/susceptibility to defoliating and sap-sucking insects and foliar pathogens. Battisti, A. (*Padova University, Italy; andrea.battisti@unipd.it*), Klapwjik, M., Larsson, S. (*Swedish University of Agricultural Sciences Sweden; Maartje.Klapwijk@ekol.slu.se; Stig.Larsson@ekol.slu.se*), Bonello, P. (*Ohio State University, USA; bonello.2@osu.edu*).

Foresters have often associated weather conditions with the occurrence of pest outbreaks. As climate change might result in an increased magnitude and/or frequency of outbreaks, it seems important to tease apart the direct effect of climate change on the organism from the indirect effect on tree resistance/susceptibility. The indirect effects based on alteration of tree physiology are mainly associated with an increase of temperature and/or decrease of precipitation, both promoting drought stress. Increase of temperature and/or decrease of precipitation may also affect tree vigor, with potential consequences for species damaging vigorous plants. Temperature change may also alter tree phenology, for example budburst, possibly affecting the synchrony with the pest attack. Global warming is directly pointing to a general increase of pestilence in temperate and boreal forest ecosystems, mainly because all these organisms are generally limited by temperature. Developmental times are predicted to become shorter, which may or may not correspond to an increase frequency of attacks. Combining direct and indirect effects of climate change is a difficult task. There are also a number of interactions among organisms that may affect the outcome, such as biotic facilitation between insects and fungi, competition, and natural regulation by enemies.

Genomic bioprospecting of uncharacterized gene pools for biotic and abiotic stress tolerance: a case study from *Casuarina equisetifolia.* Dasgupta, M., Veluthakkal, R., Ramasamy Y., Varadarajan, M. (*Institute of Forest Genetics and Tree Breeding, India; modhumitaghosh@hotmail.com; radha_vinodkartha@yahoo.com; yasodha@icfre.org; mohan@icfre.org*).

Forests are important repositories of terrestrial biological diversity, and their genetic resources are uncharacterized and underutilized. Xenogenomics targets the genomic bioprospecting of novel genes conferring stress tolerance from these uncharacterized gene pools. The present study was undertaken to isolate and characterize pathogen defense-related genes for the tropical tree species, *Casuarina equisetifolia*, known for its adaptability to drought and salinity. Transcript profiling was conducted in pathogen elicitor. Treated and untreated complementary DNA pools and the transcripts that over expressed during elicitation included: resistance genes; cytochrome oxidase involved in hypersensitive reactions; cell wall proteins such as arabinogalactan; genes involved in systemic acquired resistance such as chitinase and glucanase; genes induced during symbiosis such as nodulin; other genes such as 26S proteasome, signal recognition particle, cyclin-dependent kinase, and genes involved during drought stress. A class I chitinase with approximate size of 1.7 Kb was cloned and characterized. The expression pattern of these genes during biotic and abiotic stresses was determined. Phylogenetic analysis of the transcripts revealed genetic distinctness of the sequences from other crop and tree species. Characterization of such unique genomes will create a true gene bank with functional inventories and accelerate the utilization of candidate genes in transformation programs.

Effects of climate change on the interaction between a bark beetle and its conifer host. Krokene, P., Lange, H., Økland, B. (*Norwegian Forest and Landscape Institute, Norway; paal.krokene@skogoglandskap.no; holger.lange@skogoglandskap.no; bjorn.okland@skogoglandskap.no*).

Today the spruce bark beetle *Ips typographus* is always univoltine in northern Europe including Norway and completes development from egg to adult between May and August. Farther south in Europe, development is bivoltine, with the completion of two generations in most years. A temperature-driven developmental model suggests that by 2070–2100 the voltinism of *I. typographus* will change dramatically in Norway. If summers become only 2.5 °C warmer than today, bivoltinism can be expected every single year in the major spruce growing areas in southern Norway. This is likely to have dramatic effects on forestry since two generations per year will give two, instead of one, attack periods each summer. In addition to increasing the number of attacked trees, the effect of the attacks may also be more severe, as Norway spruce is more susceptible to beetle attacks later in the summer. However, climate change will probably also change the phenology of Norway spruce and thus its susceptibility to attack by *I. typographus* and its phytopathogenic fungal associates. We are currently modelling how tree resistance varies with temperature and tree phenology to provide more well-founded advice to forest managers on the interaction between bark beetles and trees in a future climate.

Climate factors and tree resistance/susceptibility to boring insects and wood pathogens. Paine, T. (*University of California, USA; timothy.paine@ucr.edu*).

Tree resistance to bark beetles, wood borers, and wood pathogens is a directly related to environmental conditions and tree stress. As global climate changes progress, tree growing conditions will also change. Changes in precipitation patterns and temperature conditions may lead to changes in tree growth patterns and allocations to reproduction and defense. Similarly, the active periods and survival of insects colonizing host trees will change with changing environmental conditions. Consequently, forest stand conditions across altitudinal and longitudinal gradients are predicted to shift, which will alter susceptibility to infection or invasion by pest species. Forests growing at the margins of their geographic ranges (e.g., at the lower elevation limits) may be at risk of either being eliminated or may be subject to improved conditions (e.g., at the highest elevation limits) as global change progresses. These changes may be further influenced by anthropogenic factors including increased nutrient deposition from

pollutants and increased fire frequencies. Understanding the mechanisms of resistance and the effect of environmental conditions on those processes can generate predictions of the patterns of changes and enable forest manage to develop appropriate management strategies.

Resistance of *Pinus merkusii* against a new invasive pest, *Pineus boerneri*, in Jawa plantation, Indonesia. Siregar, U.J., Napitupulu, D. (*Bogor Agricultural University, Indonesia; siregaruj@gmail.com; napitupulu@yahoo.com*), Suwarni, E. (*State Forest Enterprise, Indonesia; endaperhutani@yahoo.com*).

Since 1970 *Pinus merkusii*, which is native species of Indonesia, has been widely grown in plantations throughout Java Island, with no reported serious pest attack. Recently plantations have suffered severely from a new invasive pest, which was identified as *Pineus boerneri* (Aldegidae; Hemiptera). Pest attack started in West Java in 1997 and spread rapidly to Central and East Java, covering thousands of hectares in area. The insect attacks all stages of plant growth, started from seedling, sapling, to mature tree. Among severely attacked trees, some individuals showed resistance, as appear from the healthy greenish foliage, despite the insect presence on their needles base and twigs. Further microscopic investigation on cross-section of several needles and bark showed differences in the resin canals of resistant trees compared to susceptible ones. In susceptible individuals, resin canals were empty due to fluid sucking action of the insect pest, while the resistant trees were full of resin fluid. Clustering based on RAPD analysis showed that most resistant trees clustered separately from susceptible ones, indicating differences in the genetic background between the two classes. This resistance is important for improvement program of *P. merkusii* against this new pest.

Test of pathogenic variation to *Pinus thunbergii* isolates of pitch canker pathogen, *Fusarium circinatum,* and responses of natural selection *Pinus* × *rigitaeda* to branch inoculation in a seed orchard. Woo, K.S., Yoon, J.H., Han, S.U., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; woo9431@forest.go.kr; black7988@ynu.ac.kr; sanguhan@forest.go.kr; jskim20@forest.go.kr*).

A half-sib family of two 4-year-old seedlings of *Pinus* × *rigitaeda* was inoculated with each of 20 *P. thunbergii* isolates of *Fusarium circinatum* from two pitch-canker-damaged sites in Jeju island, Republic of Korea. Initial symptoms of needle damages were visible on most of the seedlings at 18 days after inoculation. The tested 20 isolates were not statistically varied in the degree of disease severity on the seedlings based on the lesion length. However, lesion length was 82% greater than total mean on seedlings inoculated with isolate FT-7. Some seedlings began to die 45 days after inoculation. All but one seedling inoculated with each of isolates FS-2 and FS-13 were dead by 68 days after inoculation. Using the most virulent isolate FT-7, eleven 38-year-old natural selection *P.* × *rigitaeda* were inoculated on branches in a seed orchard in Jeju Island to determine their variation in susceptibility to the pathogen. The 11 trees differed significantly in susceptibility to *F. circinatum* based on average lesion lengths. The susceptibility of natural selection *P.* × *rigitaeda* trees is more likely affected by interaction with *F. circinatum* rather than environmental conditions.

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Soil enzyme activities under two different populations of *Cedrela odorata.* Alarcón-Gutiérrez, E. (*Universidad Veracruzana, México, enalarcon@uv.mx*), Martínez Cruz, Y. (*Benemérita Universidad Autónoma de Puebla, México, yaneli.martinez@fbio.buap.mx*), Perroni Ventura, Y. (*Universidad Veracruzana, México, yperroni@uv.mx*).

Microbial enzymes contribute to nutrient mineralization and organic matter degradation in forest soil. The aim was to estimate and compare: fluorescein diacetate hydrolase (FDA), acid phosphatase (APH), and basic phosphatase (BPH) in soil from two populations of *Cedrela odorata*; a natural forest and a monoculture. In both populations, non-infested and infested trees by *Hypsiphyla grandella* were considered. Soil samples (0–5 cm depth) were collected and enzyme analyses were done. High FDA activity was found in natural forest, but no significant differences (Kruskal-Wallis, $p < 0.05$) were observed between infested and non-infested. In the natural population, APH did not differ between non-infested and infested. In monoculture, APH ranged from 0.0012 to 0.0007 nkat/gDM in non-infested and infested trees, respectively. In the monoculture, BPH shown significant differences between natural forest and monoculture, and between non-infested and infested. In the natural population, there was no difference between non-infested and infested due to the surrounding vegetation. In monoculture non-infested trees, high activity of both enzymes was shown, suggesting that the hydrolysis of inorganic phosphorus is higher in non-infested trees. The low enzyme activity in infested trees may be due to a kind of weakness in the tree's immune system caused by the borer attack.

Forest susceptibility to different *Heterobasidion* spp. in primeval and plantation forests of Carpathian mountains. La Porta, N. (*FEM-IASMA, Italy; nicola.laporta@iasma.it*), Grudniski, M. (*University of Suceava, Romania; grudnickim@yahoo.com*), Korhonen, K. (*Finnish Forest Research Institute, Finland; k.korhonen@metla.fi*).

In the Carpathian mountains, *H. annosum* represents the most important wood-destroying fungus in natural forests and plantations of Norway spruce, particularly in stands of high site quality. So far, there is a lack of knowledge about the presence of different species of *Heterobasidion* and their different adaptation to climatic changes. Fifty-seven basidiocarp specimens of *Heterobasidion* spp. collected from seven forest stands in Carpathians mountains, were identified with the aid of mating tests. The forests were pure or mixed stands of silver fir (*Abies alba*) and Norway spruce (*Picea abies*). Basidiocarps of *H. abietinum* and *H. parviporum* were frequently found both in natural stands and plantations. *H. abietinum*, the most thermophilic one, was the dominant species in forests containing high proportion of fir, and *H. parviporum* dominated in forests with high proportion of spruce. There was, however, one exception: only *H. abietinum* was found in a 55-year-old plantation of Norway spruce. *H. annosum s.str.* was not found in the spruce and fir forests, nor in a large 85-year-old *Pinus sylvestri*s forest plantation. *H. parviporum* and *H. abietinum* are recorded for the first time in Romania. The results are discussed in the context of climatic changes to improve sustainable silvicultural practices.

Current status of chestnut ink disease and screening of susceptibility and resistance of chestnut cultivars in Korea. Lee, S.H., Kim, K.H., Seo, S.T. (*Korea Forest Research Institute, Republic of Korea; shlee4@Korea.kr; kyung624@forest.go.kr; stseo@forest.go.kr*), Lee, J.K. (*Kangwon National University, Republic of Korea; jongklee@kangwon.ac.kr*).

Chestnut blight (*Cryphonectria parasitica*) is the famous pathogen in chestnut plantations, and ink disease (*Phytophthora katsurae*) was first found at Hadong, Hapcheon (Gyungsangnam-Do) and Youngkwang (Chullanam-Do), in Korea. Chestnut ink disease is a destructive disease in chestnut plantations of the United States as well as European countries including Italy, Spain, and Portugal. The disease mainly occurs on the lower trunks of the tree and the infected trees usually die within 3 to 4 years after infection. The typical symptoms on chestnut trees are black-ooze and cinnamon-colored tissue on trunk. When the bark is peeled off a distinct necrotic margin is shown between healthy and dead tissue. American (*Castanea dentata*) and European (*C. sativa*) chestnut trees are reported to be susceptible to *Phytophthora cinnamomi* and *P. cambivora*, while Japanese and Chinese chestnut are known to be relatively resistant. However, *P. katsurae* was reported as a trunk rot fungus in Japan and Korea. Resistance or susceptibility of the most commonly planted chestnut cultivars, which are *C.crenata*, *C. mollissima*, or hybrids of both, against ink disease were evaluated by artificial inoculation of the pathogen to the 3-year-old seedlings in the pot. Riheiguri and Daebo was relatively resistant, while Parkmi2 and Arima were susceptible.

Effects of the pitch canker pathogen *Fusarium circinatum* inoculation on disease development and gas exchange rate in the seedlings of *Pinus thunbergii, P. densiflora,* and *P. rigida* in a greenhouse. Woo, K.S., Yoon, J.H. (*Korea Forest Research Institute, Republic of Korea; woo9431@forest.go.kr; black7988@ynu.ac.kr*), Woo, S.Y., Lee, S.H., Kwak, M.J. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr; emay@uos.ac.kr; 016na8349@hanmail.net*), Han, S.U., Kim, C.S. (*Korea Forest Research Institute, Republic of Korea; sanguhan@forest.go.kr; jskim20@forest.go.kr*).

Four-year-old seedlings of *Pinus thunbergii, P. densiflora*, and *P. rigida* were inoculated with *P. thunbergii* isolates (FT-7) of the pitch canker pathogen *Fusarium circinatum* on July 21, 2009, to evaluate the effects of the pathogen on disease development and gas exchange rate. Ten seedlings of each species were inoculated with FT-7, and five of each with PDA (potato dextrose agar), and five of each with non-treatment as a control. Needle dehydration was evident on 2 of 10 seedlings of *P. thunbergii* and *P. rigida* inoculated with FT-7 at 18 and 21 days after inoculation, respectively. No symptoms were observed in *P. densiflora* seedlings throughout the experiment. Gas exchange stopped completely 25 days after inoculation in 4 of 5 measured seedlings of *P. thunbergii* and 2 of 5 measured seedlings of *P. rigida*, and 39 days after inoculation in the remaining 3 seedlings of *P. rigida*. Disease development was faster in *P. thunbergii* seedlings than *P. rigida* seedlings. By the time the experiment was ended at 78 days after inoculation, 9 of 10 *P. rigida* seedlings and 8 of 10 *P. thunbergii* seedlings treated with FT-7 had died, but all *P. densiflora* seedlings were still alive.

G-17 Managing cone and seed insects to preserve the regeneration of future forests

Organizer: Jean-Noël Candau, *Natural Resources Canada, Canada, jcandau@nrcan.gc.ca.*

Molecular phylogeny of *Megastigmus* seed chalcids (Hymenoptera: Torymidae) evidence of invasive species groups associated with host plant families. Auger-Rozenberg, M.-A., Roques, A. (*INRA, France; Marie-Anne.Auger-Rozenberg@orleans.inra.fr; alain.roques@orleans.inra.fr*).

The genus *Megastigmus* (Chalcidoidea: Torymidae) consists of small wasps showing diverse feeding patterns from parasitism of gall-formers to seed parasitism on trees and shrubs. The phytophagous species were considered to be mainly associated with conifer seeds, but growing evidence shows that a number of angiosperm families have also been colonized, e.g., Rosaceae, Anacardiaceae, Myrtaceae, Tiliaceae, Rhamnaceae, and Fabaceae. The exponentially increasing international seed trade for ornamentals and afforestation is largely facilitating accidental introductions of seed chalcids from one continent to another. Some introduced species became highly invasive in seed orchards. To understand their degree of specialization with regard to hosts as well as to clearly prove the presence of introduced species, we investigated the phylogenetic relationships among members of the genus, using cytochrome b mitochondrial DNA and nuclear 28S rDNA sequence data. Both maximum likelihood and maximum parsimony analyses showed that taxa formed monophyletic groups according to host family. This is in agreement with the strong specific insect-plant association of obligate seed feeders which develop entirely within a single seed. Molecular data were also used to confirm the presence of invasive Nearctic species in the Palaearctic, and to demonstrate the existence of new species and cryptic species complex.

How to invade a Mediterranean forest ecosystem? A lesson from seed insects in French *Cedrus atlantica* (Pinaceae) forests. Boivin, T., Chalon, A., Sondo, M., Candau, J.N. (*INRA, France; boivin@avignon.inra.fr; chalon@avignon.inra.fr; sondo@avignon.inra.fr; Jean-Noel.Candau@avignon.inra.fr*).

Worldwide exchange of tree materials is a major factor favouring insects' invasions in forest ecosystems through considerable extensions of their distribution ranges. Here we describe the biological and ecological mechanisms involved in the recent invasion of southeastern French cedar (*Cedrus atlantic*a) stands by the invasive seed predator *Megastigmus schimitscheki* (Hymenoptera: Torymidae). Despite the presence of resident direct competitor (*M. pinsapinis*), French *M. schimitscheki* populations display a continuous increase in abundance due to multiple adequations of its life cycle with its new environment. Specifically, adult emergence is well-synchronized with the timing of cedar's fructification, and interannual variations in resource abundance may be counterbalanced by prolonged diapause, temporally dispersing individuals of a cohort. Adult emergence and realized fecundity in *M. schimitscheki* were found significantly earlier and higher (respectively) than in *M. pinsapinis*, suggesting enhanced abilities of *M. schimitscheki* to exploit local resources compared to *M. pinsapinis*. Consequently, we observe recurrent local exclusion by the invasive species. Population genetics of *M. schimitscheki* also suggest high long-distance dispersal abilities. Our analysis of key components of both local and regional dynamics of this species shed a critical light on the processes involved in a successful insect invasion in a French Mediterranean ecosystem.

Sex pheromones of *Dioryctria abietella* Den. et Schiff. (Lepidoptera: Pyralidae) and *Cydia strobilella* (Lepidoptera: Tortricidae)—serious pest species in seed orchards. Löfstedt, C. (*University of Lund, Sweden; christer.lofstedt@ekol.lu.se*), Rosenberg, O. (*Skogforsk, Sweden; olle.rosenberg@skogforsk.se*), Wang, H., Svensson, G. (*University of Lund, Sweden; hong-lei.wang@ekol.lu.se; glenn.svensson@ekol.lu.se*), Roques, A. (*INRA, France; alain.roques@orleans.inra.fr*), Millar, J. (*University of California, USA; millar@ucr.edu*), Bengtsson, M. (*Swedish University of Agricultural Sciences, Sweden; marie.bengtsson@ltj.slu.se*), Jirle, E. (*University of Lund, Sweden; erling.jirle@ekol.lu.se*).

Pest insects feed on cones and seeds in seed orchards and are important factors causing a deficit of seeds for reforestation today. Two of the most important species in northern European spruce seed orchards are *D. abietella* and *C. strobilella*. If it were possible to attract these species to monitoring traps, it would improve possibilities for counter measures. The pheromone for *D. abietella* was identified in 2006, and a study in 2009 confirmed that the pheromone is effective. A study of six different rubber septum dispensers loaded with the same dose of the pheromone for *D. abietella* showed that the quality of the dispenser is critical for attraction. In 2009 a pheromone, a two-component acetate blend, for *C. strobilella* was identified. It is attractive in very low doses, which is in line with the extremely low amount emitted from the female. The pheromone was different from the one attracting the Canadian *C. strobilella* and the one attracting *C. strobilella* in Poland. The pheromones developed will be a great tool for knowing if, and when, insecticides should be used.

Monitoring of *Dioryctria abietella* Den. et Schiff. (Lepidoptera: Pyralidea) in northern Europe using pheromone traps. Rosenberg, O. (*Skogforsk, Sweden; olle.rosenberg@skogforsk.se*), Ylioja, T. (*Finnish Forest Research Institute, Finland; tiina.ylioja@metla.fi*), Krokene, P. (*Skog og Landskap, Norway; paal.krokene@skogoglandskap.no*), Ravn, H.P. (*Skov og Landskab, Denmark; hpr@life.ku.dk*), Voolma, K. (*Estonian University of Life Sciences, Estonia; kaljo.voolma@emu.ee*), Harala, E. (*Finnish Forest Research Institute, Finland; eevamaria.harala@metla.fi*), Löfstedt, C. (*University of Lund, Sweden; christer.lofstedt@ekol.lu.se*), Savonen, E.M. (*Finnish Forest Research Institute, Finland; eira-maija.savonen@metla.fi*).

Cone and seed insects reduce seed production in seed orchards by feeding on cones and/or seeds and thus cause a lack of seedlings for reforestation. One of the most serious pest species in conifers is the spruce cone worm, *Dioryctria abietella*. Since 2007, we have used pheromone traps to monitor the flight of this species in Denmark, Finland, Norway, and Sweden (and Estonia from 2009). In addition to monitoring, all countries have measured air temperatures in the vicinity of the traps. It is thus possible to correlate flight activity with temperature and temperature sums (accumulated day degrees >5 °C). In Sweden, cone development has also been registered throughout the monitoring period. Our results show that *D. abietella* has an extended flight period in northern Europe, which lasts from late May to late September, and that flights begin when the cones have reached their full length. Further research is needed to determine if late-flying individuals oviposit on shoots or in cones. Increased knowledge about the flight period of *D. abietella* and how it coincides with temperature and cone development may help us develop better control measures against this important pest.

Research on insect pest management in Swedish spruce seed orchards between 1996 and 2010. Weslien, J., Rosenberg, O. (*Skogforsk, Sweden; jan.weslien@skogforsk.se; olle.rosenberg@skogforsk.se*), Glynn, C. (*Swedish University of Agricultural Sciences, Sweden; carolyn.glynn@adm.slu.se*).

Due to insect damages in spruce seed orchards, there is a substantial lack of genetically improved spruce seedlings for reforestation in Sweden. The economically most important species are *Dioryctria, abietella*, *Cydia strobilella* (Lepidoptera), and *Strobilomyia anthracina* (Diptera). Between the years 1996 and 2009 different insecticides have been evaluated either conventionally sprayed or by injection. In seed orchards, genotypes (grafted ramets) are replicated over the entire area. Some studies had a factorial design, controlling for genotype. Up to 80% damage reduction was obtained but the variation in reduction varied much between methods, years and species. For *C. strobilella* no reduction was obtained. With a better understanding of insect phenology, the efficacy may be improved with conventionally sprayed insecticides. Insecticides for injection can be efficient, also over more than one growing season, but the method is time consuming and expensive. The cost efficiency may be increased if the trees at the same time are injected with the hormone gibberellin, which increases flowering the following year. There seems to be a genotypic variation in susceptibility to insect damage, but the mechanisms are so far unknown.

Posters

Non-target insect response to semiochemicals: a case study of *Conophthorus spp* (Coleoptera: scolytinae) in Mexico. Del Rio Mora, A.A. (*Universidad Michoacana de San Nicolas de Hidalgo, Mexico; aadelrio54@yahoo.com*), Gilletie, N.E., Mori, S.R. (*U.S. Forest Service, USA; ngillette@fs.fed.us; smori@fs.fed.us*).

Trans-pityol, verbenone, conophthorin, and 4-allylanisol were tested for behavioral activity in field trials in Mexico. Target cone beetle species included *Conophthorus conicolens* (*Pinus pseudostrobus*), *C. teocotum* (*P. teocote*), *C. edulis* (*P. cembroides*), and *C. michoacanae* (*P. michoacana = P. devoniana*). The effect on non-target insects was variable. The response of clerids, snakeflies, and hymenopteran (chalcidoids) insects was synergized with trans-pityol blends containing 4-allylanisol. Pityol combined with other terpenoid compounds was attractive to the non-target beetles *Pityophthorus schwertfergeri* and *P. crassus*, whereas in California, USA, blends of pityol and conophthorin synergized the response of *Pityophthorus* spp. Pollinator insects such as *Apis mellifera* and others were attracted by most of the semiochemicals tested. It is suggested that further studies be conducted to measure the response mechanisms of beneficial insects to semiochemicals and the possible use of sprayed microencapsulated semiochemicals concentrates (mecs) in control programs as a way to lessen the effects on this insect group. These results highlight the multifunctional aspect of behavioral chemicals across taxa, and underscore the importance of both laboratory and field trials in identifying all behaviorally active components in a pheromone blend.

Insect damage on *Acer pictum* subsp. *Mono* (Maxim.) Ohashi seeds in the Korean peninsula. Kim, G.T. (*Sangji University, Republic of Korea; gtkim@sangji.ac.kr*), Kim, H.J. (*Seoul National University, Republic of Korea; hjkim0916@gmail.com*), Um, T.W. (*Sangji University, Republic of Korea; ecoregion@sangji.ac.kr*).

To examine the possibility of natural regeneration of *Acer pictum* subsp. *mono* in broadleaved mixed forest in Korean peninsula, six samples of tree seeds were collected at three natural forests from August to October 2009, and seed viability and seed insects were tested using the cutting method. Seeds were divided into four groups—sound, under-developed, empty, and decayed or damaged. Decayed or damaged seeds of *A. pictum* subsp. *mono* ranged from 48 to 72% of collected seeds; mean values were 62.33%. Half of decayed or damaged seeds (30% of all tested seeds) had the openings made by *Bradybatus sharpi* Tournier(Curculionidae). *B. sharpi* proved the main seed insect to *A. pictum* subsp. *mono* in Korea. Viable seeds of *A. pictum* subsp. *mono* were ranged from 6% to 22% of collected seeds; mean values were 13%. Considering the post-dispersal seed predators, viable seeds of *A. pictum* subsp. *mono* produced in the natural forests in Korea might be insufficient for seedling establishment. This study shows that viable seed supply might be a key factor in natural regeneration of *Acer pictum* subsp. *mono* in Korea.

Relationships among fluctuations in seed production, seed predation, and seed hoarding: application of the hypothesis by Ims. Ueda, A. (*Forestry and Forest products Research Institute, Japan; akira@ffpri.affrc.go.jp*).

The predator satiation hypothesis is often used to explain interactions between synchronous seed production and seed predators. For generalist predators faced with asynchronous production of seeds, the hypothesis by Ims (1990) has been used to explain how some tree species may escape seed predators due to the mast seeds of nearby alternative host species attracting the generalists. Based on this hypothesis, both flat seed production and defense against predators should evolve on tree species due to the difficulties of forecasting the masting of the other tree species, and diverting potential predators to the more suitable seeds of other tree species. Among the 16 principal tree species present in a deciduous forest of central Japan, the greatest fluctuation in seed production is known to occur on a species in the family Fagaceae, whereas the flattest seed production also occurs on two other species of Fagaceae. Results from my studies of both pre- and post-dispersal seed predation on each of five Fagaceae species were consistent with both the predator satiation and Ims's hypotheses. Other results were also consistent with the Ims hypothesis, as the reproductive success of several tree species depend on seed-caching vertebrates for facilitating the dispersal of their seeds.

G-18 Diseases and insects in pines threatening global forest health in the 21st century

Organizers: Kyung Joon Lee, *Seoul National University, Republic of Korea, fraxinus@snu.ac.kr*; Ho Duck Kang, *Dongguk University, Republic of Korea, hdk0225@dongguk.edu.*

Molecular underpinnings of systemic induced resistance to pathogens in pine: a future disease management tool? Bonello, P. (*Ohio State University, USA; bonello.2@osu.edu*).

Under natural conditions, forest ecosystems are usually stable, despite the constant presence of arthropods and pathogens inherently capable of killing their tree hosts. It is likely that the phenotypic plasticity of trees, which includes inducible resistance mechanisms against attacking organisms, plays a crucial role in these interactions. Systemic induced resistance may be a common and important phenomenon in forest trees, one that allows for balanced partitioning of available resources between growth and defense. However, there is also evidence that systemic induced resistance and its counterpart, systemic induced susceptibility, may be operative concurrently in the same tree, depending on the specific organs under attack. Lastly, all these host responses can be strongly modulated by systemic cross-effects between pathogens and/or insects. The latest information on the molecular basis of systemic induced resistance in Austrian pine in response to the tip blight and canker pathogen *Diplodia pinea* will be presented, including studies using genomic, proteomic, and metabolomic approaches. While SIR holds promise as an environmentally friendly disease management tool, particularly for pine plantations, there currently are significant limitations to its implementation, which will be discussed.

Patterning population dynamics of the pine needle gall midge, *Thecodiplosis japonensis* (Diptera: Cecidomyiidae) by using a self-organizing map. Choi, W.I., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea; wchoi@forest.go.kr; shinsc99@forest.go.kr*), Park, Y.S. (*Kyung Hee University, Republic of Korea; parkys@khu.ac.kr*).

The population dynamics of the pine needle gall midge (PNGM), *Thecodiplosis japonensis*, in Korea were analyzed using the percentage of pine needle pairs infested by PNGM at 67 monitoring areas from 1986 to 2005. To examine the population dynamic patterns of PNGM in each monitoring area, an autocorrelation function (ACF) was estimated and then the amplitudes of each ACF were analyzed using a self-organizing map (SOM), which is an unsupervised artificial neural network. Through the SOM learning process, five clusters were identified based on the similarity of ACFs in 67 monitoring areas, reflecting geographical differences in the population dynamics of PNGM at different monitoring areas. Furthermore, the population dynamics of each cluster followed either an unstable, damped oscillation, or limit cycle model. Differences in population dynamics in each area were possibly caused by difference in dispersal history of PNGM, geographical variation in host species, environmental factors such as temperature, and interaction with natural enemies such as parasitoid. Our results showed that difference in population dynamics was induced by interactions among factors rather than by one dominant factor.

Modeling spatial distribution of damages caused by the common pine sawfly (*Diprion pini*) in managed boreal forests. Kantola, T., Talvitie, M., Lyytikainen-Saarenmaa, P., Holopainen, M. (*University of Helsinki, Finland; tuula.kantola@helsinki.fi; mervi.talvitie@helsinki.fi; paivi.lyytikainen-saarenmaa@helsinki.fi; markus.holopainen@helsinki.fi*).

Climate change has been observed to be related to the increase of forest insect damages in the boreal zone. The prediction of the changes in the distribution of insect-caused forest damages has become a topical issue in the field of forest research. The common pine sawfly (*Diprion pini* L.) is regarded as a significant threat to boreal pine forests. The field of spatial modelling produces a vast array of effective tools for the prediction of spatial distribution of species and for the risk assessment of the

damages. Mixed-effects models provide a powerful and flexible tool for the analysis of heterogeneous forest data. We carried out the field work in Eastern Finland (62°53´, 30°54´), where *D. pini* has caused considerable damages in an area of 10,000 ha. The linear correlation between the defoliation by *D. pini* and site variables was examined. Mixed effects models were used to describe the defoliation level. The study also aimed to find out if mapping of spatial distribution of pest insect damages can be successfully applied in monitoring and modeling damage risks and range extensions of pests.

Apothecium development of *Cenangium ferruginosum* in various *Pinus* spp. and discovery of anamorph from the diseased *P. koraiensis*. Kim, K.H., Seo, S. T., Lee, S.H. (*Korea Forest Research Institute, Republic of Korea; kyung624@forest.go.kr; stseo@forest.go.kr; saimonlee@empal.com*), Kwon, Y.N. (*Chungbuk National University, Republic of Korea; imspirits@hanmail.net*).

Cenangium ferruginosum, a discomycetous fungus, causes dieback of pines; however, in nature its imperfect stage has not been found yet. In spring 2009, many pine trees in different species (*Pinus densiflora, P. thunbergii, and P. koraiensis*) in Gyeongnam province died entirely or lost some of their branches. Immature fruiting bodies of *C. ferruginosum* were observed from all the dead or dying *Pinus* spp., but pycnidia could be collected only from the diseased branches and stems of *P. koraiensis*. To determine the pathogen, the fungus was isolated from dying branches of pine trees, the ITS region of its rDNA was sequenced, and finally it was identified as *C. ferruginosum*. The pycnidia on *P. koraiensis* showed exactly same sequence with *C. ferruginosum*. To investigate the development of apothecia, twigs of three pine species, which have immature fruiting bodies, were collected in mid-May and kept in the forest of the Korea Forest Research Institute. In *P. densiflora* and *P. thunbergii*, apothecia matured in mid-June and produced ascospores. All the ascospores were released out during the rainy season and left the apothecia empty. However, in *P. koraiensis, C. ferruginosum* showed somewhat different ecology by producing an imperfect stage and keeping apothecia immature until spring.

White pine blister rust: comparisons of invasive and endemic white pine blister rust in North America and Asia. Kim, M.S. (*Kookmin University, Republic of Korea; mkim@kookmin.ac.kr*), Klopfenstein, N.B. (*U.S. Forest Service, USA; nklopfenstein@fs.fed.us*).

In an era of expanded world trade, the introduction of exotic pathogens critically threatens stable functioning of natural ecosystems. The white-pine-blister-rust pathogen (*Cronartium ribicola*) was introduced into North America in the late 1800s, where it has continued to cause significant mortality of five-needled, white pines over the past 100 years. Asia has been identified as a putative center of diversity for blister rust fungi and a potential source of *C. ribicola* introduced to North America via Europe. Presently, phylogenetics of blister rust fungi infecting white pines is largely unresolved; however, several related *Cronartium* taxa are found in Asia, but not in Europe or North America. This paper briefly reviews the history, distribution, status, research, and management of *C. ribicola* and related blister rust fungi in eastern Asia, including Korea, Japan, China, and Russia. We compare behavior and genetics among blister rusts in eastern Asia and North America, and discuss the potential evolutionary and management implications. A critical understanding of worldwide genetic structure, diversity, and evolutionary relationships among isolates of *C. ribicola* and related species is needed to help manage this pathogen and predict potential future invasions.

Toward predicting potential impacts of climate change on Armillaria root disease in coniferous forests. Klopfenstein, N.B., Hanna, J.W. (*U.S. Forest Service, USA; nklopfenstein@fs.fed.us; jhanna@fs.fed.us*), Kim, M.S. (*Kookmin University, Republic of Korea; mkim@kookmin.ac.kr*).

Armillaria root disease causes large losses in tree growth/volume in areas of western North America and other worldwide regions. *Armillaria solidipes* (= *A. ostoyae*) typically infects coniferous trees including *Pinus* spp., and resulting disease is predicted to be more severe in trees that are maladapted to climate-induced stress. Furthermore, weakly pathogenic *Armillaria* spp. could also cause more disease problems in trees stressed by climate. Precise information on distribution and behavior of accurately indentified *Armillaria* species is needed to predict disease distribution (and activity) under present and changing climates. Climate-based predictions of Armillaria root disease can help guide forest managers to implement appropriate forest practices to manage Armillaria root disease under the current and projected future climates. Currently, a multi-institutional collaborative study is underway to predict the present and future suitable climate space for *Armillaria* spp. in the interior western USA. Developing methods to predict potential distribution of Armillaria root disease pathogens and implications of prediction models will be discussed. Because Armillaria root disease is so widely distributed and causes significant damage worldwide, the development of prediction models will have wide applications for diverse forests around the world.

A spreading pattern of *Fusarium circinatum* and relative infection rates in pitch, loblolly, and their hybrid, pitch-lolly pines. Lee, K.J. (*Seoul National University, Republic of Korea; fraxinus@snu.ac.kr*), Lee, S.K., Kim, K.H., Woo, K.S., Noh, E.R. (*Forest Research Institute, Republic of Korea; leesk77@forest.go.kr; kyung624@forest.go.kr; woo9431@forest.go.kr; enohkfri@hanmail.net*), Kwon, K.W. (*Chungnam National University, Republic of Korea; kiwon@cnu.ac.kr*), Park, Y.G. (*Kyungpook National University, Republic of Korea; ygpark@knu.ac.kr*).

Korea introduced pitch pine (*Pinus rigida*) in 1922 and developed pitch-lolly hybrid pine (*P. rigida* × *taeda*) in 1954, which had combined desirable characters of both parents. Pitch canker caused by *Fusarium circinatum* was first observed in South Korea in 1997. We have monitored a spreading pattern of the disease during the past 13 years and also compared the relative infection rates of pitch, loblolly, and pitch-lolly pines. The disease was first noticed in the upper western coast of South Korea in the pitch pine plantations and has spread east and south reaching most parts of the country. At the beginning, the disease heavily infected and killed many pitch pine trees, with mortality rate being over 50% near the coast and in some islands. At present the disease has caused much less damage to pitch pine throughout the country, with the damage being still high but significantly lower than before near the western coast, and being much lower in inland. Loblolly and pitch-lolly pines have shown significantly less damage than pitch pine, with lowest damage in the hybrid.

Posters

Population monitoring of the pine processionary moth (*Thaumetopoea pityocampa*) by pheromone trapping on southern limit of distribution of *Pinus halepensis* in eastern Algeria. Chenchouni, H. (*University of Batna, Algeria; chenchouni@yahoo.fr*), Zanati, K., Rezougui, A., Briki, A. (*Forest Conservation of Batna City, Algeria; kamelzanati@yahoo.fr; abderrahmaneRezougui@yahoo.fr; brikatmane@yahoo.fr*), Arar, A. (*University of Batna, Algeria; bionacer@live.com*).

By following emergence dates of adults to determine local population density and the life cycle of the pine processionary moth (*Thaumetopoea pityocampa*), we used 126 synthetic pheromone traps placed randomly on trunks of Aleppo pine (*Pinus halepensis*) located in the major pine forests of Batna City (eastern Algeria). In our approach, we harvested daily contents of traps installed at an average height of 1.70 ± 0.30 m, where we totaled 19,339 individuals (males) captured from August 2008 to September 2008 with an average catch of 153.5 ± 179.4 per trap. Furthermore, it appears that pheromone traps is an important tool to assess population density and rhythms of flight. In addition, different findings are discussed such as infestation levels correlated with dendrological measurements and temperatures. Additionally, this moth caused (begin 2009) a defoliation reaching up to 80%, with 10% of dieback. This study is based on the use of mating disruption and mass trapping of males (a) to limit reasonably heavy outbreaks by causing reproductive failure, and (b) by providing data on exact dates of adult emergence to monitor future outbreaks and use the appropriate control technique.

Seasonal changes of functional groups in coleopteran communities in pine forests. Choi, W.I., Choi, K.S. (*Korea Forest Research Institute, Republic of Korea; wchoi@forest.go.kr*), Lyu, D.P., Lee, J.S., Lim, J.G., Lee, S.H., Shim, S.C., Chung, Y.J. (*Korea Forest Research Institute, Republic of Korea*), Park Y.S. (*Kyung Hee University, Republic of Korea*).

Fauna assemblages reflect their habitat condition relating to ecological function in an ecosystem. The functional groups are concerned with how a resource is processed by different species to provide a specific ecosystem service or function. We elucidated seasonal changes of coleopteran functional groups in forests, and evaluated their ecological roles related to their available food resources. Coleopteran communities were collected weekly or biweekly using Malaise traps at nine sampling sites in the Japanese red pine forests in Korea from late June to September 2005. Compositions of the functional groups were compared at different sampling sites and sampling times with respect to taxa richness and abundance. Cluster analysis and non-metric multidimensional scale were used to characterize spatial and temporal changes of functional groups. Our results showed that herbivores and dead/live wood feeders regulating primary production in the pine forests were the dominant coleopteran groups in July, followed by detritivores and predators that dominated from July to August, resulting from the accumulation of detritus. Then, fungivores became dominant due to increased fungal biomass in the forest. Seasonal changes of coleopteran functional groups shifted from regulators of primary production to regulators of decomposition, reflecting their available food resources.

Biological characteristics of *Diprion hani* (Hymenoptera; Diprionidae) and its influence on growth of *Pinus koraiensis*. Kim, E.H. (*Chung cheong buk-do Institute of Forest Protection and Management Research, Republic of Korea; pacjee@hanmail.net*), Koo, C.D. (*Chungbuk National University, Republic of Korea;*), Cho, S. (*Chungbuk National University, Republic of Korea; koocdm@chungbuk.ac.kr; chosoowon@gmail.com*), Lee, G.Y., Han J.H., Pyo, S.H., Yoo, J.H. (*Chung cheong buk-do Institute of Forest Protection and Management Research, Republic of Korea; yong103@korea.kr; handyman@korea.kr; lovemush007@korea.kr; whddb11@korea.kr*).

This study was to understand the biological characteristics of a new defoliation sawfly species, *Diprion hani*, and its damaging effect on *Pinus koraiensis* trees. The cocoons of *D. hani* were collected in *P. koraiensis* stand and were cultured in a lab to investigate it morphology and life cycle. The effect of the sawfly on *P. koraiensis* was measured growth. Its eggs were ivory, long, and elliptical. The larvae were shiny black on the head, light green on the body, and had species characteristic two black lines on the back and one line each side. The cocoons were light beige to deep brown, long, and elliptical. Antenna of the pupae and adults was serrate in the female while plumose in the male. Its emergence rate was 53.6%. Its female to male sex ratio was 1:1. It reproduced both bisexually and in arrhenotoky. The infection rate of natural enemies such as parasitoids and predators was ca 50% during January to February. *D. hani* seriously decreased the growth of damaged trees. This sawfly population rapidly reproduced with three generations a year to severely damage *P. koraiensis* stands, but dramatically decreased by natural enemies to create no more damage in 2 years.

Outbreak area characteristics of *Diprion hani* Smith and Cho (Hymenoptera: Diprionidae) and a report of a torymid parasitoid. Lee, J.S., Kim, I.K., Choi, W.I. (*Korea Forest Research Institute, Republic of Korea; jscrown@nate.com; ilkwons91@scientist.com; wchoi@forest.go.kr*).

Diprion hani Smith and Cho was first reported as a new species from South Korea in 2007. Major outbreaks occurred in September 2007 and were restricted geographically to only three inland areas of central Korea that had previously been reforested with Korean white pine, *Pinus koraiensis* Seib. and Zucc. The outbreak areas were limited within around 50 km in diameter. Contrary to the previous year, the sawfly populations subsided drastically to an extremely low a level, almost nil, in 2008. Environmental factors of the outbreak sites were investigated as a first step so as to characterize the sites and understand the population dynamics of the sawfly; we collected detailed information on the locations and monthly fluctuation of temperature and precipitation. During the outbreak, the average temperature of the sites was higher by 1.3º C than the 30-year average, but the average rainfall was lower by around 300 mm. In addition, *Monodontomerus dentipes* (Dalman), a well-known torymid parasitoid of many other sawflies, is reported as a gregarious cocoon parasitoid of *D. hani*, which is a new host of the parasitoid.

Field survey on the twig and branch death process of pines caused by *Cenangium ferruginosum* and the meteorological factors related with mass-mortality of pine forests in Korea. Lee, S.K., Lim, J.H., Kim, K.H., Park, N.C. (*Korea Forest Research Institute, Republic of Korea; leesk77@forest.go.kr; limjh@korea.kr; kyung624@forest.go.kr; pnch@forest.go.kr*).

Five episodes of mass-mortality of pines have been recorded in Korea in the past 20 years. The damaged pines were *Pinus densiflora*, *P. thunbergii,* and *P. koraiensis*. The pine mass mortality that occurred in 2009 was extremely severe, with total damage estimated at about 1,064,000 trees and 9,064 ha. Field surveys on the partially living trees with dead and living branches were irregularly mixed, showed that fruiting bodies of *Cenangium ferruginosum* were formed on about 80% of dead twigs and branches. In the totally dead trees, many fruiting bodies of the fungus were only found around the branch-diverging points of main stem, but not between them. The fungus was also successively isolated from the live needles. Based on these observations, it is considered that *C. ferruginosum* can be an endophyte in the fresh needles of healthy trees and becomes a pathogen to kill twigs and branches, leading to the death of an entire tree and mass mortality when trees are stressed from environmental causes. Analysis on meteorological data of pine mass mortalities showed that the damage occurred during a spring season after an unusually warm winter that succeeded a severe autumn drought in the previous year.

Analyses of occurrence patterns of the pine caterpillar, *Dendrolimus spectabilis* (Lepidoptera: Lasiocampidae), in Korea. Park, Y.S. (*Kyung Hee University, Republic of Korea; parkys@khu.ac.kr*), Chung, Y.J., Shin, S.C. (*Korea Forest Research Institute, Republic of Korea*).

The correct understanding of outbreak regularity could help to establish long-term control of pests. In this study we analyzed short-term as well as long-term occurrence patterns of pine caterpillar (*Dendrolimus spectabilis*), which was one of the most injurious defoliators of pine trees in northeast Asia, especially Korea during the 1960s and 1970s. Since the 1970s, the density of pine caterpillar in Korean Peninsula has gradually decreased, and low densities have been maintained since the 1980s. Outbreaks of this species have a long history in Korea. Since about 600 years ago, damage of pine forest by this species and its control were recorded in the Annals of Choson Dynasty (Choson Wangjo Shillok) which cover 472 years (1392–1863) of the history of the Choson Dynasty. Data from these annals were used to characterize the long-term periodicity of outbreaks of this species. In addition, the changes of densities of pine caterpillar surveyed in 22 monitoring sites from 1968 were analyzed for short-term periodicity of outbreaks. Time series analyses showed the periodicity of about 100 years in long-term outbreaks, while 5 years in short-term outbreaks.

Economic value of growth reduction by the common pine sawfly (*Diprion pini*). Talvitie, M., Kantola, T., Lyytikainen-Saarenmaa, P., Holopainen, M. (*University of Helsinki, Finland; mervi.talvitie@helsinki.fi; tuula.kantola@helsinki.fi; paivi.lyytikainen-saarenmaa@helsinki.fi; markus.holopainen@helsinki.fi*).

The outbreak of unprecedented magnitude by the common pine sawfly (*Diprion pini* L.) occurred in boreal forests of Finland, driven by climatic and man-made factors. Defoliation by *D. pini* caused growth losses and tree mortality of Scots pine (*Pinus sylvestris* L.), depending sawfly population density in a given area. Our study area is situated in eastern Finland, where *D. pini* caused vast needle losses in managed Scots pine stands. We estimated economic value of growth losses in mature stands using SIMO growth simulator software, applying a method of a net present value. We simulated tree increments on undamaged and defoliated areas. Number of defoliated trees and defoliation intensity caused a difference in the economic value of stands, which was calculated with average timber prices of the current year. A current value of increment loss was calculated using the net present value method with 3% and 6% discount rates. The economic loss of a stand was considerable if defoliation intensity reached over 20% of the needle biomass. Our methodology of simulating economic estimates for growth losses will be of great importance for integrated pest management and sustainable forest management.

G-19 Forest dieback caused by novel ambrosia beetle/*Raffaelea* pest complexes

Organizers: Kazuyoshi Futai, *Kyoto University, Japan, futai@kais.kyoto-u.ac.jp*; Naoto Kamata, *University of Tokyo, Japan, kamatan@uf.a.u-tokyo.ac.jp.*

Pest risk to climate mitigation efforts using fast growing poplar: the case of the ambrosia beetle, *Megaplatypus mutatus*. Alfaro, R. (*Natural Resources Canada, Canada; ralfaro@pfc.forestry.ca*), Gonzalez, P. (*Armed Forces Scientific and Research Institute, Argentina; pgonzalezaudino@citefa.gov.ar*), Allegro, G. (*Istituto di Sperimentazione per la Pioppicoltura Casale Monferrato, Italy; allegro@populus.it*).

Accelerated warming of the earth's atmosphere, resulting from human activity, is prompting renewed calls for use of fast-growing forests to mitigate climate change, because they offer accelerated CO_2 uptake and have potential as bio-energy. Poplars are a preferred choice because of their fast growth and multiple uses. However, reforestation efforts with this species are threatened by native and invasive pests. Accelerated global trade will increase the likelihood of cross-continental introduction of insects and diseases, plants, and animals alien to native ecosystems, causing transformation and economic loss to ecosystems already stressed by global warming. The ambrosia beetle *Megaplatypus mutatus* (Chapuis), native to the subtropical area of eastern South America, has extended its range in Argentina, reaching as far south as Neuquén in the Argentinean Patagonia. A recent introduction to Italy demonstrates that this insect can be transported long distances between countries, and therefore, presents a threat to poplar cultivation world-wide. Damage is caused by adults, which bore large gallery systems into living poplars and many other broadleaf species. The galleries not only degrade the lumber, but weakened trees often break during windstorms. Forest pest management can play a role in mitigating the effects of climate change on forests and society.

Ecology of *Platypus quercivorus*-associated yeasts. Endoh, R. (*Kyoto University, Japan; rikiyasu@kais.kyoto-u.ac.jp*), Suzuki, M. (*RIKEN, Japan; msuzuki@jcm.riken.jp*), Takeuchi, Y, Futai, K (*Kyoto University, Japan; yuuko@kais.kyoto-u.ac.jp; futai@kais.kyoto-u.ac.jp*).

Platypus quercivorus, a vector of oak wilt pathogen *Raffaelea quercivora* in Japan, is known as a member of fungus-growing ambrosia beetles. Although the fungal associates of *P. quercivorus* appeared to include certain yeast species, they had not been identified. I sampled yeasts from beetle galleries of *P. quercivorus* in specimens of *Quercus laurifolia, Castanopsis cuspidata,*

Q. serrata, Q. crispula, and *Q. robur* located in Kyoto Prefecture, Japan. Yeast species isolated in this study were characterized by standard methods. As a result, 25 yeast species were isolated. Among them, two novel yeasts were frequently and dominantly isolated from the galleries irrespective of host tree species, suggesting a close association with *P. quercivorus*. Two yeasts were assigned to the genus *Candida*, one of which was described as *Candida kashianagacola* sp. nov. The pathogen *R. quercivora* was also isolated from all tree species. In conclusion, although it is not known whether they serve as the beetle's primary food source and are essential for the completion of the beetle life cycle, two yeasts and *R. quercivora* are very likely primary symbiotic fungi of *P. quercivorus*.

Chemical ecology of *Platypus koryoensis*. Kim, J., Kim, E., Park, H.-M., Shin, S.-C., Park, I.-K., (*Korea Forest Research Institute, Republic of Korea; junheon@gmail.com; kea7013@smu.ac.kr; pham83@naver.com; shinsc99@forest.gor.kr; parkik1@forest.go.kr*).

The ambrosia beetle, *Platypus koryoensis*, is a vector of *Raffaelea quercus-mongolicae*. Their massive attack against oak trees (mainly *Quercus mongolica*) causes Korean oak wilt disease. Towards the goal of developing semiochemical-based control method, the aggregation pheromone of the beetle was investigated. Whole body extract and body part extracts of male and female *P. koryoensis* were analyzed using GC and GC-MS. All samples of male extracts contained four monoterpenoids—nerol, neral, geraniol, and geranial—which were not detected from any female extracts. In addition to those compounds, citronellol was detected from the extract of boring dust produced by an unmated male. However, none of the five compounds were detected from the extract of boring dust produced by mated males and females or in artificial sawdust obtained from a beetle-infected *Q. mongolica* log. Male and female antennae of *P. koryoensis* responded to all five compounds in an electroantennography test. The blend of five components was tested in the field and was found to be attractive to male and female *P. koryoensis*. We concluded that the blend of citronellol, nerol, neral, geraniol, and geranial served as an aggregation pheromone to *P. koryoensis*.

Social behavior in the Japanese oak borer *Platypus quercivorus* (Coleoptera: Platypodidae). Kobayashi, M. (*Kyoto Prefectural University, Japan; masakun@kpu.ac.jp*), Nozaki, A. (*Kyoto Prefecture Nantan Promotion Administration Office, Japan; a-nozaki11@pref.kyoto.lg.jp*), Ueda, A. (*Forestry and Forest Products Research Institute, Japan; akira@ffpri.affrc.go.jp*), Mizuno, T., Kajimura, H. (*Nagoya University, Japan; t.mizuno2002@amail.plala.or.jp; kajimura@agr.nagoya-u.ac.jp*).

Japanese oak wilt disease associated with the ambrosia beetle, *Platypus quercivorus* (Pq), has become prevalent in Japan. Since Pq prefers larger oaks and dead oaks, we proposed that both an excessive number of mature oaks and an increase in naturally fallen oaks left in forests after the change from wood to fossil fuels in the early 1960s, have led to an increase in suitable hosts for Pq. We also speculated that the present epidemic is maintained by a high reproductive capacity of Pq. We reared Pq using oak logs and confirmed their high reproductive capacityty (a maximum of 552 beetles emerged from each pair). Next, we assumed that this high reproductive rate was maintained by the social behavior of Pq. When rearing Pq in glass bottles, we observed how the last instar larvae excavated their galleries, carried their sibling eggs to suitable positions, and sprayed their body fluid on the gallery walls. This last behavior was considered to be for the purpose of cultivating ambrosia fungi. We also observed the larvae feeding a milky-white liquid discharged from their abdomens to other larvae, suggesting nutrition exchange between larvae. These observations suggest that the last instar larvae act as workers or helpers.

Laurel wilt: an exotic, ambrosia beetle-vectored disease in the southeastern USA. Ploetz, R.C., Smith, J.A., Hughes, M. (*University of Florida, USA; kelly12@ufl.edu; jasons@ufl.edu; mhughes741@ufl.edu*), Blanchette, R.A., Held, B.W. (*University of Minnesota, USA; robertb@umn.edu; bheld@umn.edu*).

Laurel wilt is an exotic disease in the southeastern USA. It kills members of the Lauraceae, including avocado (*Persea americana*) and keystone and endangered U.S. endemics (*Persea* spp., *Sassafras albidum*, *Lindera benzoin*, *Litsea aestivalis,* and *Lindera melissifolia*). The recently described pathogen, *Raffaelea lauricola*, is a symbiont of an Asian ambrosia beetle, *Xyleborus glabratus*, which appears to be its sole or primary vector. AFLPs and RAPDs indicate a genetically uniform pathogen that is presumed to reflect a single founder effect and clonal reproduction. With the exception of one closely related taxon, SSU-based PCR primers distinguish *R. lauricola* from other *Raffaelea* and *Ambrosiella* symbionts. Surviving individuals of the important native, redbay (*P. borbonia*), have been clonally propagated in a search for resistance. Resistance is also sought in commercial avocado cultivars, as are efficacious and cost-effective fungicides and fungicide application measures. Histological examinations of redbay and avocado have revealed distinguishing reactions to infection that may help identify resistant germplasm in the future. The epidemiological interface between natural and agricultural ecosystems is poorly understood; better data are needed on the factors that are involved in the movement of *X. glabratus* and *R. lauricola* from native hosts to cultivated avocado.

Influence of JOW incidences on ambrosia beetle guild attacking deciduous oak (*Quercus serrata*) trees. Sanguansub, S. (*University of Tokyo, Japan; sanguansub@uf.a.u-tokyo.ac.jp*), Goto, H. (*Forestry and Forest Products Research Institute, Japan; gotohide@affrc.go.jp*), Kamata, N. (*University of Tokyo, Japan; kamatan@uf.a.u-tokyo.ac.jp*)

In Japan, Japanese oak wilt (JOW), caused by a fungus *Raffalea quercivora* and carried by an ambrosia beetle, *Platypus quercivorus*, has been epidemic in Japan for more than 15 years. To determine influence of JOW incidence on ambrosia beetle fauna, we investigated ambrosia beetle guild attacking *Quercus serrata* trees at three locations in Japan. We checked ambrosia beetles on bait bolts, artificially felled trees, and oak trees that were killed by JOW. *Platypus quercivorus* (Pq) was found only in one location, in which JOW incidence was observed. In this location, the number of attacks on baited bolts was much greater (c. 5 times) than in the other two locations. In addition to Pq, three species belonging to the genus *Xyleborus* (*X. kadoyamensis, X. defensus, Xyleborus* sp.1) showed large numbers of attacks. Pq tended to prefer fresh bolts and lower portions, in which size is greater in individual trees. On the contrary, the three *Xyleborus* species had strong preference to old bolts. It is likely that these species could increase their numbers by utilizing trees killed by JOW because as their ecological niche (i.e., multivoltine life histories), and their preferences to old wood and smaller portions of individual trees.

Role of adults and larvae of *Platypus quercivorus* (Coleoptera: Platypodidae) in galleries estimated from frass production. Tarno, H., Hongye, Q., Futai, K. (*Kyoto University, Japan; h_gustarno@yahoo.com; sai.kougyou@aw8.ecs.kyoto-u.ac.jp; futai@kais.kyoto-u.ac.jp*).

Platypus quercivorus is a vector of *Raffaelea quercivora*, a Japanese oak wilt disease pathogen in Japan. Their behavior has not been completely elucidated, because most of their activities go on in the gallery. Frass production by the beetles is related to their gallery-forming activity for feeding and reproduction. Based on the type and amount of frass produced, we estimated beetle activity in the gallery. We examined beetle behavior, combining four methods: semi-artificial rearing experiment using logs of six tree species, a continuous observation with small log disks sandwiched between two transparent plates, a continuous measuring of frass production by electrical balance, and a periodic field sampling of frass. The results obtained were as follows. (1) There was a linear relationship between the frass amounts produced and tunnel length. (2) Adults and larvae have different patterns of frass production; powdery frass was produced only when larvae were found in the gallery, while only fibrous frass was produced in the galleries containing just adults. (3) Adults initiate making tunnels and stop digging when larvae start digging. During larvae continue activities, male and female adults collaborate to clean the tunnel. Powdery frass amount increased with increase in the progeny's number.

Host selection by *Platypus quercivorus* in primary and secondary forests of Japan. Yamasaki, M. (*Kyoto University, Japan; risei@kais.kyoto-u.ac.jp*).

Oak wilt of Japan is caused by the pathogenic fungus *Raffaelea quercivora* transported by the ambrosia beetle *Platypus quercivorus*. Assuming that the host selection by *P. quercivorus* is not random, its selection process was analyzed in primary and secondary forests of Japan. In a primary forest dominated by non-host tree species, the probability of a *Quercus crispula* tree being attacked by the beetle was predicted by a generalized linear model. The results suggested that *P. quercivorus* first flew to a cluster of *Q. crispula*, and they chose thick trees as their attack target. In a secondary forest dominated by host tree species of *P. quercivorus*, the beetle activity on three species of Fagaceae was monitored for 2 years. Thicker trees had a higher probability of attack by *P. quercivorus* than thinner trees, and trees infected by the beetle in the previous year had a lower probability of attack. The flying and boring activities of *P. quercivorus* were highest on *Q. crispula*, the most susceptible species. The difference in beetle activity among the three species of Fagaceae suggested beetle discrimination of tree species before landing.

Posters

Population genetic analysis of *Raffaelea lauricola*: the causal agent of laurel wilt in the southeastern United States. Hughes, M., Anderson, C., Smith, J.A., Ploetz, R.C. (*University of Florida, USA; mhughes741@ufl.edu; claire.anderson1@hotmail.com; jasons@ufl.edu; kelly12@ufl.edu*).

In less than a decade, laurel wilt has decimated populations of native redbay (*Persea borbonia* (L.) Spreng) and other lauraceous hosts in maritime forests of the southeastern United States. The asexual pathogen *Raffaelea lauricola* (T.C. Harr., Fraedrich and Aghayeva sp. nov.) is a fungal symbiont of the mycetophagous and exotic redbay ambrosia beetle, *Xyleborus glabratus* Eichhoff. Little is known about genetic diversity in *R. lauricola* or whether significant structure exists in populations of the pathogen in the United States. Amplified fragment length polymorphisms (AFLPs) were used to assess genetic variation among 54 isolates of *R. lauricola* from all known hosts and throughout the eastern coastal range of the fungus (Georgia, Florida, and South Carolina, USA). Six primer pairs, with three selective nucleotides per pair, were used to generate more than 200 AFLP fragments. With the exception of three isolates with a single polymorphism and one isolate with 2 polymorphisms, the examined isolates were genetically identical. The results indicate low genetic diversity in the collected isolates, and support the hypotheses that a single founder population of *R. lauricola* arrived with *X. glabratus* when it entered the USA in 2002, and subsequent reproduction has been asexual in nature.

An antifungal substance isolated from *Quercus crispula* sapwood inoculated with *Raffaelea quercivora*. Ichihara, Y. (*Forestry and Forest Products Research Institute, Japan; ichiyu@ffpri.affrc.go.jp*), Yamaji, K. (*University of Tsukuba, Japan; yamajik@sakura.cc.tsukuba.ac.jp*), Nakashima, T., Kubono, T. (*Forestry and Forest Products Research Institute, Japan; tshima@ffpri.affrc.go.jp; kubono@ffpri.affrc.go.jp*).

Mass mortality of oak trees (mainly *Quercus crispula*) has occurred by the infection of a pathogenic fungus (*Raffaelea quercivora*) vectored by an ambrosia beetle (*Platypus quercivorus*) in Japan. *Quercus crispula* trees wilt is caused by the high density of *P. quercivorus* attack into the trunks, although they survive a low density of attack. Therefore, it is expected that antifungal substances against *R. quercivora* may exist in the sapwood. In this study, we conducted an isolation of an antifungal substance against *R. quercivora* from the methanol extract of discolored sapwood of *Q. crispula* inoculated with *R. quercivora*. An antifungal substance showing antifungal activity against *R. quercivora* was isolated from ethyl acetate phase of the methanol extract by column chromatography and bioassay. The substance was identified as 2,6-Dimethoxy-1,4-benzoquinone (DMBQ) by NMR. Antifungal activity against the colony growth of *R. quercivora* was recognized in the malt extract agar containing DMBQ. HPLC analysis showed that DMBQ was accumulated in discolored sapwood after the inoculation with *R. quercivora*. These results suggest that DMBQ may work as one of the antifungal substances against the spread of *R. quercivora* in the sapwood.

Differential spread of discoloured and non-conductive sapwood among four Fagaceae species inoculated with *Raffaelea quercivora*. Ito, S., Murata, M. (*University of Tokyo, Japan; murata@anesc.u-tokyo.ac.jp*), Matsuda, Y. (*Mie University, Japan; ito-s@bio.mie-u.ac.jp; m-yosuke@bio.mie-u.ac.jp*), Yamada, T. (*University of Tokyo, Japan; yamari@uf.a.u-tokyo.ac.jp*).

Mass mortality of oak trees has been occurring at some localities on Honshu Island along the Japan Sea since the late 1980s. *Raffaelea quercivora* was frequently isolated from discolored sapwood in damaged Fagaceae tree species, and the pathogenicity of this fungus was demonstrated by inoculation to *Q. crispula* and *Q. serrata*. To reveal the relationship between the susceptibility of Fagaceae species to *R. quercivora* and the tangential expansion of regions of discolored and non-conductive sapwood among

the species, the fungus was inoculated into branches of three *Quercus* species and one *Castanopsis* species. The sapwood around the inoculation hole in all four species became non-conductive in response to the infection before the discoloration. The expansion of the region of non-conductive sapwood ceased within 2 weeks after the inoculation. The region of non-conductive sapwood in *Q. crispula* and *Q. serrata* was larger than that in *Q. glauca* and *C. cuspidata* var. *sieboldii*. These results suggest that the region of non-conductive sapwood expanded soon after the infection by *R. quercivora*. It was also clear that the transverse non-conductive sapwood has a close relationship with the susceptibility among Fagaceae species to *R. quercivora.*

Comparisons in morphological, cultural, and molecular characteristics of *Raffaelea* species, causing oak wilt disease, and fungicide application for the management of the disease by trunk injection. Lee, J.K., Choi, E.H., Shin, K.C., Kim, H.J., Lee, S.Y. (*Kangwon National University, Republic of Korea; jongklee@kangwon.ac.kr; cehvega@hanmail.net; keumchulshin@kangwon.ac.kr; hj-kim@kangwon.ac.kr; sangyong@kangwon.ac.kr*).

Oak wilt has been reported predominantly on *Quercus mongolica* in central Korea since 2004. The disease symptom was identical to symptoms of mass mortality occurring on *Q. serrata* and *Q. mongolica* var. *gorsseserrata* in Japan since the 1980s. Causal agent and insect vector in Japan were reported as *Raffaelea quercivora* and *Platypus quercivorus*, in 1998. However, the pathogenic fungus in Korea, *Raffaelea* spp., was reported to be transmitted by different insect vector, *P. koryoensis*. In this study, Korean and Japanese fungal isolates causing oak wilt were compared in morphological, cultural, and molecular characteristics. Mycelial growth and sporulation were compared on culture media supplemented with wood or bark extracts from 6 different oak species: *Q. mongolica, Q. dentata, Q. variabilis, Q. acutissima, Q. aliena*, and *Q. serrata* under different culture conditions. The Japanese isolate showed better mycelial growth than Korean on all kinds of culture media. The Japanese isolate showed 3 times of higher sporulation than Korean isolate on media with all kinds of extracts at the same final concentration, and the highest sporulation by Japanese isolate was obtained on media with sapwood extract from *Q. serrata*. Partial sequences of small subunit (SSU) ribosomal DNA and β-tubulin(TUB) were compared.

Laurel wilt of avocado: assessing genotypic responses, factors that influence disease development, and the potential for management with fungicides. Ploetz, R.C., Pérez-Martínez, J.M., Smith, J.A., Hughes, M. (*University of Florida, USA; kelly12@ufl.edu; jperezma@ufl.edu; jasons@ufl.edu; mhughes741@ufl.edu*).

Three botanical races of avocado, *Persea americana*, originated in MesoAmerica: Mexican (M) (var. *drymifola*), Guatemalan (G) (var. *guatemalensis*), and West Indian (WI) (var. *americana*). Commercial cultivars are pure or hybrid genotypes of the races; M and MxG cultivars prevail in California, whereas WI and GxWI cultivars are most important in Florida. Studies were conducted to assess responses of commercial cultivars to laurel wilt, factors that influence disease development, and disease management with fungicides. Plants were inoculated with either mycelium or conidial suspensions of the pathogen, *Raffaelea lauricola*. Disease severity differed significantly ($P < 0.05$) among 22 accessions, and WI cultivars were more susceptible than either G or MxG genotypes. For a given genotype, plant size (stem diameter) was significantly ($P < 0.01$) and positively correlated ($r^2 = 0.35$) with disease severity. Regardless of genotype, newly grafted plants (≤1 cm dia) developed little disease and recovered from inoculation. Fourteen different fungicides in nine different classes were tested for inhibition of growth of *R. lauricola in vitro*. Several triazoles, as well as benzimidazole, phosphonate, pyrimidine, and strobilurin fungicides, were tested in pot studies. Drench, granular, and trunk applications of propiconazole significantly ($P < 0.0001$) reduced symptom development and colonization of the host vascular system by *R. lauricola*.

Morphological characteristics of *Raffaelea* spp. associated with oak wilts from Japan and Korea. Seo, M.Y., Matsuda, Y., Ito, S. (*Mie University, Japan; 509M107@m.mie-u.ac.jp; m-yosuke@bio.mie-u.ac.jp; ito-s@bio.mie-u.ac.jp*).

Recent application of scanning electron microscopy (SEM) for characterization of the fungi in the genus *Raffaelea* indicated that the conidium development was by annellidic percurrent proliferation as well as by conventional sympodial proliferation. In Asia, oak wilts caused by *Raffaelea* species have emerged in Japan and Korea. The aim of this study was to determine morphological characteristics of the Japanese pathogen of *R. quercivora* and the Korean pathogen of *R. querci-mongolicae* using light microscopy and SEM. Thirty-one Japanese isolates and 14 Korean isolates were subjected to observation by both methods. The length/width ratio of conidia of Japanese isolates ranged from 1.3 to 5.3 and that of Korean isolates was 1.2–4.3. The range of conidia size of the former was 3.3–10.6 × 1.1–4.5 μm and the latter was 3.1–11.8 × 1.3–4.8 μm. The isolates from both Japan and Korea showed the same group of conidia shapes: obovoid to pyriform, oblong, claviform. The isolates from both the countries were conidiogenous cells proliferating sympodially or percurrently. These results suggest that the morphological characteristics of *R. quercivora* and *R. querci-mongolicae* are similar.

Laurel wilt disease on red bay, *Persea borbonia*: distinct communities of endophytic fungi in diseased and healthy trees. Shin, K.C., Hughes, M., Smith, J.A., Ploetz, R.C. (*University of Florida, USA; keumchul@ufl.edu; mhughes741@ufl.edu; jasons@ufl.edu; kelly12@ufl.edu*).

Surviving red bay trees have been studied in areas of high laurel wilt mortality, caused by *Raffaelea lauricola*. For this study, 0.09-ha plots were established with large (>7.6-cm DBH) disease-free red bay trees in the center. Within each plot, GPS coordinates, DBH, and the incidence of laurel wilt disease were recorded for all red bay trees. It is assumed that endophytic fungi living in surviving trees of the laurel wilt mortality might be associated with the life cycle of the pathogen (*Raffaelea lauricola*). Endophytic fungi were isolated from the sapwood of branches of asymptomatic trees and re-sprouts of laurel wilt killed dead red bay (invariably, the later trees eventually die). Fungi with eight different colony morphologies were recovered from 68% of the healthy trees, whereas four different fungi were recovered from 6% of the diseased trees. For the endophytes, Shannon's diversity indices were, respectively, 0.329 and 0.141 for healthy and re-sprouted trees. One of the endophyte morphotypes from healthy trees comprised 84% of the endophytes from these trees; we are studying its identity, function in red bay, and use as biological control agent against laurel wilt.

Raffaelea **species isolated from the mandibular mycangia of the redbay ambrosia beetle, *Xyleborus glabratus*.** Shin, K.C., Smith, J.A., Ploetz, R.C. (*University of Florida, USA; keumchul@ufl.edu; jasons@ufl.edu; kelly12@ufl.edu*), Choi, E.H., Lee, J.K. (*Kangwon National University, Republic of Korea; cehvega@daum.net; jongklee@kangwon.ac.kr*).

Laurel wilt disease has spread rapidly in the U.S. since the vector, the redbay ambrosia beetle (*Xyleborus glabratus*), was first reported in 2002. The pathogen, *Raffaelea lauricola*, is carried in the mandibular mycangia of *X. glabratus*, with which it has a symbiotic relationship. Beetles were recovered from sticky traps on redbay (*Persea borbonia*) trees that died from laurel wilt. Fungi were isolated on semi-selective CSMA medium to characterize them in the mycangia of *X. glabratus*. Colonies grown were classified into four different morphological groups. *Raffaelea* sp. TPML04300, which causes a wilt disease on oak trees in South Korea, was compared with isolates from the above groups. Small subunit ribosomal (SSU) DNA sequences were amplified by PCR and sequenced using the primers NS1 and NS4. BLASTn searches of *Raffaelea* sp. PL746 showed homology to *R. lauricola* (GenBank Accession No.EU257806, 89% similarity), whereas PL747 was 100% similar. PL748 and 749 were most similar to *R. ambrosiae* (AY497518). Despite low variation in the SSU sequences, *R. lauricola* appeared to be quite different from other Asian wilt pathogens. In the future, large subunit rDNA sequences of the mycangial communities will be assessed, and as will the use of nonpathogenic fungi as biological control agents.

Genetic diversity of the pathogen of Japanese oak wilt, *Raffaelea quercivora*, in the gallery bored in an oak tree, and mycangia of the ambrosia beetle, *Platypus quercivorus*. Takahashi, Y., Matsushita, N., Hogetsu, T. (*University of Tokyo, Japan; y_takah@fr.a.u-tokyo.ac.jp; matusita@fr.a.u-tokyo.ac.jp; ho@fr.a.u-tokyo.ac.jp*).

Raffaelea quercivora is the pathogenic fungus causing Japanese oak wilt. A female of a monogynous ambrosia beetle, *Platypus quercivorus* carries the fungus in its mycangia on the pronotum, and bores a gallery in an oak tree with her partner. The fungus is inoculated and proliferates on the gallery wall. Larval daughters of the beetle pair grow up to adults and leave the gallery with the fungus carried in their mycangia. To investigate the genetic diversity of the fungus, we developed polymorphic microsatellite markers of *R. quercivora*, and investigated fungal genets in the gallery and mycangia of the beetle. From five galleries randomly chosen from a dead *Quercus serrata* tree, small wood pieces were sampled at a 5- to 10-mm intervals from the gallery wall. Five female adult beetles were also sampled from another dead tree. *Raffaelea quercivora* mycelia in the gallery wall and mycangia were isolated and genetically analyzed using three microsatellite makers. In each gallery, 5 to 10 genotypes were distributed. In mycangia, at least 3 genotypes were isolated from each beetle individual. These results indicate that diverse genotypes of *R. quercivora* were vectored to and from the gallery, and thereby conserved during the infection cycle.

The hyphal distributions within trunks of oak seedlings inoculated with *Raffaelea quercivora*. Torii, M., Matsuda, Y., Ito, S. (*Mie University, Japan; 509M105@m.mie-u.ac.jp; m-yosuke@bio.mie-u.ac.jp; ito-s@bio.mie-u.ac.jp*).

In Japan, mortality of Fagaceae trees has become obvious since the 1980s. The wilting symptom of the trees suggested the spread of non-conductive sapwood, which is one of the defense responses to the hyphal growth of *Raffaelea quercivora*. To relate the susceptibility of the trees to the fungus and its hyphal distributions within trunks at a finer level of scales, both *Quercus crispula* (susceptible) and *Q. glauca* (less-susceptible) seedlings were examined after inoculation with *R. quercivora*. The inoculation was conducted on both species of seedlings in July and October 2008. Areas of transverse non-conductive sapwoods and hyphal locations in transverse sections were examined. Transverse non-conductive areas in *Q. crispula* were larger than those in *Q. glauca*. All hyphae were observed in vessels. In July, hyphal locations detected in *Q. crispula* were wider than those in *Q. glauca*. The hyphal distributional pattern in *Q. crispula* was different from that in *Q. glauca*, as demonstrated by Morisita's Iδ index. These results suggest that the pattern of hyphal growth in the trunk of seedlings is different between two oak species, and the difference may be closely related to differences of vessel arrangements in transverse sections between the two species.

Two novel mycoviruses isolated from *Raffaelea quercivora*. Yokoi, T., Masuya, H., Kikuchi, T. (*Forestry and Forest Products Research Institute, Japan; yokoi@ffpri.affrc.go.jp; massw@ffpri.affrc.go.jp; kikuchit@ffpri.affrc.go.jp*).

Two novel mycoviruses were found in some strains of *Raffaelea quercivora* isolated in Taiwan. One virus was shown to be isometric particles with a diameter of about 28 nm, and to contain two segmented double-stranded RNA (dsRNA) genome (2.8kb, 1.7kb). The nucleotide sequence of the viral genome RNA revealed that the genome putatively encodes three proteins, RNA-dependent RNA polymerase (RdRp), capsid protein, and unknown protein. Phylogenic analysis based on RdRp showed that this virus is closely related to *Pleurotus ostreatus* virus, a member of the genus *Partitivirus*. It is suggested that this novel virus be classified as a member of the family Partitiviridae, and named as *Raffaelea quercivora partitivirus* 1 (RqPV1). While the other virus has no viral particle, a dsRNA genome approximately 3.7kb of this virus was sequenced. Under the fungal mitochondrial translation code, the genomic RNA was found to contain a long open-reading frame including conserved motifs characteristic of RdRps of fungal mitochondrial viruses. It is proposed that this virus belongs to the genus *Mitovirus* in the family Narnaviridae and should be designated as *Raffaelea quercivora mitovirus* 1 (RqMV1).

G-20 Frontiers in forest microbiology

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Umbrella pine dieback caused by *Fomitiporia* sp. Hattori, T., Ota, Y. (*Forestry and Forest Products Research Institute, Japan; hattori@affrc.go.jp; yuota@affrc.go.jp*), Tanaka, M. (*Nara Forest Research Institute, Japan; tanaka-masami@office.pref.nara.lg.jp*), Kuriu, T. (*Wakayama Research Center of Agriculture, Forestry and Fisheries, Japan; kuriu_t0001@pref.wakayama.lg.jp*).

Japanese umbrella pine (*Sciadopitys verticillata*) is planted as a garden tree and also an important forest product used for Buddhist ceremonies in Japan. Recently, serious decline of umbrella pine has been reported in plantations in Nara and Wakayama prefectures, two major product centers of this tree crop in Japan. The initial disease symptom is browning and death of a single branch followed by death of other longitudinally arranged branches. It sometimes also induces mortality of the whole trees when

multiple infections occur. In the later stage, a longitudinal hollow is often produced on the stem, and infected sapwood is white rotted, frequently with yellowish mycelia. Brownish basidiocarps are often produced on the stem or underside of the dead branches of damaged trees. Microscopical examination revealed that the basidiocarps are those of a *Fomitiporia* spp. with globose, dextrinoid, and thick-walled basidiospores. ITS sequences revealed that Hymenochaetaceae isolates obtained from most of the damaged trees are conspecific with the *Fomitiporia* spp. This is usually isolated from well-decayed dead branches that are frequently present near the newly damaged branches, suggesting that dead branches are possibly important infection centers of this disease.

Molecular characterization of the cherry leaf roll virus. Langer, J., Von Bargen, S., Bandte, M., Büttner, C. (*Humboldt-Universität zu Berlin, Germany; langerj@rz.hu-berlin.de; susanne.von.bargen@agrar.hu-berlin.de; martina.bandte@agrar.hu-berlin.de; carmen.buettner@agrar.hu-berlin.de*).

The cherry leaf roll virus (CLRV) is globally distributed, primarily on deciduous and fruit trees from at least 17 genera. Reports about CLRV occurrence are from temperate regions of Europe, the former USSR, North America, Syria, New Zealand, Japan, and Chile. In these countries, CLRV could be proved consistently in the forest, public greens, plantations, and nurseries, mainly on birch, English walnut, black elderberry, and sweet cherry. In Finland we observe an increasing impact of epidemic-like CLRV-infections within all investigated native *Betula* species. The exceptionally wide woody host range and geographical distribution of CLRV indicates a genetic heterogenecity among CLRV-isolates of different origins. This was shown by sequence analysis of different genome regions and by serological testing. The genome organisation of the bipartite RNA virus (family *Comoviridae*) corresponds to the classification as a subgroup c nepovirus. But there are some unique molecular features within the two CLRV-RNAs. One characteristic concerns the CLRV non-coding regions, which are the shortest at the 5´ends and the longest at the 3´ends of the RNAs. The screening for translation-associated elements and secondary sequence analysis suggests a different functional regulation of translation as generally known for this virus family.

Selection of *Eucalyptus camaldulensis* Dehnh. clones for resistance to *Cryptosporiopsis eucalypti* leaf spot disease by the rapid screening method. Sangwanit, U., Duangnamol, D. (*Kasetsart University, Thailand; fforuws@ku.ac.th; psddcd@ku.ac.th*).

The survey of *Cryptosporiopsis eucalypti* leaf spot disease was carried out in eucalyptus plantations in Prachinburi, Rayong, Chonburi, Ratchaburi, and Kanchanaburi Provinces in central Thailand. It was found that there were 10 *Eucalyptus* clones planted and they had different levels of the disease incidence as follows: low level (A17 and CT76), medium level (C1 and C2), severe level (CT190 and No. 3048), and very severe level (CT37, SF5, SF7 and T5).The fungus *C. eucalypti* from each clone was isolated into a pure culture. However, by determination of the fungal growth characteristics on potato dextrose agar, only 2 isolates, CT76 and SF5, were used in the selection of *Eucalyptus* resistance clones. The selection was carried out by following the rapid screening method. Spore suspension of each isolate was sprayed on seedlings of 5 *Eucalyptus* clones—W13, CT37, CT76, W118, and W1. The experiment revealed that W1, W118, and CT76 were resistant clones, while W13 and CT37 were susceptible clones. The performance of CT76 and CT37 corresponded with the field survey at the beginning of the study. Therefore, the rapid screening method can be used for selection of *E. camaldulensis* resistant clones to *C. eucalypti* leaf spot disease.

Prospects of a new microsporidium (*Nosema* sp) for biological control of the teak defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae). Sasidharan, T.O. (*Ashoka Trust for Research in Ecology and the Environment, Bangalore, India; tosasi@atree.org*), Remadevi, O.K., Jayeeta, B. (*Institute of Wood Science and Technology, Bangalore, India; okremadevi@icfre.org; bh_jayeetha@yahoo.co.in*), Priyadarsanan, D.R. (*Ashoka Trust for Research in Ecology and the Environment, Bangalore, India; priyan@atree.org*).

The teak defoliator, *Hyblaea puera* causes extensive defoliation of teak in southern India, affecting the growth and productivity of trees considerably. A virulent microsporidian parasite was isolated from this pest, which induced pronounced pathological effects in this insect. Spores of the microsporidium had a mean size of 5.2 ± 0.18 µm × 2.8 ± 0.06 µm. The growth and development of the larvae were severely affected by the microsporidian infection. Mid gut and fat body were the primary tissues infected, followed by tracheal epithelium, malpighian tubules, and gonads. Infection of the ovaries resulted in trans-ovarian (vertical) transmission to the extent of 88.5%. Among the tissues, highest spore yield was obtained from mid gut. Spore yields from gonads and fat bodies were comparable. Laboratory studies showed that a single infected larva could cause >90% infection among the individuals of a group of larvae when reared together, which implied the high potential of the parasite for horizontal transmission in natural populations of the pest. Horizontal transmission complemented by vertical could play a significant role in regulating natural populations of the pest. The results indicate prospects of the parasite as a bio-control agent against the teak defoliator.

Growth-promoting-effects of ectomycorrhizal fungi on the seedlings of *Pinus* spp. and *Picea korainesis.* Song, R., Deng, X., Zhou, X. (*Northeast Forestry University, China; songrq1964@163.cm; dxhappy@126.com; zhouxiuhua905@yahoo.com.cn*).

Single-inoculations were done on different age transplanting seedlings of Korean pine (*Pinus koraiensis*), Mongol scotch pine (*P. sylvestris* var. *mongolia*) and Koyama Spruce (*Picea koraiensis*). The liquid cultures of ectomycorrhizal fungi were used as inoculums. Different inoculating methods were used on different age seedlings. Mixed-inoculation were done on 3-year-old transplanting seedlings. Thus the effects of different inoculating methods, different combinations, and different single fungus strains to promote the growth of different kinds of seedlings were studied. The results showed that all single strains and combinations in this experiment can, in varying degrees, promote the growth of different kinds of seedlings. The growth-promoting effect that inoculated by the method of root soaking with a liquid culture of ectomycorrhizal fungi is higher than that by lister inoculating method; inoculation with the mixture of the high-effect strain and other single strains could weaken the growth-promoting effect of the high-effect strain; the activity of hydrogen peroxidase and the root activity of seedlings are not correlated with its biomass.

***Trichoderma* as a biocontrol agent: case studies in Indonesia.** Widyastuti, S.M., Djoyobisono, H. (*Gadjah Mada University, Indonesia; smwidyastuti@yahoo.com; harjono@gmail.com*).

Fungal species of *Trichoderma* are cosmopolitan in soils, on decaying wood, and in other organic matters. This considerable variation, coupled with their amenability to cultivation on inexpensive substrates, makes *Trichoderma* isolates attractive candidates for a variety of biocontrol applications. Antagonistic interactions between *Trichoderma* spp. and other fungal pathogens have been classified as antibiosis, mycoparasitism, and competition for nutrients. These mechanisms are not mutually exclusive, and a given antagonistic mechanism can fall into several of these categories. In order to find an effective *Trichoderma* as biocontrol agent, several steps were carried out, i.e. isolation, identification, and antagonistic tests *in-vitro* and *in-planta* (screening), as well as tests in the field. For the latter purpose, a prototype of pellet of alginate and calcium carbonate has been developed. Isolates of *Trichoderma* spp. show a great degree of biocontrol capability. Specificity between isolates of pathogen and of *Trichoderma* were observed. In general, application of *Trichoderma* was more successful in controlled environments such as nurseries. Several specific case studies are discussed, including problems and successes in the development of *Trichoderma* as a biocontrol agent.

Functional partition within subterranean ectomycorrhizal network caused by mycelial incompatibility. Wu, B.Y., Maruyama, H., Teramoto, M., Hogetsu, T. (*University of Tokyo, Japan; bingyun@fr.a.u-tokyo.ac.jp; maruyama@fr.a.u-tokyo.ac.jp; mthope@fr.a.u-tokyo.ac.jp; ho@fr.a.u-tokyo.ac.jp*).

Nutrient transfer within ectomycorrhizal networks is ecologically significant. Here, we experimentally investigated transfer of ^{14}C-labeled photosynthates between neighboring ectomycorrhizal mycelia. Ectomycorrhizal seedlings of *Pinus thunbergii* colonized by *Pisolithus* sp.1 (Sp1) or *Pisolithus* sp.2 (Sp2) were cultivated on an artificial flat substrate, Oasis. After the extraradical mycelium developed, Oasis was cut and the mycelium on it was also cut. Two seedlings were paired in a flat rhizobox as mycelia contacted each other at the cut edges of Oasis. The combination of seedlings was made of those colonized with Sp2 and Sp2, or Sp1 and Sp2. After 2 weeks, the mycelium-contacting area was observed, and one of paired seedlings was labeled by $^{14}CO_2$. Movement of ^{14}C-photosyntates was chased by time-course autoradiography. In combination of Sp2 and Sp2, both mycelia were bridged by hyphae, and ^{14}C was transferred from leaves of the donor seedling to the mycelium of itself and the receiver seedling. In combination of Sp1 and Sp2, no hyphal fusion and no ^{14}C-transfer occurred. The results indicate that no carbon transfer occurs between incompatible mycelia without hyphal fusion, and provide a new concept that the subterranean ectomycorrhizal network in forest is functionally partitioned due to structural partition caused by mycelial incompatibility.

Posters

Effects of arsenic and phosphorus on growth and biomass yield and translocation of arsenic in three clones of *Populus alba* × *P. glandulosa* uninoculated or inoculated with arbuscular mycorrhizal fungi. Aggangan, N.S. (*National Institute of Molecular Biology and Biotechnology, Philippines; nelly_aggangan@yahoo.com*), Han, S.H., Choi, Y.I., Noh, E.W. (*Korea Forest Research Institute, Republic of Korea; simhee02@forest.go.kr; yichoi99@forest.go.kr; ewnoh@forest.go.kr*), Lee, Y.S. (*Pohang University of Science and Technology, Republic of Korea; ylee@postech.ac.kr*).

To determine the effects of arsenic (As) and phosphorus (P) on the growth and biomass yield of non-transgenic (NT) and two clones of transgenic (PCP301CG0R6 and NYCf7) *Populus alba* × *P. glandulosa*, non-mycorrhizal and arbuscular mycorrhizal [mixture of unidentified species of *Glomus* and *Acaulospora* species (AMM6) from Bonghwa mine tailing, Korea)] microplants were transplanted in cups filled with autoclaved peat perlite vermiculite medium and incubated under growth room conditions. After 1 month, the seedlings were transferred into bigger pots filled with the same medium but not autoclaved, with 8 mg P $(CaH_2PO_4)_2$ kg soil^{-1}) or without P and with 1.75 mg As ($Na_2HAsO_4.7H_2O$) kg soil^{-1}) or without As. After 4 months in a glasshouse, growth and biomass yield of all the three clones were reduced by As. Mycorrhizal inoculation increased total dry weight of NT and NYCf7. Application of 8 mg P kg soil^{-1} in the mycorrhiza-inoculated plants alleviated the growth reduction effect of As in NT and PCP301CG0R6. Arsenic concentration was highest in fine roots > coarse root > leaves > and the lowest was in the stem. Arsenic concentration was higher in the fine roots of non-mycorrhizal than in mycorrhizal plants. Non-mycorrhizal and mycorrhizal plants had similar leaf As concentration.

Arbuscular mycorrhiza vs ectomycorrhizal fungi for improved growth and nutrient uptake of *Eucalyptus pellita* and *Populus alba* × *P. glandulosa.* Aggangan, N.S. (*National Institute of Molecular Biology and Biotechnology, Philippines; nelly_aggangan@yahoo.com*), Han, S.H., Han, M.S., Moon, H.K., Choi, Y.I., Noh, E.W. (*Korea Forest Research Institute, Republic of Korea; simhee02@forest.go.kr; mshan99@forest.go.kr; hkmoon@forest.go.kr; yichoi99@forest.go.kr; ewnoh@forest.go.kr*), Lee, Y.S. (*Pohang University of Science and Technology, Republic of Korea; ylee@postech.ac.kr*).

Four concurrent experiments were conducted to compare the effectiveness of arbuscular mycorrhiza (AM) or ectomycorrhizal (ECM) fungi in promoting growth and nutrient uptake in *Eucalyptus pellita* and three (cd26c11, PCP301CG0R4, and PABC21) transgenic clones of *Populus alba* × *P. glandulosa.* AM was a mixture of unidentified species of *Glomus* and *Acaulospora* from mine tailings in Bonghwa, Korea, while ECM was vegetative mycelia of *Pisolithus tinctorius*. The plants were grown in autoclaved peat-perlite vermiculite medium under glasshouse conditions. PCP301CGoR4 was the most responsive to mycorrhizal inoculation and PABC21 was not affected at all. AM promoted total dry weight of *E. pellita* and cd26c11 but comparable with ECM plants. ECM and AM comparably promoted total dry weight and N, P, and K uptakes of PCP301CGoR4. ECM promoted better Ca, Mg, and Cu uptakes in PCP301CGoR4 and N, Mg, Na, and Cu in *E. pellita* than the control. Control *E. pellita* and PCP301CGoR4 took the lowest nutrients. In conclusion, plant species and clones respond differently to mycorrhizal inoculation. Generally, AM and ECM promoted better growth and nutrient uptake of *E. pellita*, PCP301CGoR4 and cd26c11 but not PABC21. Field trials should be conducted to determine the growth-promoting capabilities of the mycorrhizal fungi.

Phosphorus response of non-mycorrhizal and mycorrhizal *Kalopanax septemlobus* plantlets grown in non-sterile and sterile medium during acclimatization period. Aggangan, N.S. (*National Institute of Molecular Biology and Biotechnology, Philippines; nelly_aggangan@yahoo.com*), Moon, H.K. (*Korea Forest Research Institute, Republic of Korea; hkmoon@forest.go.kr*).

This study was conducted to determine the maximum phosphorus level for better growth and biomass yield of mycorrhizal and non-mycorrhizal *Kalopanax septemlobus* during acclimatization period. Somatic embryo plantlets were uninoculated or inoculated with a mixture of unidentified species of *Glomus* and *Acaulospora* (AMM6) from Bonghwa, Korea, and grown in rectangular boxes filled with non-sterile or autoclaved peat perlite vermiculite medium. After 2 months, seedlings were transferred into pots filled with the same medium amended with six P rates—0, 2, 4, 8, 16, and 32 mg P (as $Ca(H_2PO_4)_2$ kg^{-1} soil). After 4 more months, plant survival, growth, and dry weight were higher in sterile than in non-sterile soil. Total plant dry weight of mycorrhizal plants was 50% higher than non-mycorrhizal counterparts. In sterile soil, the total dry weight of non-mycorrhizal plants was promoted significantly at P8 and highest at P16. Total dry weight at P16 by non-mycorrhizal plants was attained at P4 when plants were mycorrhizal with AMM6. In non-sterile soil, total dry weight of mycorrhizal plants was increased at P8. By contrast, non-mycorrhizal plants did not respond to applied P rates. In conclusion, plantlets grew better in sterile medium, with mycorrhizal fungi and 4–8 mg P kg $soil^{-1}$.

Degradation of endocrine disrupting chemicals by genetic transformants in white rot fungi with inducible laccase and manganese peroxidase genes. Lee, S.S., Ryu, S.H. (*Korea Forest Research Institute, Republic of Korea; lsungsuk@forest.go.kr; shryu@forest.go.kr*), Choi, H.T. (*Kangwon National University, Republic of Korea; htchoi@kangwon.ac.kr*).

White rot fungi have lignin degrading enzymes, such as laccase, lignin peroxidase, and manganese peroxidase (MnP). These enzymes are also involved in the degradation of many recalcitrant chemicals such as dye, endocrine disrupting chemicals (EDCs), and pesticides. We have cloned a MnP gene from *Polyporus brumalis* and a laccase gene from *Phlebia tremellosa*, and we constructed an expression vector (pMnP-gLac) for two genes. White rot fungi *Irpex lacteus* and *P. tremellosa* were genetically transformed using pMnP-gLac expression vector to obtain increased laccase- and MnP-producing strains. A stable integration of the vector was confirmed by PCR, and the transformants showed increased laccase and MnP activities. When the transformants of *I. lacteus* and *P. tremellosa* were grown with EDCs (bisphenol A or benzylbutylphthalate), they showed the degradation of benzylbutylphthalate more than 90% in day 3 respectively. The degradation of bisphenol A was slower than these of benzylbutylphthalate, but transformant showed higher degradation rate than the wild type. When the estrogenic activity generated by benzylbutylphthalate was examined, more than 80% of estrogenic activities were removed by transformants of *I. lacteus* and *P. tremellosa* respectively. The transformants also showed increased removal rates of estrogenic activity than wild type towards bisphenol A.

Incidence of shisham (*Dalbergia sissoo* Roxb.) dieback in various agro-ecological zones of Punjab. Mukhtar, I., Bajwa R. (*University of the Punjab Lahore, Pakistan; erumm21@yahoo.com; rukhsanabajwa@yahoo.com*).

Shisham (*Dalbergia sissoo* Roxb.) is an important timber tree of Indian subcontinent. Gradual change in eco-edaphic factors have induced stress conditions, which invited fungal attacks on shisham. A detailed survey was conducted during 2005–06 in selected areas of different agro-ecological zones to assess the incidence and severity of shisham dieback disease in Punjab. The selected zones were IIIA and IIIB-sandy deserts (Bahawalpur, Bahawal nager, Khushab, Mianwali); IV-A-northern irrigated plains (Multan, Sahiwal, Sargodha, Faisalabad, Lahore, Sheikhupura, Gujranwala, and Sialkot); V-Barani (Jhelum, Chakwal, Rawalpindi, Attock); and X- Sulaman piedmont (D.G. Khan). Survey results showed that shisham dieback incidence, severity, disease index, and disease prevalence in different zones was 16.3–31.4, 0.5–0.9, 10–24.46, and 50–100 respectively. Maximum disease severity and prevalence was recorded in zone V, while the lowest disease severity and prevalence was observed in IIIA sandy desert. During the survey, it was also found that dieback disease is age-specific; this disease occurs in old-age trees. Shisham dieback is not a nursery disease. Root bark, seeds, and soil samples were also collected for the pathogenic studies. No correlation was found between soil pH, physical structure, and rainfall to shisham dieback.

General Posters: Frontiers in Forest and Tree Health

A new super Shiitake strain "Gaeulhyang". Bak, W.C., Lee, B.H. (*Korea Forest Research Institute, Republic of Korea; wcbak@forest.go.kr; Bonghun90@naver.com*).

Selective breeding was attempted to make shiitake (*Lentinula edodes*) strains for bed-log cultivation, and the results obtained are as follows. Shiitake strains were cultivated by bed-logs. Among them, a mid-temperature type strain was turned out to be a super strain with excellent productivity of 35 kg dried fruit body per 1-m^3 log, and the strain is named as "Gaeulhyang". Concerning the characteristics of Gaeulhyang, hyphal density is dense. Hyphal tunicate is present. Color of colony surface is white. Optimal temperature for mycelial growth is 27 °C. Vertical shape of cap is flat. Color of upper side of cap is brown. Cap thickness is thin to medium. Distribution of cap scale is whole. Color of cap scale is white. System of gill row is straight. Ratio of diameter of cap/length of stipe is large. Gill width is narrow. Gill density is medium. Optimal season of harvest on natural cultivation is autumn to summer. Optimal temperature for fruit body flushing is 13–25 °C. Fruit body distribution is aggregated.

The habitat, spatial dispersal, and ecological invasion of two exotic plants in Taiwan. Chen, J.C. (*Shih-Chien University, China-Taipei; zzz.john@msa.hinet.net*), Wei, C.H., Chen C.T. (*National Pingtung University of Science and Technology, China-Taipei; andy3520@gisfore.npust.edu.tw cct@gisfore.npust.edu.tw*).

This study, based on different investigative documents and analytical methods, elucidates spatial distribution of habitats for two major invasive exotic plants, *Mikania micrantha* and *Leucaena leucocephala*, in Taiwan. Results show that *M. micrantha* is most harmful to broad-leaved trees and its invasion directly relates to changes in the physical environment. The upper limit for its distribution is 2,000 m elevation; the lower the elevation, the more the detrimental effect. The most favorable environment for the plant to grow is that with abundant sunshine and moist soil. *L. leucocephala* can bloom and bear fruits all year round; during the period of seed sprouting and saplings, the invasion varies greatly among different soil types. *L. leucocephala* prefers weakly acidic soil, although it grows well with other soil textures and nutrients as well. The average spreading rate of *L. leucocephala* is 42.3% on abandoned farm land calculated from the aerial photographs taken in 1992, 1994, 1996, and 1998. The annual average

dispersion speed of *L. leucocephala* is related to the lands of cultivation given up. As for *L. leucocephala* on the land of different use types, the average dispersion speed should be studied further.

Antifungal activity of leaf and wood essential oils and their constituents from *Cunninghamia konishii* Hayata against six plant pathogenic fungi. Cheng, S.S. (*National Taiwan University, China-Taipei; d89625006@ntu.edu.tw*), Lin, C.Y., Gu, H J., Wang, Y.N., Chang, S.T. (*School of Forestry and Resource Conservation, China-Taipei; aisiteru555@hotmail.com; cula3028@yahoo.com.tw; m627@ntu.edu.tw; peter@ntu.edu.tw*).

Cunninghamia konishii Hayata is an endemic tree in Taiwan. In this study antifungal activities of essential oils from wood and leaf of *C. konishii* against six plant pathogenic fungi were investigated. In addition, the yields of essential oils obtained by water distillation were compared and their constituents determined by gas chromatography (GC) and gas chromatography-mass spectroscopy (GC-MS) analyses. The yields of wood and leaf essential oils from *C. konishii* were 21.34 mL/kg (2.03%) and 4.29 mL/kg (0.09%), respectively. Using GC and GC-MS analyses, the major compounds of wood essential oil are cedrol (53.03%) and α-pinene (25.57%); of leaf essential oil are α-pinene (34.89%) and *p*-cymene (16.66%). According to the antifungal tests, wood essential oils of *C. konishii* used against *Rhizoctonia solani*, *Fusarium solani*, *Pestalotiopsis funereal*, and *Ganoderma australe* had strong antifungal activities at 400 μg/mL, with IC_{50} values of 48.5, 43.9, 62.4, and 63.5 μg/mL, respectively. Furthermore, among the seven constituents of *C. konishii* wood essential oil, cedrol strongly inhibited the growth of *R. solani*, *F. solani*, and *P. funereal* at 100 μg/mL, with antifungal index of 63.8, 75.5, and 71.6 μg/mL, respectively, indicating it may be used as potential antifungal agents for the control of fungal diseases in plants.

RNA interference of Apolipophorin-III is related to expression of antioxidant protein in *Hyphantria cunea.* Cheon, H.M (*Korea Forest Research Institute, Republic of Korea; mayjun@forest.go.kr*), Kim, H.J., Kim, Y.I., Kwon, Y.M., Seo, S.J. (*Gyeongsang National University, Republic of Korea; hongjaac@daum.net; lovegorilla@daum.net; jichi9@naver.com; sookjae@gnu.ac.kr*).

Apolipophorin-III (apoLp-III) is a hemolymph protein that associates hydrophobically with lipoprotein surfaces to facilitate lipid transport in an aqueous medium, and plays a critical role in the transport of lipids during flight in several species of insects. ApoLp-III is synthesized not only by fat body cells but also by a variety of other cells, including those in the hemocyte, ovary, and testis. Recently, apolipophorin-III in *Galleria mellonella* and *Hyphantria cunea* was shown to play an unexpected role in insect immune activation. We show here a novel possible function/role of apoLp-III in insects. To investigate the genes that have a relationship with apoLp-III in fall webworm larvae, we reduced endogenous *Hc* apoLp-III mRNA levels in larvae *via* RNA interference (RNAi). The RNAi-mediated *Hc* apoLp-III reduction resulted in the reduction of antioxidants, like MnSOD, catalase, and glutathione S transferase as well as immune proteins. In particular, expression of MnSOD commonly decreased in fat body, midgut, and hemocytes following the knockdown of *Hc* apoLp-III, which induced an elevated level of superoxide anion in *Hyphantria cunea* larvae. The observed effect of *Hc* apoLp-III RNAi suggests that *Hc* apoLp-III is related to the action/expression of antioxidants, especially MnSOD.

Molecular cloning and expression patterns of two SOD genes against various stresses from fall webworm, *Hyphantria cunea.* Cheon, H.M. (*Korea Forest Research Institute*, *Republic of Korea; mayjun@forest.go.kr*), Kim, Y.I., Kim, H.J., Kwon, Y.M., Seo, S.J. (*Gyeongsang National University, Republic of Korea; lovegorilla@daum.net; hongjaac@daum.net; jichi9@naver.com; sookjae@gnu.ac.kr*).

Reactive oxygen species (ROS) are produced as a byproduct of aerobic metabolism. ROS such as hydrogen peroxide (H_2O_2), superoxide anion (O_2^-), and the hydroxyl radical (OH^-) can be very harmful to living organisms because of their oxidizing potentials within living cells. ROS is toxic to living organisms, because its high reactivity causes oxidative damage to proteins, nucleic acids, and lipids. Superoxide dismutase (SOD) is an enzyme facilitating the removal of superoxide anions from living organisms. The SODs are classified according to the metal ion cofactor required for their activity: the copper/zinc type (Cu/ZnSOD), the manganese type (MnSOD), the iron type (FeSOD), and nickel type (NiSOD). This study focused on the cloning of MnSOD cDNA from *Hyphantria cunea* and its induction upon bacterial infection and various stresses. The open reading frame of MnSOD is composed of 645 bp, encoding 215 amino acid residues. The theoretical molecular mass and pI of putative MnSOD was evaluated to be 24,276 Da and 9.14, respectively. The MnSOD from *H. cunea* is highly similar to human MnSOD (59.5%) as well as *Bombyx mori* MnSOD (76.2%). MnSOD showed no big induction upon bacterial infection and stresses, compared to that of Cu/ZnSOD.

Differences of physiological response of American sycamore seedlings during and after water and ozone stress. Han, S.H., Kim, D.H., Lee, J.C. (*Korea Forest Research Institute, Republic of Korea; simhee02@forest.go.kr; dhkim@forest.go.kr; jaeclee99@forest.go.kr*).

We investigated physiological damages and repair capacity of American sycamore (*Platanus occidentalis*) during and after water stress (WS), O_3 stress (O_3S) and the combined stress of water and O_3 (WO_3S). Height-relative growth rate (HRGR) of seedlings didn't decrease at the O_3-exposed seedlings, but decreased at WS- and WO_3S-exposed seedlings 4 weeks later. At the recovery stage, WS- and WO_3S-exposed seedlings showed higher HRGR than that of control seedlings, and O_3S-exposed seedlings have a similar HRGR with control. Diameter-relative growth rate (DRGR) decreased during WS, O_3S and WO_3S treatments. WS- and O_3S-exposed seedlings represented higher DRGR than that of control at recovery stage. Chlorophyll (*Chl*) contents of WS- and WO_3S-exposed seedlings were higher than control, and that of O_3-exposed seedlings was similar with control. At recovery stage, *Chl* contents of WS- and WO_3S-exposed seedlings were similar to that of control, but O_3-exposed seedlings showed lower *Chl* content than that of control. After stress exposure, malondialdehyde (MDA) content increased at all seedlings. In particular, those of WS- and WO_3S-exposed seedlings were higher than those of O_3-exposed seedlings. At recovery stage, O_3- and WO_3S-exposed seedlings represented higher MDA content than control, but that of WS-exposed seedlings was lower than control.

The effects of drought on the relationship between photosynthetic rate and stomatal conductance, and change of chlorophyll fluorescence in three broadleaved tree species. Je, S.M., Sung, J.H., Kim, S.H. (*Korea Forest Research Institute, Republic of Korea; Jesmi@uos.ac.kr; JHS033@forest.go.kr; sands02@korea.kr*).

Climatic change predictions are that extreme weather conditions, particularly in terms of temperature and precipitation, will be frequent in the future. Fluctuations in water availability, including periods of drought, may become more common. To investigate adaptation of broadleaved tree species in drought regimes, we did water-withholding for 11days and subsequent re-watering on potted trees (*Cornus kousa*, *Asculus turbinata*, *Acer mono*). During the water stress, stomatal conductance and photosynthetic rate were gradually reduced in every species. The liner slopes of the regressions between maximum photosynthetic rate and stomatal conductance of all species were reduced by decreasing the soil water content. Especially, R^2 of the regressions in *C. kousa* and *A. turbinata* (R^2 = 0.0121 and 0.0432, respectively) decreased just before re-watering, except that of *A. mono*. And maximum photochemistry efficiency (F_V/F_M) of *C. kousa* and *A. turbinata* drastically decreased, while that of *A. mono* showed slight decrease compared with initial value. These results suggest that the reason why only *A. mono* recovered physiological ability after re-watering while other species had withered leaf eventually despite re-watering is the moderate irrigation time when no permanent photoinhibition occurred during the water stress and the close relationship between photosynthetic rate and maintenance of stomatal conductance.

Contamination and spatial distribution of heavy metals in roadside soils of main roads in Changbai Mt. Natural Reserve. Jin, Y.H., Li, S. (*Chinese Academy of Sciences, China; jinyh@iae.ac.cn; helloandwelcome@163.com*).

The concentrations, distribution patterns, and contamination of heavy metals in roadside forest soils within 50 m adjacent to main roads were studied in Changbai Mt. Natural Reserve. The influence of forest type and intensity of road use was estimated. Topsoil samples (0–20 cm) were taken at different distances from the roadway and were analyzed for heavy metal (Zn, Pb, Cu, and Ni) contents. Results showed that: with increase of intensity of road utilization, the average concentrations of Zn and Pb in roadside soils were enhanced significantly in broad-leaved forest and *Betula ermanii* forest. However, the change in values of Cu and Ni were reversed in broad-leaved forest. The concentration of Zn varied in conformance with distance from the road edge in the same type of forests, even if the intensity of road utilization was different. In the meantime, the concentration of Pb varied more diversely at distances from 0 to 50 m, even when forest type was the same. The contamination index (P(i)) values for Zn and Pb were higher than Cu and Ni in all sites. Most soil samples were slightly polluted by Zn, but only samples collected in *Betula ermanii* forest were slightly polluted by Pb.

Termite-associated nematodes in Kenting National Park, Taiwan, and Miyako and Hateruma islands, Okinawa, Japan. Kanzaki, N. (*Forestry and forest Products Research institute, Japan; nkanzaki@affrc.go.jp*), Li, H.-F. (*University of Florida, USA; houfeng@ufl.edu*), Lan, Y.-C. (*Leader University, China-Taipei; yenchiu@mail.leader.edu.tw*), Kosaka, H. (*Forestry and Forest Products Research Institute, Japan; hkosaka@affrc.go.jp*), Giblin-Davis, R.M. (*University of Florida, USA; giblin@ufl.edu*), Akiba, M., Sahashi, N., Ota, Y. (*Forestry and Forest Products Research Institute, Japan; akiban@affrc.go.jp; sahasi@affrc.go.jp; yuota@affrc.go.jp*).

Termite-associated nematodes were surveyed in Kenting National Park, Taiwan, and Miyako and Hateruma islands, Okinawa, Japan, as forest biodiversity indicators. Eight species (63 colonies) of termites were collected and examined for nematode associates. Twenty to 40 workers were randomly chosen from each colony, and squashed onto a 2.0% water agar plate to establish the associated nematode cultures. The culture plates were kept at room temperature and examined daily for 1 month. The successfully cultured nematodes were observed with a light microscope, subcultured, and sequenced for morphological and molecular typing. Based on fragments of SSU and D2/D3 LSU, 12 molecular operational taxonomic units (MOTU) (one *Pseudaphelenchus* spp., *Poikilolaimus floridensis*, *Poikilolaimus* spp., six *Halicephalobus* spp., and three *Oigolaimella* spp.) were identified from five species of termites, *Neotermes koshunensis*, *Cryptotermes domesticus*, *Coptotermes formosanus*, *Nasutitermes takasagoensis*, and *Odontotermes formosanus*. The results of MOTU analysis were confirmed by the general morphology of cultured nematodes, and at least two species, one each of *Poikilolaimus* spp. and *Pseudaphelenchus* spp. were considered to be undescribed. The nematode association pattern of termites in South Taiwan and the Japanese subtropics appeared similar to those in the American neotropics, and termite-associated nematodes were regarded as good indicators for forest biodiversity.

Chemical control of moss in container-grown conifer seedling. Kim, J.J., Song, K.S., Cha, Y.G., Choi, K.S. (*Konkuk University, Republic of Korea; jjkimm@konkuk.ac.kr; xps@hanmail.net; spree84@naver.com; ckscks0909@naver.com*), Lee, K.J. (*Korea Forest Research Institute, Republic of Korea; kyts65@hanmail.net*), Yoon, T.S. (*Suppro Plant Environment Research Center, Republic of Korea; lkj0217@forest.go.kr*), Chung, Y.S. (*Konkuk University, Republic of Korea; 04space@naver.com*).

The purpose of this study was to develop a method to effectively control mosses that are generated in containers. To meet the goals, 6 kinds of chemical agents were applied to the container seedlings of *Pinus densiflora* with liverwort (*Marchantia polymorpha*) growing, and of *Chamaecyparis obtusa* with hair cap moss (*Polytrichum commune*) growing at different concentrations. It was found that quinoclamine was the most effective chemical agent to control moss; Quinoclamine was effective in controlling liverwort (100% controlled) and hair cap moss (95.5% controlled) at its concentration of 1.0 g L^{-1}. Next to quinoclamine, it was found that liverwort was effectively controlled by 5-time dilution of pyroligneous liquid (81.7%), which was followed by flumioxazin 3.0 mℓ L^{-1} (79.8%), benomyl 0.2 g L^{-1} (76.9%), oxyfluorfen 3.0 mℓ L^{-1} (72.1%), and captan 0.2 g L^{-1} (21.2%) respectively. At the above concentrations, it was found that hair cap moss was effectively controlled by 5-time dilution of pyroligneous liquid (92.8%), followed by flumioxazin (89.1%), benomyl (39.3%), captan (35.7%), and oxyfluorfen (21.4%), respectively. On the other hand, it was found that the chemical agents resulted in no damage caused to container seedlings hereof.

Effects of benomyl and wood vinegar from *Quercus* species on ectomycorrhizal formation on red pine seedlings. Kim, N. K., Obase, K., Lee, S.Y., Chun, K.W., Lee, J.K. (*Kangwon National University, Republic of Korea; kimnamkyu@kangwon.ac.kr; 0ba-suke@yahoo.com; sangyong@kangwon.ac.kr; kwchun@kangwon.ac.kr; jongklee@kangwon.ac.kr*).

Mycorrhizal association of pine seedling roots with ectomycorrhizal fungi in soil is known to be very important for the growth of pine seedlings. During mass production of containerized pine seedlings grown for the reforestation of damaged pine forests, ectomycorrhizal formation rates in seedlings were increased in greenhouse conditions. Ectomycorrhizal formation and seedling growth were compared after artificial inoculation of four ectomycorrhizal fungi—*Hebeloma cylindrosporum, Pisolithus tinctorius*,

Rhizopogon rubescens, and *Suillus bovinus*—on pine seedlings, and application of benomyl or wood vinegar by drenching into the soil. Generally, application of benomyl by drenching into the soil showed significant increase in ectomycorrhizal formation rate and seedling growth. When the effects were compared in both sterilized and non-sterilezed soil, better results were obtained by applying into the sterilized soil at the concentration of 25 mg/100ml at 2-week intervals. On the other hand, application of wood vinegar from *Quercus* species by drenching had no effects on ectomycorrhizal formation and seedling growth, depending on mycorrhizal fungi. Rather, wood vinegar drenched in sterilized soil decreased the ectomycorrhizal formation. Drenching of benomyl had effects on ectomycorrhizal formation, and applyication concentration and frequency would be important factors.

Cloning and expression patterns of STAT protein against bacterial infection from *Hyphantria cunea*. Kwon, Y.M. (*Gyeongsang National University, Republic of Korea; jichi9@naver.com*), Cheon, H.M. (*Korea Forest Research Institute, Republic of Korea; mayjun@forest.go.kr*), Kim, H.J., Kim, Y.I., Seo, S.J. (*Gyeongsang National University, Republic of Korea; hongjaac@daum.net; lovegorilla@daum.net; sookjae@gnu.ac.kr*).

Innate immunity responses are triggered by the immune challenge and therefore involve signaling processes. The cellular response is initiated by hemocytes and mainly involves phagocytosis and encapsulation of intruders by these cells. To address whether Hc-STAT is activated upon bacterial challenge, we examined the subcellular location of STAT protein in hemocyte by immunostaining. A new insect member of the STAT family of transcription factors (Hc-STAT) has been cloned from the lepidopteran, *Hyphantria cunea*. The domain involved in DNA interaction and the SH2 domain are well conserved. The gene is transcribed at a low level during all stages of development, and the protein is present in hemocytes, fat body, midgut, epidermis, and Malphigian tuble (Mt). Especially, hemocytes and Mt showed transcriptional activation of Hc-STAT upon Gram (-) bacteria and fungal challenge. Gram (-) bacteria and fungal challenge specifically results in nuclear translocation of Hc-STAT protein and induction of DNA-binding activity that recognizes a STAT target site in *H. cunea* hemocyte. *In-vitro* treatment with pervanadate translocates Hc-STAT to the nucleus in hemocyte cells. Here we report the first evidence for the involvement hemocyte JAK/STAT pathway upon microbial infection in lepidopteran insect.

Spatial modelling applied to conifer root decay caused by fungal pathogens. La Porta, N., Rocchini, D., Neteler, M. (*FEM-IASMA, Italy; nicola.laporta@iasma.it; duccio.rocchini@iasma.it; markus.neteler@iasma.it*).

A GIS-modelling framework was developed for assessing at a regional scale the environmental impact of root rots of conifers caused by *Heterobasidion annosum s.l.* This fungal pathogen caused the most economically serious damages in conifer forests of the boreal hemisphere. The system integrates data on *H. annosum*‘s biological requirements, and silvicultural and stational data within a GIS-based modeling frame. Stational data were extracted by the open -ource application GRASS-GIS from the available digitized forest map databases where geographical, silvicultural, climatic, pedological, and historical data were joined at the woodland management plans compartment (WMPC) level. The cartographic results illustrated root and butt rot susceptibility of about 257,000 hectares of conifer forest in Trentino, Italian Alps. In this application, GIS is considered as a screening tool in a WMPC selection process to narrow the number of susceptible sites. Results revealed the potential for developing a decision support system based on *H. annosum* loss potential indices, although further validation of this field-scale model at the WMPC level is needed. From preliminary *H. annosum* incidence data in Trentino, the *H. annosum* damage appears surprisingly high. The modelling framework assessed the vulnerability for *H. annosum* rots of a pilot regional study in Trentino.

Morphological and cultural characteristics of *Phytophthora katsurae*, causing chestnut ink disease in Korea, and their molecular detection. Lee, J.K., Jo, J.W., Jang, H.N., Lee, H. (*Kangwon National University, Republic of Korea; jongklee@kangwon.ac.kr; jun-hu79@hanmail.net; ezzi11@naver.com; lh001@hanmail.net*), Lee, S.H. (*Korea Forest Research Institute, Republic of Korea; shlee4@foa.go.kr*), Lee, S.Y. (*Kangwon National University, Republic of Korea; sangyong@kangwon.ac.kr*).

The causal fungus was isolated from dead or dying chestnut trees showing inky ooze on necrotic trunks by placing infected tissues on selective media or using rhododendron leaves as a bait for the infested soil. The isolates produced homothallic oogonia with protuberances on V-8 medium. Numerous sporangia were formed in creek water. Isolates had 100% similarity with *Phytophthora katsurae* isolates from Japan and New Zealand, and 99.6% with others in ITS sequences. All Korean isolates were identical in sequences. Numerous sporangia were formed in filtered unfiltered creek water, but no sporangia formed in sterile distilled water during 10 days’ incubation. Unfiltered water was more effective than filtered. Sterilization of unfiltered water did not give a difference in oospore and sporangia formations. Light-induced sporangia formed at 500 and 1,000 lux, but did not induce oospore formation. β-sitosterol slightly increased mycelial growth in both solid and liquid media, but the difference was not significant. β-sitosterol increased oospore formation up to 1.3 to 14 times the control depending on the medium. For detecting *Phytophthora katsurae*, PCR-SSCP of nuclear DNA β-Tubulin, was used. *P. katsurae* isolates showed a unique pattern in SSCP analysis and was easily distinguished from other Phytophthora species used as controls.

***In-vitro* ectomycorrhizal symbiosis between *Tricholoma matsutake* and *Pinus elliottii* seedlings.** Liao, Y.K., Lee, S.H., Yang, S.C. (*National Chiayi University, China-Taipei; ykliao@mail.ncyu.edu.tw; shlee@mail.ncyu.edu.tw; s0940070@mail.ncyu.edu.tw*).

Tricholoma matsutake is attributed to Tricholomataceae. It is famous as an edible fungus all over the world. It has many pharmacological activities including anti-tumor effects and enhancement of immunity. However, due to tremendous decrease in wild field populations and difficulty to be cultivated by humans, the amount of *T. matsutake* is limited. Therefore, it is highly desired to develop technology to cultivate this valuable fungus. The purpose of this study was to examine the optimal cultural conditions of the *T. matsutake*. The environmental and nutritional conditions required for the growth of *T. matsutake* were studied in detail to produce the best active mycelium used for *in-vitro* host infection. Different inoculation methods in substrate were also tested to determine the best growth conditions between mycorrhizal fungus and host. The results show that the MNC^{+} solid medium is better than other tested media. The pH conditions between mildly acidic and neutral are optimal for the growth of *T. matsutake*. Stratification is necessary to promote germination of well-developed host seeds. After 12 weeks of culture, *T. matsutake* was found performing symbiosis with the host. Therefore, this study demonstrated that ectomycorrhizal infection of *P. elliottii* by *T. matsutake* could be successfully achieved.

Wood physical and mechanical properties in a *Pinus pinea* L. forest: possible interactions with the presence of *Heterobasidion annosum* (Fr.) Bref. Marchi, E. (*Florence University, Italy; enrico.marchi@unifi.it*), Sciré, M. (*Molise University, Italy*), D'Amico, L. (*CRA-PAV, Italy*), Lo Monaco, Sciascia, N., Picchio R. (*Tuscia University, Italy; lomonaco@unitus.it; r.picchio@unitus.it*).

The present research aimed at assessing any possible effect caused by the cariogenic agent *Heterobasidion annosum* (Fr.) Bref. on the physical and mechanical properties of *Pinus pinea* L. wood of Circeo National Park (central Italy) as well as on its xylochronological features. The choice of the area where to get the material for analysis was based on the need for the pathogen to not be present. This condition has ensured that all observations are attributable to inoculations and are therefore under controlled environmental conditions. Different isolates, from America and Europe, were inoculated on wood samples. The effects of the various isolates on wood were not statistically different after 16 weeks. A xylochronological survey was carried out to date wood carrots and stem discs taken from snag and log dead plants as well as to observe eventual different reactions of dead trees relative to living trees in the years prior to their death. The action of *H. annosum* slightly decreases tree growth during 5–10 years before death. In particular, *H. annosum* of American origin takes several years (8–10) to cause trees to die, so it would seem to be less virulent than those of European origin (5 years).

Comparison of fungal endophytes in leaves of five tree species in rural and urban forests of Kanto area, eastern Japan. Matsumura, E., Fukuda, K. (*University of Tokyo, Japan; emi-matu@nenv.k.u-tokyo.ac.jp; fukuda@k.u-tokyo.ac.jp*).

Some fungal endophytes are host-specific and others have wide host-range, and their proportions may change by environmental factors. We aimed to understand the interactions between fungal endophytes and their host trees, and compared endophytic assemblages in multiple host tree species growing under different environments. Healthy mature leaves from 5 tree species, composed of two evergreen conifers and two evergreen and a deciduous broadleaf, were sampled in rural and urban forests of the Kanto area, eastern Japan. Samples were cut out from surface sterilized leaves, and incubated on modified 1/2 PDA. Isolated fungal colonies were identified or grouped by morphological and/or molecular characters. Regardless of sites, the same host species shared many common dominant fungi. In some host species, host-selective fungi were dominant in rural forest, while wide-range fungi were dominant in urban forest. Result of cluster analysis of fungal species composition showed that some groups consisted of the same host species, while some groups consisted of different host species growing in the same stand. Therefore, we suggest that the endophytic assemblage reflects phylogeny of host plants as well as the environments.

Reproductive cost of *Actinidia polygama* and the influence of gall formation caused by *Pseudasphondylia matatabi*. Nakayama, H., Miyake, K. (*Niigata University, Japan; sunny-summer@nifty.coml kmurascb@yahoo.co.jp*), Miyake, T. (*Gifu University, Japan; tmiyascb@yahoo.co.jp*), Nirei, T. (*Saitama Museum of Natural History, Japan; ulmus_r7@nifty.com*), Sakio, H. (*Niigata University, Japan; sakio@agr.niigata-u.ac.jp*).

Acitinidia polygama is a morphologically androdioecious plant. However, hermaphrodites are thought to produce only pseudo-pollen and thus the species is considered as functionally dioecious (cryptic dioecy). We reinvestigated the sexuality by several observations and field experiments and found that it is surely dioecious. Differential reproductive cost between sexes is of great interest because it affects evolution and maintenance of sexual dimorphism. We compared reproductive cost of males with that of females. While males invested more resources in reproduction than females at the floral stage, females invested more than males when fruit production was included. When *Pseudasphondylia matatabi* lay eggs in floral buds of *A. polygama*, the buds will develop into galls. The gall formation could have great influence on reproductive cost. Galls were found not only on females but also on males. Dry weight of a gall on males was 23 times as heavy as that of a male flower. There is no significant difference in dry weight of a gall males and females. We will discuss the influence of the gall formation on reproduction of males and females.

Damage to natural deciduous forest caused by sika deer bark-stripping in the southwestern part of Shikoku Island, Japan. Okumura, H., Okuda, S., Ito, T. (*Forestry and Forest Products Research Institute, Japan; okumurah@affrc.go.jp; okuchan@affrc.go.jp; takeharu@affrc.go.jp*), Sakai, A. (*Japan International Research Center for Agricultural Sciences, Japan; golgo@affrc.go.jp*).

Sika deer, *Cervus nippon*, populations have recently increased in Japan. Damage to natural vegetation caused by deer becomes an urgent problem in addition to forestry and agriculture. On Shikoku Island, few natural forests remain after large-scale clearcutting and artificial regeneration during the latter half of the 20th century. Here we present the critical state of the natural deciduous forest around Mt. Sanbongui (1,226 m), containing the southernmost beech forest of Shikoku Island. Predominant species of the study area are *Acer sieboldianum* and *Fagus crenata*. Floor vegetation, consisting mainly of two dwarf bamboo species, which are primary forage for deer, has almost disappeared. We established six permanent plots in spring 2006, where we measured DBH and the size of feeding wounds of all living trees. We checked new dying trees and measured new wounds in every spring from 2007 to 2009. Thirty-two percent of all trees in six plots had feeding wounds in 2006; 5% of all trees died by 2009, and 80% of them had suffered bark-stripping. *A. sieboldianum* occupied 25% of all trees; 55% of them had feeding wounds in 2006, and 9% died until 2009. These results show that this forest is rapidly declining by deer bark-stripping.

Cone damage of Korean white pine trees by red squirrels (*Sciurus vulgaris*). Park, Y.C., Kim, E.K. (*Kangwon National University, Republic of Korea; parky@kangwon.ac.kr; keuik98@hanmail.net*), Chang, C.G. (*EcoForest, Republic of Korea; expfor@kangwon.ac.kr*), Yoo, B. H. (*National Institute of Environmental Research, Republic of Korea; bhyoo7777@korea.kr*), Kim, J.K. (*Kangwon National University, Republic of Korea; jongkuk@kangwon.ac.kr*).

Korean white pine trees, *Pinus koraiensis*, are among the most popular silvicultural species in Korea, and pine-nut-related businesses have been recently increased in Korea. Since pine nuts are one of the main food items for red squirrels (*Sciurus vulgaris*), damage of the pine nuts by the squirrels has also been increasing rapidly. Squirrel damage has been severe in young trees in plantations. The pine cones grew slowly from October to March of the next year, and then rapidly until August. Main damages by the squirrels have been observed between September and the next April of every year during the research periods of 2002 to 2004. Most damage occurred in premature cones. Cone damages were lowest during November in 2002 to 2004; highest damages occurred in February in 2003 and August in 2004. Average damages were 51.1% in 2002 to 2003 and 35.0% in 2003 to

2004, respectively. Cone damages from October 2002 to August 2003 were over 39.7% to 99.2% and average damage of them was 71.5%. Damages from October 2003 to August 2004 were over 44.0% to 84.0% and average damage of them was 65.5%.

The nutrient uptake potency of *Shorea javanica* K. and V. seedlings with the treatment of ectomycorrhizal and growing media. Prameswari, D. (*Forest and Nature Conservation Research and Development Center, Indonesia; diana_eko@yahoo.com*), Supriyanto, S. (*Bogor Agricultural University, Indonesia; supriyanto@ipb.ac.id*), Santosa, E. (*FORDA, Indonesia; erdy_s@forda.co.id*).

The success of forest plantation development depends on the availability of seeds at appropriate times. In general, *Shorea javanica* does not produce fruit every year, and the seeds have recalcitrant properties. To enhance seedling quality, mycorrhizal innoculation in an appropriate medium for its growth is needed. The objectives of the research were to know the compatibility level of *Scleroderma columnare*, S. *dictyosporum*, and *Laccaria laccata* mycorrhizal fungi to *S. javanica* seedlings; to know the appropriate medium composition of rice husk compost suitable for growth of *S. javanica* seedlings; to know the interaction between rice husk compost and species mycorrhizae that is effective in increasing growth of *S. javanica* seedlings; and to know the effect of ectomycorrhizal infection to nutrient uptake by *S. javanica* seedlings. Completely randomized design in factorial, consisting of two factors(growing media and mycorrhiza), was used. Results showed that the best combination of mycorrhizal fungi innoculation and rice husk compost for producing the best growth of *S. javanica* seedlings was obtained in soil: mixed rice husk compost: 1:1 and innoculated with *S. dictyosporum* mycorrhizal fungi. Mycorrhizal fungi innoculation increased the nutrient uptake of N, P, K, Mg, Ca, S, and Cu compared with the non-innoculated seedlings.

Survey on fungal diversity in Jeollanam-do, Korea: a new species of *Marasmius*. Ryoo, R., Ka, K. H. (*Korea Forest Research Institute, Republic of Korea; rryoo@korea.ac.kr; kasymbio@forest.go.kr*).

During field excursions to various localities in Jeollanam-do in 2009, the authors collected numerous macro-fungi. Descriptions of their macro- and microscopic features with a discussion of similar taxa are given in this study. Among them, one taxon was recognized as new to science, tentatively called here *Marasmius* sp. 1. To date, approximately 500 species of *Marasmius* and 1,600 epithets have been validly published in worldwide distribution. Most of *Marasmius* species are represented by a large number of species in the tropical flora. In the Republic of Korea, 26 *Marasmius* species have been recorded to date. In tropical regions especially, *Marasmius* species are mostly wood- and litter-inhabiting fungi as the saprophytic basidiomycetes. These species, which are efficient decomposers and recyclers of nutrients in dead leaves, have important ecological value. *Marasmius* sp. 1 collected in the field excursion is characterized by having a pileipellis with well-developed Siccus-type broom cells. Their taxonomic position was confirmed by DNA data. Phylogenetic analysis of ITS and LSU rDNA supported the identity of this species based on macro- and micro-morphological characteristics. The result of Baysian analysis indicates strongly the independent taxonomic status of this new species from other similar *Marasmius* species.

Biodegradation of *Quercus accutisma* and *Pinus densiflora* by white-rot fungus, *Polyporus brumalis*. Ryu, S.H., Cho, M.K., Kim, B.Y., Kim, M.K., Lee, S.S. (*Korea Forest Research Institute, Republic of Korea; shryu@forest.go.kr; mibo97@nate.com; kamael@korea.com; mkkim@forest.go.kr; lsungsuk@forest.go.kr*).

White-rot fungi are common inhabitants of forest ecosystems and are also responsible for the destructive decay of wooden structures due to their lignin-degrading enzymes, such as laccase, lignin peroxidase, and manganese peroxidase. *Polyporus brumalis* is one of the white-rot fungus strains in Korea, KFRI 20912. In this study, we conducted genetic transformation for *P. brumalis* to enhance lignin biodegradation ability of the fungus. The laccase cDNA, *pblac1*, was cloned and transferred into the over-expression vector containing the GPD promoter and the hygromycin resistance gene (hph) as a selectable marker. The transformation was performed by the restriction enzyme-mediated integration method with slight modification. Stable integration of the constructed DNA was confirmed by PCR using vector specific primers. As a result, the transformants showed 3–10 times higher laccase activity than that of the wild type when *o*-tolidine was used as the enzyme substrate. We investigated the lignin-degrading activity on the wood blocks of *Quercus accutisma* and *Pinus densiflora*. After 30 days of the treatment with the transformants, the highest lignin loss was 28.6% in *Q. accutisma* and 11.7% in *P. densiflora*y. These results suggest that the over-expression of a laccase gene contributes to the fungal lignin degradation.

Clonal distribution of *Cylindrobasidium argenteum* in a river valley forest as determined by somatic incompatibility, and significance of basidiospores for its dispersal. Sahashi, N., Akiba, M., Ishihara, M., Miyazaki, K., Seki, S. (*Forestry and Forest Products Research Institute, Japan; sahasi@affrc.go.jp; akiban@affrc.go.jp; makolin@affrc.go.jp; miyazaki@affrc.go.jp; seki@ffpri.affrc.go.jp*).

Cylindrobasidium argenteum, the white stem blight pathogen, is transmitted to healthy trees through contact with infected neighboring branches. To clarify whether basidiospores of *C. argenteum* are involved in the dispersal, we investigated clonal distribution of the fungus in a river valley forest using a somatic incompatibility test. Thirty-eight and 50 isolates were collected from diseased trees along two census lines at the bottom of river valley and from four experimental plots on the slope of the valley, respectively. When the isolates from the valley bottom were paired, a narrow clear zone line appeared in 701 out of 703 pairings, suggesting that basidiospores play an important role for dispersal. In contrast, vegetative spread proved to be more frequent on the slope of the valley. On lower parts of such slopes, opportunities of healthy trees for meeting infectious agents may increase because infected broken branches frequently move downwards on the slope. Based on these results, we suggest that *C. argenteum* adopts following dissemination strategies: (i) it spreads chiefly by basidiospores and infects trees, and (ii) after colonizing stems or branches and producing an extensive mycelial mat, secondary infections of adjacent trees occur by contact with infectious agents such as diseased branches.

Protection of red pine seedlings by ectomycorrizal fungi from the infection of root pathogenic fungi. Seo, I.W., Lee, S.K., Lee, S.Y., Chun, K.W., Lee, J.K. (*Kangwon National University, Republic of Korea; seoilwon@kangwon.ac.kr; lskyou@hotmail.com; sangyong@kangwon.ac.kr; kwchun@kangwon.ac.kr; jongklee@kangwon.ac.kr*).

To demonstrate the roles of ectomycorrhizal (ECM) fungi in protecting red pine (*Pinus densiflora*) seedlings from infection of root pathogenic(RP) fungi, both *in-vitro* and *in-vivo* experiments were carried out by investigating mycelial growth inhibition of RP fungi on culture media and disease suppression on pine seedlings. Pairing cultures of 11 ECM fungi and 5 RP fungi showed great variations in mycelial growth of RP fungi. *Pisolithus tinctorius* and *Lepista nuda* showed strong inhibition of mycelial growth by *Armillaria mellea* and *Phytophthora katsurae*, respectively. Culturing of RP fungi on culture media containing culture filtrates of ECM fungi showed that culture filtrates of *Hebeloma cylindrosporum* may inhibit the mycelial growth of all tested root pathogens upto 60%. Culture filtrates of ECM fungi also give effects on sporulation and germination of *F. oxysporum*. Antifungal metabolites released by ECM fungi may inhibit mycelial growth as well as sporulation and germination. Artificial inoculation of ECM fungi and RP fungi on red pine seedlings by three inoculation methods showed that pine seedlings were dead within 6 days after inoculation by pre-inoculating pathogenic fungi before ECM fungi. However, no dead seedlings were shown by simultaneous inoculation of both fungi or post-inoculation of RP fungi.

Occurrence of *Entomosporium* leaf spot on *Eriobotrya japonica* in Korea. Seo, S.T., Oh, H.Y., Lee, S.H., Shin, H.D. (*Korea University, Republic of Korea; stseo@forest.go.kr; ohy1984@hanmail.net; saimonlee@empal.com; hdshin@korea.ac.kr*).

A fruit of wide appeal, the loquat (*Eriobotrya japonica*), of the rose family, Rosaceae, has been called Japan or Japanese plum. In Korea, it is planted only southern areas due to its poor winter hardiness. On April 2008 plantings in a nursery in Goheung were severely affected by a leaf spotting and defoliating disease. The initial symptom of the disease appears as minute circular spots on either side or on both sides of the leaves. The continued infection finally leads to excessive premature defoliation of the affected trees. The leaf spot lesions and the fungus were examined under a microscope. Acervuli were gray to dark grayish, amphigenous, or sometimes epiphyllous, circular to irregular, produced subepidermally, dehiscent by irregular rupture of the cuticle when mature. Conidia were hyaline, cruciform, 4- to 5-celled, and 22–30 × 9–11 μm. Appendages on apical and each lateral cell were unbranched, tubular, flexuous, attenuated gradually toward the distal end, and 11–20 μm in length. Based on these morphological characteristics, the causal fungus of leaf spots on *Eriobotrya japonica* was identified as *Entomosporium mespili* (DC.) Sacc.

Invasive tendencies in exotic deciduous tree *Broussonetia papyrifera:* risk assessment for early detection. Singh, H.P. (*Panjab University, India;hpsingh_01@yahoo.com*).

Broussonetia papyrifera (paper mulberry tree; Moraceae), is a deciduous tree native of China, and introduced in other parts of the world for paper, shade, and ornamental purposes. However, in the introduced areas, it shows invasive tendencies and spreads fast in the forest margins, vacant areas, and even along roadsides. *B. papyrifera* is a dioecious tree with male and female flowers produced on the separate trees. The tree has an effective seed dispersal mechanism and is taken to long distances by fruit-eating birds and other wildlife. Besides, the plant spreads via its root system, which is thick and dense, and is capable of multiplying vegetatively by suckers. In the reserve forests in and around Chandigarh (India), the tree has been seen growing extensively, spreading very fast, and affecting the herbaceous understorey and regeneration of native forest trees, thereby having serious implications to forest health and sustainability. Thus, there is an urgent need to assess the risks posed by the invasion of *B. papyrifera,* and develop strategies for its management to stop its further spread and consequent impact on forest health. The present paper discusses biology, ecology, and risk assessment of *B. papyrifera*, an invasive forest tree.

Assessment of tree vigor condition in *Cerasus* species using remotely sensed indices. Song, Y.K., Imanishi, J. (*Kyoto University, Japan; songkoon@song.mbox.media.kyoto-u.ac.jp; imanishi@kais.kyoto-u.ac.jp*), Hashimoto, H. (*Meijo University, Japan; hihashi@ccmfs.meijo-u.ac.jp*), Hagiwara, A. (*Kyoto University, Japan; songkoon@gmail.com*), Morimura, A. (*University of Human Environments, Japan; morimura@uhe.ac.jp*), Morimoto, Y. (*Kyoto University, Japan; ymo@kais.kyoto-u.ac.jp*), Kitada, K. (*Nakanihon Air Service Co. Ltd, Japan; kkitada@nnk.co.jp*).

The vigor condition of trees is an important indicator for forest management. Remote sensing is expected to be more efficient at the broad scale than ground work. However it is unclear how to link field diagnosis with remote-sensing data. In this study, tree vigor condition was assessed by remote sensing. Forty-three *Cerasus* × *yedoensis* 'Somei-yoshino' and 23 *Cerasus jamasakura* (Siebold ex Koidz.) H. Ohba var. *jamasakura* were assessed on the ground, and airborne imagery of narrow bandwidths from visible to near-infrared was acquired. To estimate correlations between tree vigor condition and remotely sensed indices, we evaluated the 21 published vegetation indices and 66 other potential spectral combinations. As a result, the ratio or the normalized difference computation of reflectance at red-edge (700 nm) and green (541 nm) was best correlated (rs = 0.659). R750R550, the ratio of 750 nm to 550 nm, was the highest among the published ones. These results emphasized that green region closely related to chlorophyll content has potential to indicate tree vigor condition. The best index discriminated tree vigor condition into five ranks with 84.5% fuzzy accuracy, which could be helpful to broad-scale survey.

A non-destructive method for detecting heart-rot of a standing tree by measuring the resonance frequency by impact. Suyama, H. (*Shimane Prefecture Mountainous Region Research Center, Japan; suyama-hiroshi@pref.shimane.lg.jp*).

A non-destructive method for detecting heart-rot of a standing tree was studied. The method is based on the resonance frequency when a tree is impacted laterally by a wood hammer. The product of the diameter (D) and the frequency (Fr) of the trunk in decayed trees is lower than that in healthy trees. Using this method, 240 Japanese black pines were diagnosed in one park of Matsue city, Japan. The proportion of heart-rot in the cross vertical section of each trees were calculated from the D × Fr values measured at 1-m height, after the relationship between both was found in advance by analysis of the finite element method. The frequencies were measured efficiently in most trees but were troublesome to be identified in some because of other frequencies by impacting. The proportions in 30 trees were compared with that presumed by the drilling resistant method. A high correlation between both methods was observed. In six trees, the proportions of rot were estimated to be over 40% in either method.

Analysis of aluminum-binding compounds in roots of *Eucalyptus camaldulensis.* Tahara, K., Hashida, K., Ohara, S. (*Forestry and Forest Products Research Institute, Japan; taharako@affrc.go.jp; koh@affrc.go.jp; oharas@affrc.go.jp*), Kojima, K.

(*University of Tokyo, Japan; kojima@fr.a.u-tokyo.ac.jp*), Shinohara, K. (*Forestry and Forest Products Research Institute, Japan; kenjis@affrc.go.jp*).

In acid soils, aluminum (Al) toxicity is one of the major factors that limit plant growth. We analyzed the Al-binding compounds in root tips of *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) to examine the high Al resistance of this species. Soluble compounds were extracted from root cells after roots of seedlings were treated with a calcium solution (pH 4.0) containing 0 or 1 mM $AlCl_3$ for 24 h. Al-binding compounds were separated from the root extract by gel filtration or high-performance liquid chromatography (HPLC). The Al-binding compound separated by gel filtration remained soluble when it formed a complex with Al. Its content in the roots increased significantly after the Al treatment, which can be explained, at least partly, by an increase of citrate. The Al-binding compound separated by HPLC became insoluble when it formed a complex with Al, suggesting that this compound is not citrate, oxalate, or malate, which are well-known Al-binding compounds in other plant species. The Al-binding compounds in roots might play an important role in the high Al resistance of *E. camaldulensis* through detoxification of Al.

Comparison of effectiveness of weeding methods to control the invasive species *Pennisetum purpureum* Schumach. grass in teak plantations in Myanmar. Than, W.W. (*Forest Research Institute, Myanmar; waiwaikyaw2007@gmail.com*).

Large-scale teak plantations were initiated in 2007. Consequently, introduced species *Pennisetum* for pasture followed, and manual weeding was not effective. Therefore, the study aimed to support better management among the weeding methods. Four blocks were selected to compare the effectiveness in manual, mechanical, and chemical weeding. A total seven plots were staked in each block, including an un-weeded plot and containing 2-year-old trees; four teak trees per plot were measured for height. The herbicide Glyphosate was applied monthly (H1), and at 2-month intervals (H2), 3-month intervals (H3), and 4-month intervals (H4). Grass was harvested from two quadrats in each plot and weighed after oven drying at 70º C for 3 days. All experiments were conducted September 2008–February 2009 in the Mya Seinn Taung Nyo teak plantation. Weed control efficacy % assessed in H1, mechanical, manual, H2, H4, and H3 were 82.2, 68.8, 68.1, 58, 58, and 49, respectively. The linear relationship between teak height and weed ODW in H1 was more highly negatively correlated than the others, with R^2 value 0.674. Lower cost of manual weeding alone is not timely enough. Herbicidal combination methods may be more effective to control the grass.

Effects of dust accumulation on Scotch pine (*Pinus sylvestris* L.) in Ulaanbaatar, Mongolia. Tsogtbaatar, J. (*GeoEcology Institute, Mongolian; geoeco@magicnet.mn*), Lee, S.W., Lee, C.H. (*Korea Forest Research Institute, Republic of Korea; soilloverlee@forest.go.kr; hwa21@forest.go.kr*), Batbold, P. (*GeoEcology Institute, Mongolian; bati_env@yahoo.com*).

Thickness of dust accumulated on Scotch pine (*Pinus sylvestris* L.) needles, concentrations of heavy metals in dust and needles, and transpiration rates were investigated at a highly air-polluted area (Ulaanbaartar, UB) and non-polluted area (Sanzai). Mean dust thickness for 4 months was 3.7-fold higher at UB compared to Sanzai. The dust at UB was not washed out by rain water even in summer season and dust concentration of heavy elements was relatively higher in UB. In the dust accumulated on needle surface and in the needles, the highest concentrations of Fe and Al were found at the polluted site UB. They were 2- to 3-fold higher than those at Sanzai, possibly derived from soil particles. However, concentrations of other toxic metals such as Cd, Pb, Zn, Cu, and Cr were not considerably different between the two sites, which indicates that the dust has not been deposited by industrial sources. Considerably lower needle transpiration rate was found at the air-polluted site (UB 3.7 kPa/s/cm^2 vs. Sanzai 12.6 kPa/s/cm^2). These results suggest that thick dust accumulation and higher concentration of some metals might affect the physiological process such as transpiration of Scotch pines.

Sustaining forest health through silviculture: the European Commission LITCOAST project. Vasaitis, R. (*Swedish University of Agricultural Sciences, Sweden; rimvys.vasaitis@mykopat.slu.se*), Lygis, V. (*Institute of Botany, Lithuania; vaidotas.lygis@botanika.lt*), Menkis, A. (*Swedish University of Agricultural Sciences, Sweden; audrius.menkis@mykopat.slu.se*).

In Lithuania, Baltic Sea coastal forests and dune vegetation are important ecosystems of high habitat conservation and recreation values to society. In 2006, the European Commission launched Marie Curie host fellowships for a transfer-of-knowledge project, LITCOAST—Management of coastal forests of Lithuania: sustaining and enhancing forest health through silviculture. The aim of LITCOAST is promoting health and sustainability of coastal forests and dune vegetation through: (1) identification of beneficial and pathogenic microorganisms in tree seedlings in forest nurseries and following the transfer to field plantations; (2) different methods of seedling mycorrhization, increasing their vitality; (3) risk assessment, identificationl and prognosis of tree decline on postfire sites; (4) identification of causes of gap formation and its dynamics in older forest stands; (5) developing novel silvicultural measures for gap restoration and minimising losses; (6) assessment of biodiversity in coastal vegetation, and outlining the measures for its sustainability and increase; (7) elaborating a complex of practical measures for improved forest management; and (8) maintenance of permanent study and demonstration plots to be used in future research and teaching, thus enhancing further transfer of knowledge.

Effects of aerosols on leaves of birch species in a cool temperate deciduous broadleaved forest of Hokkaido, northern Japan. Watanabe, Y., Watanabe, M. (*Hokkaido University, Japan; youko@for.agr.hokudai.ac.jp, nab0602@for.agr.hokudai.ac.jp*), Uemura A. (*Forestry and Forest Products Research Institute, Japan; akirauem@ffpri.affrc.go.jp*), Koike, T. (*Hokkaido University, Japan; tkoike@for.agr.hokudai.ac.jp*).

Recently various research fields have focused on effects of aerosols on forest trees. Some studies have been reported that aerosols affect surface, internal structure (such as palisade parenchyma of leaves), and physiological traits of forest trees. However, little information is available on effects of aerosols on forest trees in Japan. Therefore the objective of our study was to clarify effects of aerosols on leaves of birch species in a cool temperate deciduous broadleaved forest of Hokkaido, northern Japan. We collected leaves of birch species from several regions in Hokkaido, including urban areas, suburbs, and forests. Leaves were cut to small pieces and air-dried. Then we made samples for observation of leaf surface and observed leaf surface by scanning electron microscopy (SEM). SEM observations revealed that irregularly shaped small particles adhered on both adaxial and abaxial leaf surfaces in all samples. However, abaxial leaf surface of urban area samples shows damages of guard cells and depositions of

particles in stomata, while no damages of stomata were shown in those of the suburban samples. Deposition of particles on abaxial leaf surface might cause reduction in stomatal conductance and photosynthetic ability of birch species.

Chemical control of scab canker caused by *Scolecostigmina chibaensis* on *Pinus parviflora.* Yamada, T., Karukome, T., Ikeda, H. (*University of Tokyo, Japan; yamari@uf.a.u-tokyo.ac.jp; karukome@uf.a.u-tokyo.ac.jp; ikeda@uf.a.u-tokyo.ac.jp*).

Scab canker of five-needle pines caused by *Scolecostigmina chibaensis* induces gall and canker on stems and branches, and death of twigs and seedlings. Inhibition of natural regeneration and decline of mature trees of local refugee species *Pinus parviflora* by this disease becomes a serious problem in Boso peninsula, Pacific side of central Japan. Infection occurs on current-year branches following conidia dispersion in May and June under infested crowns. We tried to develop chemical control measures. Among 15 fungicides used *in-vitro* experiment, 9 fungicides inhibited mycelial growth of *S. chibaensis* and 7 inhibited spore germination. Six fungicides that inhibited mycelial growth *in-vitro* were selected for further field experiment. Fungicides were sprayed on potted seedlings of *P. parviflora* under infested mature trees during the period of spore dispersion, and were monitored with spore traps for 2 years. Five fungicides, thiophanate methyl, benomyl, polycarbamate, manzeb, and copper 8-hydroxyquinoline were effective in blocking natural infection perfectly. However, triflumizole, which did not inhibit spore germination, could not prevent infection at all. Inhibition of spore germination may be essential to control scab canker.

Effects of surface condition of stem wounds on wood discoloration and decay: an example of *Zelkova serrata.* Yamada, T. (*University of Tokyo, Japan; yamari@uf.a.u-tokyo.ac.jp*), Nagaishi, N. (*TOHO-LEO, Japan; nagaishi@toho-leo.co.jp*), Yamashita, T. (*FUJI UEKI, Japan;*), Koyama, T. (*FUJI UEKI, Japan; t-yamashita@fujiueki.co.jp; tkoyama@fujiueki.co.jp*), Kaniwa, M. (*ECOL, Japan; m-kaniwa@ecolsys.co.jp*), Tokue, I. (*Maguhausu, Japan; to-5@mvc.biglobe.ne.jp*).

Trees often suffer injuries due to natural and artificial, managing or accidental, factors throughout their lives. Wound surface conditions appear to affect the development of wood discoloration and decay. Effects of different wound surface treatments were investigated for the progress of arboricultural management. Eight sprout stems from one *Zelkova serrata* tree were drilled to make holes in March. Every two stems were harvested, and extension and color of wood discoloration and decay were investigated 1 and 3 years after wounding. Surface treatments were as follows: (1) downward boring, *Sphagnum* moss packing, and water-filling; (2) downward boring, water-filling beginning 1 month after wounding; (3) downward boring, water-filling beginning at the time of wounding; (4) downward boring and covering with plastic flap; (5) downward boring with upward drainage hole; (6) upward boring and thiophanate methyl paste application; and (7) upward boring. Every 1 to 2 months, maintenance was made to keep surface conditions. Extent and color of wood discoloration and decay were most remarkable for wounds with drainage holes, followed by other drying treatments. Thiophanate methyl paste had some covering effect. Water-filling was effective to minimize the area of wood discoloration and prevent decay.

Anatomical features of *Prunus* leaves infected with Witch's broom. Yamamoto, S., Ikeda, T. (*Kyoto Prefectural Univerisity, Japan; dancing_bigbird@yahoo.co.jp; tikeda@kpu.ac.jp*).

Witch's broom of cherry trees is an infectious disease caused by *Taphrina wiesneri* (Rath.) Mix. *Prunus* × *yedoensis* Matsum., which is ornamentally one of the most popular cherry trees, is very susceptible to this disease. Infected shoots hardly form flower buds, and leaf out with small leaves at the blooming season. Infected leaves turn black and defoliate in early May, and then new leaves expand again. Such morphological features of diseased leaves are well-known but anatomy is not made clear enough. We examined seasonally anatomical features of leaves infected with Witch's broom. Measured items are as follows: length; width; area; and boundary length of palisade tissue, spongy tissue, and epidermal cells. As a result, most cells of all tissues in infected leaves were smaller than those of healthy ones, length of palisade cells were particularly downsized. The shape of palisade and spongy cells in infected leaves were spherical in comparison with healthy leaves. The thickness of infected leaves before defoliation in early May was especially thick, and spongy cells were larger than healthy ones. Our observations made clear the difference in anatomy between infected and healthy leaves of cherry trees.

Feeding behavior of *Lycorma delicatula* (Hemiptera: Fulgoridae) and response on feeding stimulants of some plants. Yoon, C.M., Kim, G.H. (*Chungbuk National University, Republic of Korea; changmann@hanmail.net; khkim@chungbuk.ac.kr*).

Host preference was tested on the seven species plants against ggot-mae-mi, *Lycorma delicatula* (Hemiptera: Fulgoridae). This insect highly preferred *Ailanthus altissima* and *Vitis vinifera* but did not choose other plants preferentially. Both nymphs and adults lived longest in *A. altissima* and *V. vinifera* but lived in short and low ecdysis rates against other plants and three species of fruits. By analyzing the phloem-feeding behavior using EPG, *L. delicatula* showed the shortest time in the non-probing phase and it also exhibited the longest feeding time in *A. altissima* and *V. vinifera*, but other plants did not feed on the phloem at all. In sugar contents analysis, *A. altissima* had high sucrose proportion, followed by fructose > glucose; *V. vinifera* showed glucose > fructose > maltose > sucrose > rhamnose; *Malus pumila* was glucose > fructose; *Pyrus calleryana* was glucose > unkown > fructose; and *Hibiscus syriacus* was sucrose > glucose. Nymphs and adults of *L. delicatula* lived longest in 5% sucrose solution, and the next longest in 5% fructose solution. However, they lived shorter in other sugar solutions. *L. delicatula* nymphs and adults, according to the combination of sugar proportions found in original plants, lived longer in a sugar combination solution of *A. altissima*, and that of *V. vinifera* was next.

The 2008 China ice storm: an unprecedented disturbance to unprepared forests. Zhou, B. (*Research Institute of Subtropical Forestry, China; boozex@gmail.com*), Gu, L. (*Oak Ridge National Laboratory, USA; lianhong-gu@ornl.gov*), Yu, M., Wang, X. (*Research Institute of Subtropical Forestry, China; yumukui@sina.com; rsfyrs@126.com*), Ai, C. (*Office of Forest Resources Supervision and Administration, State Forestry Administration, China; aichang@forestry.gov.cn*), Cao, Y., Li, Z., Zhao, X., Sun, H., Kong, W. (*Research Institute of Subtropical Forestry, China; fjcyh77@sina.com; lizccaf@126.com; zhaoxia@ritf.ac.cn; honggangsun2002@yahoo.com.cn; yilucanlan@yahoo.com.cn*).

An unprecedented ice storm occurred in early 2008 in China, resulting in severe damages and huge losses to forests. With a comprehensive survey and site-specific investigation during and following the ice storm, the impact of the storm on different

forest stands was determined. About 19.4 million hectares of forest were damaged, or 1/10 of the total in China. Nearly 3 million hectares of land were deforested, with a standing volume loss of 340 million m^3. A variety of patterns of damage to forest trees were found, including bending, leaning, branch breakage, decapitation, stem breakage, and uprooting; bending, stem breakage, and uprooting were the most commonly observed. Higher elevation significantly aggravated the ice damage to Chinese fir (*Cunninghamia lanceolata*) and bamboo, and bamboos on north-oriented slopes received more damage. The exotic pine species (*Pinus elliottii* and *P. taeda*) were more susceptible to ice damage than native (*P. massoniana*). The degree of damage in bamboo and pine forests increased with stand density. Juvenile and old-growth stands of pine and Chinese fir were less affected than the middle-aged, while for mixed broadleaf, the most severe damage occurred in smaller trees. Oleoresin tapping on pine dramatically reduced its resistance to ice damage.

Theme H: Forests, Communities and Cultures

H-01 Income from smallholder forestry: can it be a driver of poverty alleviation?

Organizer: Verina Ingram, *CIFOR, Indonesia, v.ingram@cgiar.org.*

Institutional arrangements are a driving force for NTFPs as a livelihoods option: case study of ADEAC in Cameroon. Foundjem-Tita, D., Van Damme, P. (*Ghent University, Belgium; dftita@yahoo.com; Patrick.Vandamme@ugent.be*), Degrande, A. (*World Agrofrestry Centre, Cameroon; a.degrande@cgiar.org*), D'haese, M. (*Ghent University, Belgium; Marijke.Dhaese@UGent.be*), Tchoundjeu, Z. (*World Agrofrestry Centre, Cameroon; z.tchoundjeu@cgiar.org*).

Farmers living in forest areas are endowed with natural resources that are often underexploited due to lack of market opportunities and information. On the other hand, traders operating in urban markets lack information on the possible supply sources and potential of different production zones. These set backs coupled with poor infrastructure relegate NTFPs into a less competitive sector. Such tendencies have exposed the sector to less donor support backed by recent scientific literature as not appropriate for poverty alleviation. In this paper we investigate the success of NGO assisted bargaining groups in obtaining better sales contracts for njansang producers in Cameroon and argue that such innovations in institutional arrangements and others aimed at improving partnerships between producer bargaining groups and traders operating in urban markets can render land locked producers competitive and project NTFPs with high market demand as important sources of livelihood. This paper further provides evidence that such initiatives can enable farmers and traders share production and market information and can be used to overcome the weak institutional environments (poor market information and infrastructure) that characterize forest zones and limit trade in NTFPs.

Forest certification for smallholder forestry as an option for poverty alleviation: lessons from two cases in Indonesia. Harada, K. (*University of Hyogo, Japan; harada@shse.u-hyogo.ac.jp*), Rohman, R., Silvi, N.O., Wiyono, T.P. (*Gadjah Mada University, Indonesia; rohmanifah@yahoo.com; genki_21@yahoo.com; wiyono.putro@gmail.com*).

Through a three-month field survey conducted between 2006 and 2008, we investigated how forest certification was adapted to smallholders' forest management and how it affected local livelihoods, by comparing FSC group certification and an independent certification system (LEI PHBML) in Indonesia. Group certification was granted in April 2005 for private teak forests managed by a local forestry cooperative consisted of village farmer groups in South Sulawesi. People who would meet certain criteria could become the members of the cooperative to manage their own forests as certified. Higher income by selling certified timbers and self-confidence for their forest certified could shift the people from illegal activities to manage their forests positively. PHBML certification was granted for two neighboring villages in Central Java and all forests within the villages were certified. However, local people were not necessarily very enthusiastic to sell timbers as certified because of conservation attitudes developed in the face of past experiences of water scarcity and of sufficient alternative income sources. Outstanding issues highlighted include: 1) how people can be more involved in producing certified timbers, and 2) how certified timbers from the smallholder forestry can be more widely recognized in international timber markets.

Are community-based forest enterprises economically viable? Three cases in the Brazilian Amazon. Humphries, S. (*University of Florida, USA; shoana_h@hotmail.com*), Holmes, T. (*U.S. Forest Service, USA; tholmes@fs.fed.us*), Kainer, K. (*University of Florida, USA; kkainer@ufl.edu*), Koury, G. (*IDESAM, Manaus, Brazil; carlosgabriel@idesam.org.br*), Cruz, E. (*AMBE Project, Brazil; carlosgabriel@idesam.org.br*), Rocha, R.M. (*Mamirauá Sustainable Development Institute, Brazil; rosana@mamiraua.org.br*).

Community-based forest management is an integral component of sustainable forest management and conservation in the Brazilian Amazon as in many tropical regions. Community forestry in the Amazon has been heavily subsidized for the last 10 years, yet knowledge of the economic viability and impact of community-based forest enterprises (CFEs) is lacking. This study evaluates the profitability of three CFEs in the Brazilian Amazon: AMBE, an industrial-scale, upland forest operation producing logs in a national forest, in Pará state; ACAF, a small-scale operation in flooded forests producing boards with a portable sawmill in southern Amazonas state; and Mamirauá, one of 30 CFEs in a reserve, in northern Amazonas state producing logs and boards in flooded forests. Costs for each project were compiled by forest management activity and cost type (labor, equipment and machinery, materials, technical assistance, and administration). Annual total costs were calculated as the sum of fixed and variable costs and then subtracted from total revenue to obtain annual profit. The annual rate of return was calculated by dividing profits by total costs. The AMBE and Mamirauá cases were profitable, demonstrating rates of return of approximately 25% and 5%, respectively, while the ACAF case was not profitable.

Impacts of community forests exploitation on communities' livelihoods in Cameroon: lessons learned from two case studies. Ingram, V. (*Center for International Forestry Research, Cameroon; v.ingram@cgiar.org*).

Community forestry is considered as an efficient strategy to achieve several goals: sustainable management of natural resources, alleviation of poverty and empowerment of populations. However, evidence has shown mixed results to date. This study used questionnaires and interviews to provide a financial, economic and environmental cost and benefit analysis of two community forests in Cameroon, to examine their ability to alleviate poverty by providing more sustainable livelihoods to the populations. Results revealed that community forests are economically and environmentally slightly more profitable than compared to the situation without community forests. However, sharp differences between the economic and financial returns created highlight the importance of conditional factors. Factors influencing communities' success include technical and managerial capacities, access to finance, equipment and legal resources, insufficient market information and low levels of vertical integration. Accounting for environmental degradation as an economic cost demonstrated the high value of loss of ecosystem services, despite management providing some protection. The cases point to the limitations of current legislation and their influence on the exploitation of

community forests, and point to a pressing need for institutional reforms within the governmental and support apparatus to increase the profitability and equity of community forestry.

Poverty alleviation in Bangladesh: the case of the Participatory Agroforestry Program. Islam, K.K., Sato, N. (*Kyushu University, Japan; kamrulbau@yahoo.com; sato@ffp.kyushu-u.ac.jp*), Hoogstra, M. (*Wageningen University, the Netherlands; Marjanke.Hoogstra@wur.nl*).

In 1987, Forest Division of Bangladesh initiated a Participatory Agroforestry Program (PAP) in the denuded Sal forest area of Bangladesh for the poor people in order to alleviate poverty and protect forest resources. This study explored the question to what extent the PAP has reduced the poverty and which factors might responsible for poverty alleviation among the settlers. The research made use of three poverty measurement methods to determine to what extent poverty had decreased: the Head Count Index, Poverty Gap Index and Foster-Greer-Thorbecke Index. To determine which factors might explain possible differences in poverty alleviation, linear regression was used. Semi-structured questionnaire and face to interview methods were used to collect the data with 99 household within the study area. The results show that the PAP program has alleviated 64% poverty which improved the situation considerably. The linear regression showed that differences in poverty reduction can be explained for the larger part (72%) by the family size, months of food sufficiency, distance to market and loan facility variables of the settler. Overall the PAP has been very successful in alleviating poverty; further it can also encourage other countries that faces similar poverty situation to follow Bangladesh in this regards.

Regulatory policies and development of non-wood forest product enterprises in Central Africa. Ndoye, O., Tieguhong, J.C., Ze, A.A. (*FAO, Cameroon; ousseynou.ndoye@fao.org; chupezi@yahoo.co.uk; assengze@yahoo.fr*), Grouwels, S. (*FAO, Italy; sophie.grouwels@fao.org*), Masuch, J., Sakam, I. F. (*FAO, Cameroon; Juliane.Masuch@fao.org; fosidel2003@yahoo.fr*).

Non-wood forest products (NWFP) comprise a diversity of natural resources that support livelihoods, notably of women and minorities involved in their value chains. The Central African Forest Commission (COMIFAC) recognises the importance of NWFP in alleviating poverty, realising economic development and conserving biodiversity. However, weighing these objectives against each other through laws and regulations is a challenge. Through its convergence plan, COMIFAC aims at helping the countries of Central Africa improve and harmonize their legal and institutional policies guiding the NWFP sector. The paper contents that COMIFAC's engagement is timely because the NWFP sector is marred with regulatory and institutional policies that do not favour their sustainable management, efficient transportation, processing and commercialisation. Control measures, informalities and ways forward for resource access, transportation and marketing of NWFP are highlighted. Reference is made to key recommendations through a set of sub-regional directives for an enabling political environment for NWFP valorization, elaborated by partners in Central Africa. The directives provide the COMIFAC member countries with clear guidelines for the inclusion of NWFP in their national legal frameworks to stimulate their participatory management, strengthen NWFP value chains and regional trade, thus, increasing their contribution and visibility in the economies of Central Africa.

Improving economic outcomes for growing teak by smallholders in agroforestry systems in Indonesia: some lessons learnt for decision makers and development agencies. Rohadi D., Manalu P. (*Center for International Forestry Research, Indonesia; d.rohadi@cgiar.org; p.manalu@cgiar.org*).

Teak (*Tectona grandis*) is a commercial wood species in Indonesia, and is sought after by thousands of wood industries for high-value products including plywood, woodwork, furniture and woodcarving. While the teak from parastatal areas in Java is decreasing, millions of smallholders are growing teak in Java over an expanding area. The growing interest of smallholders on planting teak is important to help fulfilling high demand for timber in Indonesia. Smallholder timber plantations may also play an important role in poverty alleviation efforts. Smallholder teak plantations, however, are facing major hurdles that include the low productivity and poor quality of timber due to poor silviculture practices, limited capital for farmers to maintain these plantations and poor access to profitable markets. This paper presents some lessons learnt from an action research project on smallholder teak plantations at Gunungkidul district, Yogyakarta, Indonesia. The paper recommends that decision makers and development agencies pay more attention to improving institution capacity of producer organizations, market access and the linkage between producer organizations and wood-based companies. The paper also recommends decision makers to support smallholder teak plantation development through market incentive policies.

An analysis of smallholder farmer activities on the forest fringe in Madagascar as basis for developing adaptive incentives in the context of REDD. Rqibate, A. (*Johann Heinrich von Thünen-Institut, Germany; aziza.rqibate@vti.bund.de*), Rabefahiry T., Rabemanajara Z. (*École Supérieure des Sciences Agronomiques, Madagascar; yrihat@yahoo.fr; zorabema@hotmail.com*).

In a context of poverty and of ambivalence between traditional and classic land tenure, Malagasy farmers are involved in land use change which endangers their environment and traditional way of life. The study analyzes the needs of rural households that lead to deforestation and degradation. It aims for developing adapted, viable and environmental friendly alternative land uses that respect the traditions of the population and can be financed through the carbon market. Field data were collected on three regions which differ in their characteristics. Interacting functions of the forest that respond to the need of the farmers are described and uses of the forest are quantified. "Incomes from deforestation and degradation" and "non-forest income" opportunities are calculated. Then they are compared to analyze the influence of endogenous and exogenous decision parameters and of the agent's characteristics on forest use and farm output management. The study shows that the "poorest poor" are more dependent on deforestation and degradation but they gain less benefit from it than the "rich poor". In community forest management the "poorest poor" also have less influence decision-making. Results are compiled in a comprehensive set of guidelines for stakeholders involved in the project.

Role of community based forest enterprises in poverty reduction. Thapa Magar, S.K. (*ForestAction, Nepal; eco_sushila@yahoo.com*), Vacik, H. (*University of Natural Resources and Life Sciences, Austria; harald.vacik@boku.ac.at*).

Livelihoods improvement and poverty reduction is considered as "second generation issues of Community forestry (CF)" in Nepal which emphasises on shifting from subsistence towards commercial oriented CF management. Community Based Forest

Enterprises (CBFEs), a suggested strategy, has potential for uplifting livelihoods of the forest dependent poor. This study explores the contribution of CBFEs towards livelihood improvement and poverty reduction in Nepal, analyzing types of involvement of forest dependent poor and their access to the benefits from CBFEs. Participatory methods were used to collect information. The result show that enterprises include forest dependents of the community forest user groups (CFUGs) involving them as shareholders (owners) and workers. Realizing ownership and participation in decision-making as an important aspect to control and manage enterprise, CFUG and the forest dependent people own at least half of the enterprise share. It shows that when inclusiveness and ownership is maintained, CBFEs could contribute in poverty reduction. Forest dependents' livelihoods are improved with economic benefits from employment opportunities and dividends; human and social capital enhanced with their skills and knowledge development through capacity and networking building. The study contends that CBFEs are an opportunity to transform forest dependents' livelihood and reduce poverty enhancing their livelihood options.

Posters

Teak (*Tectona grandis* L.f.) planting by smallholder farmers in South Benin: typology and policy needs for sustainable wood supply. Aoudji, K.N.A., Vodouhe, F., Adégbidi, A. (*University of Abomey-Calavi, Benin; aknaoudji@yahoo.fr; vodouhefifanou@yahoo.fr; ansadegbidi@yahoo.fr*), Lebailly, P. (*University of Liège, Belgium; lebailly.p@fsagx.ac.be*).

Teak (*Tectona grandis* L.f.) plantations were established by smallholder farmers in South Benin starting in the late 1960s. These plantations are managed by coppicing to produce poles, with rotations of 3 to 5 years. Smallholder farmers are the main service wood supplier in South Benin, where almost all natural forests have been cleared. But since the early 2000s, teak plantations are being replaced by oil palm plantations. The study was carried out to assess the place of teak in the farming system and policy needs to ensure the sustainability of wood supply from smallholder teak plantations. It included formal interviews and focus group discussions with 123 teak planters in Tori-Bossito district. Three types of farmers were found among teak planters: absentee farmers, large full-time farmers, and small full-time farmers, representing respectively 11%, 56%, and 33% of the sample. The acreage of teak plantation per household was positively correlated with farm size and averaged 2.1 ha, 1.8 ha, and 0.7 ha respectively for absentee, large full-time, and small full-time farmers. Teak plantations are being removed because smallholders are not getting good price for its products. Policy needs include credit facilities and empowerment of smallholders in the wood value chain.

Nursery practice: a means of income generation for the rural households of the Jessore sadar upazila under Jessore district of Bangladesh. Islam, M.W. (*Khulna University, Bangladesh; wasiulislam7@yahoo.com*), Paul, D.M. (*Khulna University, Bangladesh; wasiulislam7@yahoo.com*).

Nursery business is one of the profitable land uses in Bangladesh. The objective of the study is to assess the profitability of nursery practice at Jessore sadar upazila under Jessore district of Bangladesh. The results indicate that nursery practices are financially and economically profitable and socially acceptable. More than 72% of nursery entrepreneurs are practicing different nursery activities in agricultural land and the rest of about 28% are practicing nursery in the home gardens. The Benefit-Cost Ratio of this practice is 3.48 and 3.57 in 2003 and 2004 respectively while Net Present Value is Tk. 1.19 million and Tk. 1.26 million respectively and Internal Rate of Return is 14% and 14.50% respectively. These results of profitability criteria indicate clearly that nursery practice is one of the most profitable businesses and investments in the study area. The significance of raising nursery is inevitable in order to ensure sustained forest yield of Bangladesh. So, the government and Non-Government Organizations should take effective steps to make this business more popular so that it can also maximize its benefits to the local people to improve their socio-economic condition which facilitates to alleviate their poverty and reduce their pressures on forest resources.

Luwu rattan collectors' quest for fairness in Sulawesi, Indonesia. Komarudin, H. (*Center for International Forestry Research, Indonesia; h.komarudin@cgiar.org*), Ariefiensyah, R. (*University of Indonesia, Indonesia; rhino.ariefiansyah@gmail.com*), Putu Oka, N. (*Hasanuddin University, Indonesia; ngakanputuoka@ymail.com*), Tako, A. (*Lapal Sulawesi, Indonesia; a.tako@yahoo.com*).

This 27-minute documentary film "*Uwweku Katuoanku*" ('my rattan is my life' in the Luwu language) portrays rattan production and processing in Indonesia and the struggle of disadvantaged rattan collectors living in villages around the forests of Luwu Utara district, South Sulawesi to obtain fair benefits from their work. The film is based on years of CIFOR research on the impact of decentralization on forests and local people's tenure and access to forest products in Sulawesi. Using a series of focus group discussions and interviews with key informants, particularly government officials, private companies and local people, through the film, the research identified major issues debated in the chain of production and distribution of rattan, which include competitive market, rattan smuggling and poliy ban on rattan export. It shows the struggle of rattan collectors who are the backbone of rattan production to have a better access to forest resources surrounding them and to get fair benefits from rattan. The film features various local stakeholders' voices for creating a scheme that benefits local people. It calls for crucial attention paid to often neglected role and livelihoods of collector and sustainability of rattan resources.

***Parkia biglobosa* (Jacq.) G. Don harvesting as a tool for conservation and source of income for local people in Pendjari Biosphere Reserve.** Vodouhê, F., Adégbidi, A. (*Université d'Abomey-Calavi, Benin; vodouhefifanou@yahoo.fr; ansadegbidi@yahoo.fr*), Coulibaly, O. (*International Institute of Tropical Agriculture, Benin; o.coulibaly@cgiar.org*), Sinsin, B. (*Université d'Abomey-Calavi, Benin; bsinsin@gmail.com*).

This study analyzed the contribution of *Parkia biglobosa* fruit harvesting as a source of income for local communities around the Pendjari Biosphere Reserve, in Benin, and the role that plays in improving the conservation status of this species. We interviewed 124 farmers in five villages and conducted field surveys to 32 plots of 50m × 50m. Farmers were selected from three pre-established groups of wealth based on criteria that local communities thought important while assessing an individual's socioeconomic position. The results showed that *P. biglobosa* contributed importantly to the livelihoods communities adjacent to

the reserve. During its fructification period, *P. biglobosa* contributed to subsistence needs and incomes in local communities, but there was no difference in the species contribution to households' net income when comparing the three wealth groups. Poorer, intermediate as well as wealthier households were equally dependent on the species. It appears that land availability is an important factor which determines the degree of household utilization of the species. Concerning *P. biglobosa* conservation status, little evidence could be found that harvesting was damaging to the resource. Therefore, for renewable resources such as *P. biglobosa* it seems possible to reconcile conservation and poverty reduction objectives.

H-02 Urban forestry: assessing and developing ecosystems services

Organizer: Cecil Konijnendijk *University of Copenhagen, Denmark, cck@life.ku.dk*

Promoting urban forest services for intercultural communities. Faehnle, M., Schulman, H. (*University of Helsinki, Finland; maija.faehnle@environment.fi; harry.schulman@helsinki.fi*), Tyrväinen, L. (*Finnish Forest Research Institute, Finland, liisa.tyrvainen@metla.fi*).

In developing green structures for urban regions, urban forests need to be planned to provide essential ecosystem services equally for different population groups. In Helsinki Metropolitan Area, Finland, the proportion of people with a different cultural background has increased rapidly and immigrants are to comprise 75% of the predicted population growth (130 000 new residents) in the area by 2025. The planning of living environments and practices of collaborative urban forest planning are, however, still based on the needs of the Finnish majority. How should planning practices and urban forest services be developed to support interculturalism, positive relations between groups and immigrants' integration with the new environment? In the project Multicultural urban nature (HENVI 2008–2010), we are studying this in the Helsinki Metropolitan Area. Results are presented based on interviews with immigrants and city authorities, including a social network analysis addressing developing needs for collaborative practices, and a literature review on the roles of urban nature for different ethnic groups and for their integration. The use of the results in new R&D partnerships will be presented as well as the use of the Finnish research and practice network on urban green structure as a forum for collaborative learning.

A planning model for urban forest management in South Korea. Lee, G.G. (*Kangwon National University, Republic of Korea; gglee@kangwoan.ac.kr*), Kim, S.K. (*Korea Forest Research Institute, Republic of Korea; ksk5409@forest.go.kr*), Lee, J.H., Lee, H.J., Lee, M.J. (*Kangwon National University, Republic of Korea; faith@kangwon.ac.kr; lhj628@kangwon.ac.kr; minju1212@kangwon.ac.kr*).

The Korean government has recently (in 2008) introduced urban forest polices which require local governments to develop plan on urban forest management plans. Guidelines to facilitate urban forest management planning, offered to all of local governments by the Korea Forest Service, provides generic methodologies for all of local governments that do not take into account the distinctive features of local forest area. This study aims to develop a model for urban forest management planning by which local governments could use to create a management plan suitable to local forest landscapes and ecological characteristics. The planning model was developed through comprehensive comparative analyses involving relevant regulations and knowledge gained from previous studies. The model suggested by this study has been tested in two pilot studies involving urban forest areas in Chuncheon and Yeongwol. The planning model includes methodologies to conserve, restore, network, reconstruct and manage urban forests and could provide guidance for planning urban forest management to many local governments.

Quantifying ecosystems services provided by urban treed spaces: data and analysis from cities in Michigan, USA. MacFarlane, D.W. (*Michigan State University, USA; macfar24@msu.edu*).

It is widely recognized that urban treed spaces contribute greatly to human well-being, but nonetheless they are likely undervalued due to the difficulty of quantifying ecosystem services provided by them and logistical difficulties in coordinating citizens and city governance to capitalize on them. Here, data and analyses are presented from studies of cities in Michigan, USA, which quantified the potential to use dead and dying urban trees as sources of locally generated bio-based fuels and / or primary and secondary (recycled) wood products and examined the potential for urban treed spaces to provide offsets for carbon dioxide emissions; the latter contributed to the development of Michigan State University's new urban forest carbon offset protocol, recently approved by the Chicago Climate Exchange. Major logistical barriers to urban wood recycling include diverse and complex treed green space ownership, a fluctuating supply of dead and dying trees from natural disasters (e.g., hurricanes or insect and disease outbreaks), and a lack of public infrastructure to coordinate activities and respond to sudden surpluses of dead trees, particularly a lack of open space for storage. Major limitations for urban carbon offsets are limited urban land area for increasing green spaces and high offset verification costs.

Assessing the ecosystem services provided by urban forest structures in the mega-city Karachi using a transdisciplinary framework for coupled human and natural systems. Qureshi, S. (*University of Karachi, Pakistan; salmanqureshi@uok.edu.pk*).

The existing fragmented knowledge of the relationships between the mega-urban development and ecosystem services by urban forest has been insufficient for policy makers and scientific community. It had been difficult to realistically instigate long-term plans towards the inclusion of the process of ecosystem services as a meaningful component of sustainable urban development. This research is based on the presumption that socio-cultural ecosystem services by urban forests in megacities are important elements of balancing urban metabolism. These could be elaborated with the understanding and integration of urban gradient model in studies along impact gradients of moderately to heavily-disturbed urban structures across megacity. The hypothesis was tested in Karachi, Pakistan. The study approach aimed at deriving a methodology to delimit the broad horizon of studies of socio-cultural ecosystem services. The study showed that mega-urban landscapes are spatial mosaics of distinct, but interconnected, ecosystems with variable ecological characteristics, population densities, and neighbourhood structures. The outcomes of the proposed research could be used to determine, using transdisciplinary methods involving natural and social scientists, how to

mitigate the misuse of ecosystem services and how to improve the management of urban ecosystems for enhancing the socio-ecological sustainability of urban ecosystems.

Posters

Assessment of the effectiveness of Solid Rain to optimize the use of irrigation water in sustainable urban reforestation projects. Aldama, A., Chacalo, A., Grabinsky, J. (*Universidad Autónoma Metropolitana, Mexico; alao@correo.azc.uam.mx; ach@correo.azc.uam.mx; jags@correo.azc.uam.mx*).

An investigation was conducted to test Solid Rain, a super-absorbent recommended for irrigation of soils during dry seasons, on the survival and growth of oak (*Quercus rugosa* Neé) and privet (*Ligustrum lucidum* Ait). The study was based on a 2 × 2 factorial experiment with ten replicates. The experiment was installed in a protected area in the Universidad Autónoma Metropolitana. The soil selected was of a type suitable for growing plants, containing high nutrients. The treatments included differing applications of the super-absorbent and water application rates. Biomass productivity was evaluated by measuring differences in stem diameter and plant height at beginning and the end of a three month observation period. Measured soil characteristics included soil humidity and temperature. An analysis of variance (ANOVA) were run for each of the four response variables. Results did not show significant differences for the mean values between trees treated with Solid Rain and trees treated with water only.

Arboriculture with *Maytenus evonymoides* Reissek along the streets Curitiba City, Paraná, Brazil. Biondi, D., Leal, L., Vegini, J., Martini, A., Bolzon, G. (*Universidade Federal do Paraná, Brazil; dbiondi@ufpr.br; gbmunize@ufpr.br*).

There is a lack of information on the potential use of small size native species in urban arboriculture in Brazilian. *Maytenus evonymoides* Reissek (Celastraceae) is a fructiferous species for the fauna and an ornamental species for its foliage of arbustive and arboreal characteristics that reaches from 3 to 6.5 m in height. The aim of this work was to assess the arboricultural use of this species along the streets of the city of Curitiba, Paraná, Brazil through the evaluation of echophysiological aspects. In August 2008, 17 saplings with average height of 1.72 m and 0.75 cm diameter were planted on selected streets. Tree development was monitored every three months for 15 months using variables: total height (m), diameter at breast height (cm), and number of pruned buds. During the study period, the saplings grew only 0.12 m in height and 0.18 cm in diameter. About three buds were pruned in each evaluated plant. Budding was observed mainly at the base of the plants, demonstrating their arbustive characteristic. During this period, 70.6% of the saplings flowered and 23.5% fruited. Considering the urban conditions and the adaptation of the species to the planting site, extended monitoring of the species is recommended.

The role of insects in promoting public awareness of urban forest services: Sandakan Rainforest Park, Sabah, Malaysia. Chung, A.Y.C. (*Sabah Forestry Department, Malaysia; arthur.chung@sabah.gov.my*).

The Sandakan Rainforest Park (SRFP) is a 148.6 ha urban forest located in the town of Sandakan in Sabah, Malaysia, surrounded by housing estates and other forms of development. Gazetted as Amenity Forest Reserve, the Park is jointly managed by the Sabah Forestry Department and the town council. Scientists from the Forestry Department have conducted research on the flora and fauna of this forest, and showcased them to the general public, as well as to tourists. Being diverse and abundant, forest insects were among the forest resources used to promote forest recreation, nature tourism and environmental education. Research findings from surveys of butterflies, moths, beetles, ants and other insects were interpreted into layman's language in order to enhance better public understanding. Various approaches were used, namely exhibition of insect specimens, colourful posters on insect diversity, seminars, a website (www.sandakanrfp.sabah.gov.my), articles in newspapers and even video clips on YouTube. In 2008, an illustrated book on the SRFP was published for leisure reading, which included a chapter on insects.

Evaluating the use of social information in urban forest planning. Faehnle, M. (*University of Helsinki, Finland; maija.faehnle@environment.fi*), Tyrväinen, L. (*Finnish Forest Research Institute, Finland; liisa.tyrvainen@metla.fi*), Schulman H. (*University of Helsinki, Finland; harry.schulman@helsinki.fi*).

To develop attractive and healthy urban environments, residents' values and experiences need to be integrated in land use and urban forest planning. Nowadays, there are many tools with which this social information can be obtained but the input from residents, however, is not always even regarded as information. How is social information actually used in planning and decision-making processes? How can these processes be evaluated in terms of use of social information? In the research project 'Greendecision' (Academy of Finland 2006–2008), we studied these questions in two case areas in the Helsinki Metropolitan Area. By combining different methods of qualitative research, we developed a tool for evaluating the use of social information in land use and urban forest planning. By testing this tool, we evaluated the integration of social and ecological information in the planning in these case areas. Results are presented on grounds of semi-structured personal interviews and focus groups carried out with 33 planners, decision makers, residents and landowners, as well as the testing including document analyses and participatory observation. Future use of the tool is discussed with the feedback we have got and with our ongoing work to develop and apply the tool in multicultural contexts.

Changes detected in street trees over a 16-year period in Mexico City. Grabinsky, J., Chacalo, A., Aldama, A. (*Universidad Autónoma Metropolitana Azcapotzalco, Mexico; jags@correo.azc.uam.mx; lchacalo@yahoo.com.mx; alao@correo.azc.uam.mx*).

Mexico City has 16 boroughs called *delegaciones*. In 1993 a representative stratified random sampling of trees along the streets of the entire city was carried out and published. Following the same methods and evaluation criteria, the originally sampled trees in several *Delegaciones* were reexamined. The sub-sample for the *Delegaciòn Miguel Hidalgo* contained 84 planting sites and trees in 14 blocks. The characteristics of these planting sites and their trees were recorded again in 2009. The main characteristics studied were species, height, diameter, the general condition of trees, and a planting site evaluation. We evaluated trees or planting sites that disappeared; species, height and diameter frequencies; and compared the numbers of standing dead trees present between 1993 and 2009. Several statistical tests of association between variables are developed and a consideration on the

representativeness of the results is discussed. The changes we observed are symptomatic of the dynamics of the urban forest care in this borough.

Carbon sequestrations of street trees in Seoul, the Republic of Korea. Kim, K.N. (*Korea Forest Research Institute, Republic of Korea; uforest81@uos.ac.kr*), Ryang, S.Z. (*University of Seoul, Republic of Korea; tovgoptwo@yahoo.co.kr*), Son, Y.M., Lee, K.H. (*Korea Forest Research Institute, Republic of Korea; treelove@forest.go.kr; kyeonghlee@forest.go.kr*), Woo, S.Y. (*University of Seoul, Republic of Korea; wsy@uos.ac.kr*).

The objective of this study was to estimate carbon sequestration by street trees using nondestructive measurements and official statistical information obtained from the Seoul Metropolitan Government. There are five major species of street trees in Seoul, namely *Ginkgo biloba, Platanus occidentalis, Zelkova serrata, Prunus yedoensis* and *Metasequoia glyptostroboides*. Diameters of stem segments from approximately 200 trees for each species were measured by using a laser dendrometer. The average carbon storage for an individual 30-year-old trees of *G. biloba*, *Z. serrata* and *M. glyptostroboides* was 117 kg C, 118 kg C and 315 kg C, respectively. Also, the annually average CO_2 removals of 30 year old tree for the species were estimated to be 31 kg CO_2/yr, 31 kg CO_2/yr and 99 kg CO_2/yr, respectively. In 2006, carbon storages of *G. biloba* (118,358 trees), *P. occidentalis* (91,885 trees) and *Z. serrata* (24,760 trees) estimated to be approximately 7,850 t C, 10,214 t C and 1,508 t C, respectively. In total, the carbon storage in Seoul (256,075 trees; 91.4% of total trees) was estimated to 20.6 thousand t C as of 2006. Also the potential annual CO_2 removals by the street trees was calculated at 9,844 tCO_2/yr in 2010.

Chandigarh – an eco-friendly model urban forest. Kohli, K.K. (*Government College Sangrur, India; kohlikumkum@yahoo.com*), Kohli, R.K., Singh, H.P. (*Panjab University, India; rkkohli45@yahoo.com; hpsingh_1@yahoo.com*).

Chandigarh, a beautiful city 78 km^2 in area created in 1950s at the foothills of the Shivalik range of the Indian Himalayas, was. Divided into 56 sectors and two industrial areas, it is the second most populated state/union territory and seventh most populated city in India. Motorized vehicular density, literacy rate and per capita income are among the highest in the country, but pollution loads are at sub-threshold levels. Credit for this goes to good urban planning, including managed greenery and avenue trees, a vigilant media, sensitive government and environment-loving residents. All roads are identified with trees; SE-NW roads are planted with broadleaved deciduous trees with dense canopies providing greater shade during summers and more light during winters for fast moving traffic, while NE-SW roads support trees with lighter foliage. Market and residential roads are planted short deciduous ornamental trees for slow traffic. Evergreen ornamental *Bougainvillea* on road-dividers serve as a bio-fence and to absorb the pollutants emitted from vehicles. Like any urban area, the city has its own constraints of increasing population; autumn defoliation, fast pace of development and changing lifestyles. However the urban forest character has a very strong buffering potential that helps its citizens and the city's administration to maintain the city's beauty.

A social experiment for the reconstruction of resilience in *Satoyama* social-ecological systems in Japan. Kuroda, K., Osumi, K., Oku, H. (*Forestry and Forest Products Research Institute, Japan; keiko@affrc.go.jp; osumi@ffpri.affrc.go.jp; hoku@ffpri.affrc.go.jp*).

Working forests surrounding rural communities are called *Satoyama*, in which Japanese people have developed a traditional socio-ecological system to utilize forest resources to sustain their farming and culture. Recently Satoyama forests have been declining due to epidemic diseases affecting *Pinus* and *Quercus* trees caused by a nematode (*Bursaphelenchus xylophilus*) and a fungus (*Raffaelea quercivora*). The factors promoting this decline were investigated and techniques to recover Satoyama health was discussed. The oak disease is occurring either in old forests that had been earlier used for fuelwood and charcoal production but have been unmanaged since the energy revolution began in the1950s, or those that have grown after occurrence of pine wilt. Today, abandoned aging coppices are widely distributed. Because the beetle vector (*Platypus quercivorus*) of the pathogen thrives in large and old tree stems, infection areas enlarge every year. To recover healthy Satoyama, rejuvenation of trees by the resumption of coppice management should be effective. NPOs and local governments are actively trying to restore management practices in once-abandoned Satoyama. However, cut logs are mostly unused and left in the stands. Those activities, without knowledge of their affects on forest health, sometimes promote decline.

Development of a Visual Ratio Indicator of Street Forest for urban forest management in South Korea. Lee, G.G., Lee, H.J., Jung, H.Y., Lee, J.S., Heo, A.L. (*Kangwon National University, Republic of Korea; gglee@kangwoan.ac.kr; lhj628@kangwon.ac.kr; sea33sky@naver.com; ljiseon@hanmaill.net; happy-days4@hanmail.net*).

The Korean government has, since 2008, obligated all local governments to develop a plan for urban forest management in local area. The Korea Forest Service has developed a guideline and offered it to all local governments, who should establish planning indicators and design quantitative management targets using these indicators for making plans such as creating urban forest, promoting local community, and implementation strategies. This study, aims to develop an indicator supporting a plan for a street forests which is one of key planning factors determining the indigenous identity in the urban forest area. As a result, the "Visual Ratio Indicator of Street Forest" was devised, defined as a relative ratio of the forest that is visible at a given point on a street. The planning methodology using the indicator provides a way to calculate quantitative planning goal in order for local government to make spatial decisions to expand and manage the amount of urban street forest. By applying the indicator in two cities the actual usefulness of the indicator could be verified as a key tool for attaining the goal of urban street forest management.

Carbon sequestration by school forests and its potential offsets for carbon emissions by energy uses of schools in Seoul, Korea. Woo, S.Y., Ryang, S.Z. (*University of Seoul, Republic of Korea; twsy@uos.ac.kr; soozin1211@yahoo.com*), Kim, K.N., Son, Y.M., Lee, K.H. (*Korea Forest Research Institute, Republic of Korea; uforest81@uos.ac.kr; treelove@forest.go.kr; kyeonghlee@forest.go.kr*), Lee, K.A., Kwon, M.Y., Song, J.E., Kim, M.J., Park, S.J. (*University of Seoul, Republic of Korea; galamment@ymail.com; ms874@naver.com; mungya@hanmail.net; g-b-r@hanmail.net; bliss1820@hanmail.net*).

The objectives of this study were: 1) to estimate carbon sequestration of school forests and 2) to evaluate its potential offsets for carbon emissions by energy use in elementary, middle and high schools in Seoul. Sixteen schools were selected as sample sites

and diameters at breast height (or root collar) of the all trees were measured. The carbon storage and annual CO_2 removals of trees were calculated by two methods from the 2006 IPCC Guidelines and volumetric equations for urban trees developed in the U.S. Calculation for expansion of the carbon sequestration by whole school forests in Seoul and for estimation of CO_2 offsets for energy use by schools applied data from the Education Statistical Year Book of Korea (2009). The present carbon storage of all school forests in Seoul (i.e., 1,268 schools) was estimated to be 13,011 t C (10,261 kg C/school). Also, the annually potential CO_2 removal for 2009–2010 was estimated to be 6,045 t CO_2/yr (4,767 kg CO_2/yr/school). This amount equaled approximately 2.2% CO_2 offset against total emissions (278,901 t CO_2/yr) through annual energy usage in Seoul's schools in 2008: 3.3% for electricity, 7.8% for gas, 45.6% for collective energy and 78.2% for waterworks, respectively.

H-03 Global comparative analysis of local incomes from the forests

Organizers: Arild Angelsen, *Norwegian University of Life Sciences, Norway; arild.angelsen@umb.no*; Nick Hogarth, Ronnie Babigumira, *CIFOR, Indonesia, n.hogarth@cgiar.org*, *r.babigumira@cgiar.org.*

Smallholders in southwest Amazonia: development policies, socioeconomic conditions and forest use. Almeyda Zambrano, A.M., Broadbent, E.N. (*Stanford University, USA; aalmeyda@stanford.edu; eben@stanford.edu*).

Smallholders have long been blamed for the conversion of large areas of forest. However, there is little understanding of how previous and current development policies and socioeconomic conditions are shaping smallholders' land use decisions. To address this question, one might compare populations in the same biophysical landscape that have different socioeconomic characteristics. The tri-national frontier of southwest Amazonia, Peru–Brazil–Bolivia, provides one such comparative setting. To this end, annual and quarterly questionnaires were applied to 250 households in 32 villages between June 2006 and October 2007. Preliminary results indicate a complex picture, as development policies and household socioeconomic conditions interact. Differences in land tenure systems are very important, as households with access to more forest tend to have more forest income. Road infrastructure has the opposite effect, as households with access to better roads tend to clear more forest. Place of birth and time of residency in the area is also important: households native to the Amazon tend to place more value on forests, and use more forest products. Understanding how households and development policies interact and affect forests is of the highest importance for balancing conservation and development, especially as this previously remote region undergoes major infrastructure development.

Quantifying the role of forests in poverty alleviation. Angelsen, A. (*UMB, Norway; arild.angelsen@umb.no*), Babigumira R. (*Center for International Forestry Research, Indonesia; r.babigumira@cgiar.org*).

Forests and other natural resources are crucial to the livelihoods of millions of poor people worldwide. But just how important are forests in alleviating poverty? What are their roles as safety nets, or as a pathway out of poverty? How do different forest management regimes and policies affect the benefits poor people acquire from forests? Surprisingly, there is a lack of data to answer these questions, data that are essential for designing effective policies to alleviate poverty. The Center for International Forestry Research's (CIFOR) Poverty Environment Network (PEN) aims to fill this gap. PEN is a tropics-wide set of uniform socio-economic and environmental data collected at multiple levels by 37 PEN partners, generating a global database based on 9000 households from 25 countries. The surveys were conducted quarterly to shorten recall periods and increase accuracy. They carefully record all income including forest and environmental sources. Preliminary results show enormous variation in forest income shares and a clear poverty profile of forest income, whereby forest dependency is significantly higher for the poorest. Preliminary analysis does not suggest a significant role of forests as safety nets; however, forests seem to play a significant role in seasonal gap-filling.

Forest income contributions to livelihoods in western Democratic Republic of Congo. Bakkegaard, R.K., Smith-Hall, C., Nielsen, M.R. (*University of Copenhagen, Denmark; rkim@life.ku.dk; cso@life.ku.dk; mrni@life.ku.dk*).

We examine the forest income of rural households in western Democratic Republic of Congo (DRC). Some 193 households were randomly selected from five villages around Luki Biosphere Reserve, Bas-Congo Province, DRC. Quarterly data on household consumption and income were collected through quantitative surveys between September 2007 and September 2008. Proximity to DRC's capital means that natural resources have long been heavily exploited, yet forest income still contributed nearly 28% of average household income, and was the second most important source of income after agriculture. Forest resources, such as firewood, bushmeat, caterpillars and wild fruits, also performed a gap-filling function to provide food security. Poorer groups were more dependent on forest resources, and forest dependence increased with increased distance to market. Households above the poverty line derived greater absolute forest income, especially in cash, and exploited a greater diversity of forest products. Poorer groups exploited mainly firewood, bushmeat and eru, among others. These findings give us a better understanding of the complexities of forest–poverty relationships, in western DRC.

Socioeconomic analysis of the contribution of two palm species to household incomes in the Brazilian Amazon estuary. Cotta, J. (*ICRAF, USA; j.cotta@cgiar.org*).

Non-timber forest products, specifically palms, play a major role in livelihood strategies in the Amazon estuary of Pará State, Brazil. Household questionnaires, applied four times over a 12-month period in 2008, assessed household income composition, including the role of açaí (*Euterpe oleracea*) and miriti (*Mauritia flexuosa*) palms in rural livelihoods in four communities in the estuary. Though economic activities in the floodplain have historically been diverse, densities of açaí palms in landholdings have increased substantially in recent years, and today açaí fruit constitutes over one third of net annual household income and over 50% of net on-farm income during half the year. In contrast, miriti palms, which are mainly important for local subsistence and ecosystem health, are declining in abundance, according to information provided during participatory mapping exercises. Nevertheless, for fourteen households dependent on miriti-derived income, the palm represented nearly 40% of net on-farm income. Furthermore, miriti represents a significant income gap-filler, constituting over 70% of net on-farm income during times

of açaí scarcity. Markets for miriti fruit and handicrafts have grown in recent years, however, market forces, coupled with government incentives for açaí intensification, have contributed to an economically and environmentally vulnerable production system based on one species.

Forests, poverty and rural economic development in Guangxi Province, China. Hogarth, N. (*Center for International Forestry Research, Australia; n.hogarth@cgiar.org*).

Despite decades of spectacular economic growth and poverty alleviation, China still faces momentous development challenges and persistent poverty. Poverty is concentrated in rural, mountainous areas in western China, where there is a strong spatial correlation between forests and poverty. Tianlin County in north-western Guangxi is one such area. In 2007, quarterly socioeconomic surveys were conducted of 240 households across six villages to determine the economic contribution of forest and environmental income to livelihoods. Although primarily an agricultural economy, forests products contributed about 23% of total household income and were the highest on-farm source of cash (22% of total cash). Cultivated bamboo shoots, tung-oil and tea-oil seeds were the most valuable products, as a result of policies that favour such tree crops but discourage utilisation of natural forest or cultivated timber. Households in the lowest income bracket were the most dependent on forest-based income in relative terms, but had the lowest forest-based income in absolute terms. Although household income from forest products was significant, poverty remains. Forest income share could be increased with improved management practices that enhance efficiency and productivity, cooperative development of forest-based enterprises for improved market access, and policies that encourage smallholder engagement in the timber sector.

Forest incomes and poverty alleviation in a participatory forest management arrangement in the Bale Highlands, southern Ethiopia. Tesfaye, Y., Roos, A. (*Swedish University of Agricultural Sciences, Sweden; Yemiru.tesfaye@sprod.slu.se; anders.roos@sprod.slu.se*), Campbell, B.M. (*Centre for International Forestry Research, Indonesia; b.campbell@cgiar.org*), Bohlin, F. (*Swedish University of Agricultural Sciences, Sweden; folke.bohlin@sprod.slu.se*).

This study investigates the contribution of forest resources to the livelihoods of rural households under a participatory management arrangement in southern Ethiopia. Data were collected through key informant interviews, group discussion and Poverty Environment Network (PEN) quarterly household surveys of 350 households in 22 user groups. Forest products are the single most important sources of income, contributing 34% of household per-capita income (53% cash income). About 41% of households fully or partly rely on forest income as a coping strategy in times of income crisis. Forest income also helps 20% of the population to remain above the poverty line. Forest income reduces inequality (Gini coefficient) by 15.5% compared to non-forest incomes. In general, the findings confirm the importance of forest income in poverty alleviation and as safety nets in times of income crisis.

Importance of forest income to the livelihoods of housholds adjoining protected areas in Cameroon. Tieguhong J.C., Ndoye O. (*FAO, Cameroon, chupezi@yahoo.co.uk; ousseynou_ndoye@fao.org*), Nkamgnia E.M. (*TTRECED, Cameroon; n_kamgnia@yahoo.fr*), Zwolinski J. (*University of KwaZulu-Natal, South Africa; zwolinskij@ukzn.ac.za*).

In Cameroon, economic data showing the extent to which villagers living adjacent to protected areas depend on forest resources are rare. This study, conducted under the Poverty Environment Network (PEN), aims to fill this gap, with particular focus on villages surrounding the Lobeke National Park (LNP). Five villages located within 50 km of the park were selected randomly, as were a total of 111 households. Eight income sources contributed to total household incomes; forest income alone providing US$ 26,558 or 44.4% of the total. The most important forest products were wild fruits, bushmeat, fuelwood, wild vegetables and medicinal plants, representing over 84% of the total cash and subsistence value of forest goods. Subsistence forest goods represented 22.5% of total household income and 50.7% of the total value of forest products. Gini coefficients showed an increase in inequality in household incomes in villages when forest income was excluded (Gini absolute income = 0.37; Gini absolute non-forest income = 0.53). Calculated Kuznets Ratios showed that the poorest 25% of households were more dependent on forest resources than the richest 25%. The documented importance of forest products to the livelihoods of forest peoples leads us to recommend that subsistence values should be properly accounted for in valuing the role of forest products in the livelihoods of forest-dependent households.

Posters

Do forests contribute to rural livelihoods in Ghana? Darko Obiri, B., Marfo, E., Nutakor, E., Cobbinah, J. R. (*Forestry Research Institute, Ghana of Ghana; bdobiri@csir-forig.org.gh; emarfo@csir-forig.org.gh; enutakor@csir-forig.org.gh; jcobbinah@csir-forig.org.gh*), Treue, T. (*University of Copenhagen, Denmark; ttr@life.ku.dk*).

The social importance of forests is officially appreciated in Ghana, however, there is little research on how forests contribute to rural livelihoods, the extent of that contribution or useful policies enhance the role of forests in rural development and poverty reduction. This paper estimates the economic importance of forests to rural households based on quarterly PEN questionnaire surveys of 600 rural households in 30 villages in the wet and transitional forest zones of Ghana. Results indicate that 13% of household income is derived from forests. Harvests from forests peak in the first quarter (December–February) when there is less agricultural activity, confirming a gap-filling function: there is a higher reliance on fuelwood, poles and game for subsistence at that time. Dependency is more pronounced in the transition where forests are degraded, with less restriction on access and limited opportunities for alternative incomes. Developing smallholder systems for forest products that boost income can potentially provide pathways out of poverty and ensure environmental sustainability.

Rural income and forest dependence –some evidence from the western highlands of Guatemala. Prado Córdova, J. P. (*Universidad de San Carlos de Guatemala; pprado@usac.edu.gt*), Smith-Hall, C. (*University of Copenhagen; CSO@life.ku.dk*), Wunder, S. (*Center for International Forestry Research; s.wunder@cgiar.org*).

This study was part of a multidisciplinary research effort conducted in the western highlands of Guatemala, to explore the linkages between the conservation status of Guatemalan fir (*Abies guatemalensis* Rehder), and its potential to generate rural

income. This poster presents the results of an in-depth quarterly Poverty Environment Network (PEN) survey in 12 randomly selected villages, with a total of 190 households, between August 2005 and December 2006. The main sources of rural income were agriculture and wages. Virtually no respondents mentioned *A.guatemalensis*, presumably because of the legal ban on its extraction; however, forest income accounted for nearly 30% of total income. Firewood and leaf litter were important for subsistence income, mainly for the bottom quintiles (i.e., the poorest). The households are regular subsistence users of forest products and their agricultural systems rely on the surrounding forest ecosystem, i.e., organic fertiliser extracted from the forest plays a major role at the agricultural plot level. This dependence makes a case for adjusting forest conservation to local livelihood strategies. Socioeconomic strata were also identified and forest income shares calculated across quintiles.

Sustainable forest management for poverty reduction through agroforestry options in the uplands of Eastern Bangladesh. Rahman, S.A. (*University of Rajshahi, Bangladesh; sumonsociology@yahoo.com*).

In eastern Bangladesh, drastic reduction in the fallow period in slash-and-burn cultivation (resulting from high population growth) is contributing to deforestation. Agroforestry is one of the few options available to lift people out of this poverty trap, and protect the existing forest by planting trees on farms. Research was conducted in eastern Bangladesh using participatory diagnostics and a structured quarterly Poverty Environment Network (PEN) survey of 140 households in Rasulpur and Dosnong villages. Agroforestry has the capacity to protect existing forest by integrating trees with agriculture. Agroforestry systems give better cash flow than shifting cultivation, but adoption rates remain low, even though an agroforestry project was carried out in the past. Common reasoning had suggested that adoption is hampered by capacity constraints, i.e., lack of capital, knowledge and land, at the farmer level. We conclude that action for agroforestry should focus first on getting supportive institutions (rules and organisations) in place before focusing on trees and field implementation projects.

H-04 Linking forest based enterprises, collective action, and livelihoods in the African dry forests

Organizer: Davison Gumbo, *CIFOR, Zambia, d.gumbo@cgiar.org*.

Patterns of subsistence harvesting of woodland products at the household level: a multi-agent approach. De Wulf, R., Joos, I. (*FORSIT, University of Ghent, Belgium; robert.dewulf@ugent.be; isabelle.joos@ugent.be*).

This paper introduces the development and implementation of an agent-based model that integrates ecological and social aspects related to change in woodland use and woodland cover in rural villages in southern Africa. The model is developed with the objective of exploring woodland use behaviour and corresponding human impacts on the relative woodland cover and the spatial distribution of woodlands within the landscape. The model does not focus on a particular study site but aims to create a generic tool for the miombo ecoregion in Southern Africa, which is dominated by miombo *sensu stricto* and related dry woodlands. The model was parameterized based on an extensive review of the miombo woodland literature. With user-defined inputs, a virtual village representing a typical subsistence-based community is created. The model simulates fuelwood and poles collection behaviour of individual households based on various key factors such as short-term needs of households, the enforcement of traditional rules and formal laws and the cost of collection, which is in turn related to labour availability, harvesting technologies and resource scarcity. Preliminary results are prestented to illustrate the application of this model and its ability to explore management and rural forest policy scenarios.

The contribution of beekeeping producer organisations to poverty alleviation and sustainable forest management in Cameroon and Zambia. Ingram, V. (*Center for International Forestry Research, Cameroon; v.ingram@cgiar.org*), Paumgarten, F. (*Center for International Forestry Research, Zambia; f.paumgarten@cgiar.org*).

There is a long tradition of forest-based beekeeping in Africa for both subsistence use and trade. In recent decades beekeeping has been identified as a pro-poor, environmentally sustainable, forest-based income generating activity and has therefore been actively promoted in many rural areas across the continent, including parts of Cameroon and Zambia. In both countries a common feature of this support has been the promotion of beekeeping producer organizations with examples dating back two decades. Despite the potential for these organizations to contribute to poverty alleviation and sustainable forest management, many have failed to meet expectations and in both countries large organizations that formerly dominated the production scene have since collapsed. With growing international markets, collapsing bee populations, pressure to meet the Millennium Development Goals and reduce forest degradation, there is renewed interest in the beekeeping sectors of Cameroon and Zambia. This study considered beekeeping producer organizations and the challenges they face in achieving sustainability, and in participating equitably and effectively throughout all stages of the global value chain. A combination of methods, including value chain analysis, focus group discussions and interviews was used. Findings indicate the need for a shift from past production orientated interventions to a more holistic approach.

The contribution of charcoal to rural livelihoods in the Miombo ecoregion. Kwenye, J., Syampungani, S. (*Copperbelt University, Zambia; Jane.kwenye@cbu.ac.zm; syampungani@cbu.ac.zm*), Geldenhuys, C.J. (*Stellenbosch University, South Africa; cgelden@mweb.co.za*).

Charcoal production and trade are important parts of the economy of the Miombo ecoregion Countries. Charcoal is the primary source of energy for the urban majority, and this makes it a lucrative business, and a source of employment for the many Miombo dwellers. It is estimated that 60% of the rural communities depends on the charcoal industry as a source of employment. Charcoal production is an important source of employment because of the high demand for charcoal across the region, which ranges from 76% in Zambia to about 85% in Mozambique. Examples of how charcoal production and trade contribute to the rural livelihoods are presented. Furthermore, an analysis of how the production and marketing of charcoal are structured and operated is also presented. The paper illustrates how some improvements on the distribution and marketing of charcoal can enhance the

economic status and therefore the livelihoods of the rural communities. Furthermore, the paper reviews technological constraints associated with charcoal production. It further suggests some improvements on the current charcoal production technologies to enhance their production efficiency.

Co-management of natural forests and forest income in the Adaba-Dodola area, Ethiopia. Tesfaye, Y., Roos, A. (*Swedish University of Agricultural Sciences, Sweden; Yemiru.tesfaye@sprod.slu.se; anders.roos@sprod.slu.se*), Campbell, B.M. (*Centre for International Forestry Research, Indonesia; b.campbell@cgiar.org*), Bohlin, F. (*Swedish University of Agricultural Sciences, Sweden; folke.bohlin@sprod.slu.se*).

In Ethiopia poverty reduction and environmental management are closely linked since poor people generally are highly dependent on natural resources for their livelihoods. The Adaba-Dodola forest in the Ethiopian highlands is since 1999 subject to a participatory forest management project where the implied population is organized in Forest Dwellers Association. This study describes the main livelihood strategies and the role of forests for the subsistence in the Adaba-Dodola region in the context of a co-management regime. The study examines the impact of collective action on livelihood strategies and on forest utilization. Data were collected through key informant interviews, group discussion, and household surveys from a total of 350 households. Income data were collected in four separate seasons at intervals of three months. Performance of collective action efforts are compared and discussed. The result shows five distinct livelihood strategies with different outcomes and levels of diversification. Both the poorest and the better-off households pursue diversified strategies. However, business-based and crop-based strategies have better outcomes in terms of income level and food security. The research provides information on the economic significance of forests, and how they can alleviate poverty among the local rural population.

H-05 Can forest tenure reforms help achieve sustainable forest management and poverty alleviation?

Organizers: Jinlong Liu, *Renmin University of China, China; liujinlong@ruc.edu.cn*; Eva Müller, *FAO-Forestry, Eva.Muller@fao.org, Italy*; Jacek P. Siry, *University of Georgia, USA, jsiry@warnell.uga.edu*.

Improved access to forest resources to support poverty alleviation and sustainable forest management: experiences in informal tenure reform from IUCN's livelihoods and landscapes strategy. Fisher, R.J. (*University of Sydney, Australia; james.gordon@iucn.org*), De Silva, J.A. (*IUCN Thailand Programme, Thailand; janaka@iucnt.org*), Shepherd, G. (*IUCN Livelihoods and Landscapes Strategy, UK; gillshepherd@compuserve.com*), Ingles, A. (*IUCN Thailand Programme, Thailand; andrew.ingles@iucn.org*), Barrow, E.G.C. (*IUCN, Kenya; Edmund.Barrow@iucn.org*).

It is commonly accepted that forest tenure reform can contribute to sustainable forest management and poverty alleviation, although there are few experiences with formal forest tenure reform that have demonstrated this to date. This paper examines case studies from the Forest Conservation Programme of IUCN, particularly the Livelihoods and Landscapes Strategy. The paper argues that, in advance of full-scale tenure reform, more modest regulatory changes and local 'informal' arrangements can achieve significant results and can act as useful "policy experiments" to support more formal change. Cases are presented from, Uganda where locally negotiated controls on grazing have facilitated agroforestry for soil conservation around the Mt Elgon National Park; Ghana where a simple tree registration system has helped ensured farmers' rights over planted trees, and northern Thailand where established but informal tenure ensures local confidence in continued use of land that can be increased through negotiated, multistakeholder land use planning processes. Supporting examples from Tanzania and Kenya are also noted. The paper will also discuss the risk that interventions can cause inequitable outcomes and suggests ways to avoid these.

A lesson for profit sharing forest management between government and local people based on Japanese experiences. Fujiwara, T. (*Kyushu University, Japan; takaf217@gmail.com*), Nguyen, V.Q. (*Centre for Sustainable Rural Development, Vietnam; nvquang75@yahoo.com*), Sato, N. (*Kyushu University, Japan; sato@agr.kyushu-u.ac.jp*).

Achieving a good balance between forest management and local people's livelihood maintenance has been increasingly important for not only economic and social aspects but also climate change mitigation. Tenure of national forests has been transferred from government to local people under decentralization policy which has been progressed worldwide. In the past, Japan faced a challenge to achieve simultaneously poverty alleviation and creation of forest land. For such occasions, a profit sharing management system between government and local people has been utilized in some Japanese national forest areas. The Japanese experience seems to contribute greatly to the discussions of ways to achieve both goals. In 2007 and 2008, we conducted historical literature review and interviews in Kitago town in Miyazaki prefecture, Japan, for this issue. The findings showed that the system had considerably contributed to the living of the contracted people and brought about improvement of forest quality until the 1980s. To stabilize participation of local people, it was necessary to revise of share rate (national government 30%, local government 7%, and local people 63%), and financial support by local government. But recently majority of the people have planned to stop their contracts due to low timber price and aging population.

Status of good governance in community forestry in Nepal. Lamichhane, D. (*Department of Forest Research and Survey, Nepal; dlamichhane@gmail.com*).

This study was carried out in five community forest user groups (CFUGs) of Gorkha district of Nepal with an overall objective to assess the status of good governance in community forestry (CF). The CFUGs were selected using stratified random sampling method. Altogether eight criteria and 56 indicators were used to assess the governance in the study area. Scoring of indicators was done in the Likert scale of 1–5 based on the priority of the respondents. The Chi-square tests show that the scores of five CFUGs were statistically insignificant at 5% level of significance. The criterion 'consensus-oriented' scored the highest (90.72%), whereas 'accountability' the lowest (65.34%) among the eight criteria. The overall status of good governance in the study area

was 76.38%. Making CFUG and its committee more accountable and responsive to all users including poor, women and disadvantaged groups was one of the major challenges. The poor users were found to have less interest in CF activities because of inequitable distribution system of forest products. The practice of auditing and reporting of funds, maintenance of minute books and other office records, and increased participation of women in forest management were some opportunities for good governance.

Implications and challenges of decentralized China's collective forest management. Liu, J. (*Renmin University of China, China; liujinlong@ruc.edu.cn*).

Until the early 1980s, China experienced a period characterized by nationalization and collectivization. Early 1980s' armed a new era that a new phase of de-collectivization and de-centralization of forest use and management. This marked a pattern of reinstituting some degree of private ownership of forest rights, and concomitantly collective rights paid less and less a function in rural affairs including forest management. While the central aim of decollectivisation and privatization is straightforward, to increase forest coverage, upgrade farmer's enthusiasm and endeavours in forest management, and improve farmers' livelihood. However, its implementation is in complex, great variation among regions, forward in some stage, and backwards in another stage, usually blocked by institutional barriers. Great resistance has been existed in forestry sector to against the tide of de-collectivization and privatization process. Somewhat paradoxically, the contradiction and conflict between collectivization or de-collectivization, centralization and de-centralization prevailed in the last 2 decades, this process was full of miserable stories of forest destruction. In the past 20 years, about 5% of the state forests have been devolved to the other types of management, including collective and private management. And about 20% of collective forests have been devolved to be under the private management.

The institutional and economic factors shaping forest tenure reform in Bolivia. Pacheco, P. (*Center for International Forestry Research, Indonesia; p.pacheco@cgiar.org*).

It is often assumed that granting formal rights to communities and smallholders should lead to secure their access to forestlands and thus enhance the contribution of forests resources to their livelihoods. However, this is not as simple in practice. This paper discusses the institutional and economic factors that influence on the outcomes of forest tenure reforms by examining the case of Bolivia, a country in which significant forest reforms have taken place since the mid-1990s, and where land reform is a policy priority of the current administration. Land reform takes place through recognizing the rights of indigenous people and agro-extractive communities and by allocating new tenure rights to smallholders. Three are the factors that influence on the outcomes of land reforms which are discussed in this paper. The first is linked to the governance mechanisms that affect decision-making regarding forest resources management, the second is related to the production capacities and the incentive structures, and the third is linked to the conditions under which tend to operate the markets. This article also suggests policy options to redirect the forest tenure reform in Bolivia, which apply to other countries in Latin America.

Beyond tenure reform: state regulations as obstacles in community forestry. Pulhin, J.M. (*University of the Philippines, the Philippines; jpulhin@yahoo.com*), Larson A. (*Center for International Forestry Research, Guatemala; alarson@alfanumeric.com.ni*).

A recent global study by the Center for International Forestry Research and Rights and Resources Initiatives (CIFOR-RRI) in selected countries in Asia, Africa and Latin America indicates that strong formal forest tenure has the potential to improve livelihoods, income, forest condition, and equity in community forestry areas. Despite such potential, however, forest tenure reform remains tenuous and its impacts still limited overall. One of the reasons for this is that, even in cases where substantial new, secure rights have been granted, government regulations, and associated high transaction costs, present significant obstacles to community access to forest products and related markets. Drawing from case study findings, this paper examines the different types of State forest regulations that are relevant to forest tenure reform, and how these regulations and their associated transaction costs serve as barriers to markets and the flow of benefits to local communities. It finds that regulations promote the persistence of government control over management decisions and use rights in community forests. The paper draws on different case studies to distil lessons regarding alternatives and identify strategic actions communities and other stakeholders can adopt to achieve the potential of forest tenure reforms.

Empowering the communities: a study of the Forest Right Act 2006 and its implications for livelihoods of indigenous people in Andhra Pradesh, India. Reddy, M.G. (*Centre for Economic and Social Studies, India*), Kumar K.A. (*Centre for Economic and Social Studies, India; mgopinathreddy@gmail.com; kursengeanil@yahoo.co.in*).

The passage of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act of 2006 by the Indian Parliament is historic legislation aimed to empower indigenous communities. For the first time in the history of Indian forests the Indian State has formally admitted that rights have been denied to forest dwelling people, and this new forest law attempts not only to correct that 'historic injustice' but also give forest communities a leading role in forest management. Based on primary research conducted in five predominantly forest rights-deprived districts in the South Indian State of Andhra Pradesh, using survey and participatory research methods, the study assess this reform process and its dynamics as well as likely impact on the livelihoods of the indigenous communities. The main results of the study indicate that the Andhra Pradesh Government is not adequately implementing the Act, that the state Forest Department continue to seek control of the forest estate and minimize local peoples' rights to forests, that the limited implementation of the new law has focused largely on conferment of individual rights rather than collective rights, and that the implementation process of the law at ground level lacks transparency.

Global forest ownership: implications for forest production, management and protection. Siry, J. (*University of Georgia, USA; jsiry@warnell.uga.edu*), Cubbage, F. (*North Carolina State University, USA; fred_cubbage@ncsu.edu*), Newmand, D. (*SUNY-ESF, USA; dnewman@esf.edu*), Izlar, B. (*University of Georgia, USA; bizlar@warnell.uga.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. 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, 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.

An empirical study of farmers' responses to forest production and the institutional reform of collectively owned forests in China. Yi, X., Ya-li, W. (*Beijing Forestry University, China; xybjfu@126.com; wenyali2003@163.com*).

The ongoing property rights reform of collectively owned forests in China was promoted to inspire farmers' willingness to participate in forest production and to contribute towards achievement of farmers' usufruct of forest lands and ownership of stumpages through a specific program known as the *Endowment of Property Right to Farmers* in China. Increased knowledge of farmers' participation in forest production is essential to understanding the performance of the reforms and their impact on sustainable forest management. This paper investigates farmers' forest production behavior after acquiring forest property rights and the factors affecting their behavior using factor analysis and linear regression model. Data used in the empirical analysis comes from 300 farmers in the collective forest zone in southern China. It found that farmers can be categorized into two groups, those who participate in forest production, and those who do not. Factors such as cognitive degree on the forestry institution, non-forestry production activities, and householders' character and so on, have significant influences on farmers' behaviors. Policy implications of these results are discussed.

China's forest tenure reform and institutional transformation: what has been done and what remains to be done? Yin, R. (*Michigan State University, USA; yinr@msu.edu*).

China has undertaken a nationwide initiative of tenure reform and institutional transformation in its rural forest sector to promote forest productivity and ecosystem sustainability. However, it remains unclear to the international science and policy communities what the main problems of the past tenure and institutional structure had been, which specific measures have been implemented in recent years, and how successful these measures are. These questions are addressed by documenting the policy changes, reviewing the academic literature, and synthesizing the empirical evidence. The greatest attention has been devoted to the tenure reform by means of contracting, leasing, or outright selling of existing forestland, defining land-use and tree-owning rights and their transferability, and delineating property boundaries. Meanwhile, many other related issues have been articulated and integrated into the reforming process. For instance, the government has made efforts to: (1) reduce and even eliminate certain taxes and fees, (2) relax harvesting restrictions, (3) reorganize the forest administration and budgeting, and (4) restructure the financial system relevant to forestry. However, the author argues that much more needs to be done along these and other directions. To attract private interest and engagement in forestry, China must adopt a broader framework and more effective approaches.

Collective forest tenure reform affects peasants' management in China. Zhang, H. (*Nangjing Forestry University, China; njhxzh@jlonline.com*).

Collective forest tenure reforms that assign peasants the initial right of operation on timberland in China influences the way they manage woodland, and policies meeting peasants' demands is one of key elements in sustainable forest management. Following a field research methodology called Rights, Activities and Benefit Analysis for Community Resources (RABA), studies were conducted in 22 villages of Fujian, Jiangxi, Anhui, Zhejiang Provinces. The study revealed that after obtaining the intial rights, peasants became much more involved, choosing tree species based on site conditions and tended to cultivate intensively and even make business plans. However, the preference for economic species is a big challenge to efforts to ecological restoration of forests. Also, land fragmentation is an important problem, and peasants' motivation to transact spontaneously or manage cooperatively are weak while external factors such as the market situation and government policies are decisively directional. Furthermore, after the Real Right Law of the People's Republic of China came into force, the protection of peasant's interest and the improvement in peasant's consciousness of self-government require responsive modification of forest management institution.

Investment behavior and it's determinants for contract households participating in national forest property right system reform in China. Zhu, H. (*Northeast Forestry University, China; honggebill@163.com*).

Logistic models to explain investment of planting and tending, and forest-based economic development have been set up respectively by taking 195 contract households participating in national forest property right system reform in Yichun city of Heilongjiang Province of China as sample data. Based on the two models, the key factors influencing management behavior of contract households were analyzed. The results showed that policy of forest right certification, site grade of forestland and a regional dummy variable had a significant influence on investment in planting and tending and forest-based economic development. Forest management scheme policies and forestland rent, education level of household head, and family's month-earning had significant influence on planting and tending of contract households, while policies related to cutting quota, distance from home to forestland, forestland area, sex and extra employment of household heads, and timber production of forestry bureau had significant influence on forest-based economic development of contract households. The results of this study suggest that policies related to the national forest property right system reform should be more timely, that forest-based economic development needs more support from government, ant that attention should be paid to the policy of charging forestland rent but exemption of farmer agricultural taxes.

Posters

Research on foresters' psychological expectation and countermeasures after the state-owned forestry property rights reformation. Cao, Y.K. (*Northeast Forest University, China; cyklk@sina.com*).

Since Yichun officially launched state-owned forestry property right system reform on April 29, 2006, there have been some achievements, although there is a big gap between the original targets of national ecology, workers' benefits, business development and community stability. Statistical surveys and empirical analysis of woodland contractors in Tieli Forestry Bureau were carried out on: the situation of individual households and of the contractor woodland, woodland contracting fund resources, contracting and operating expenses, expected income of contracting woodland, and foresters' attitude towards forestry property right system reform. This analysis of foresters' psychological expectations on forestry property right system reform revealed that: farmers require forestry right certification to identify their ownership; foresters need multi-channel loans to solve funding problems; foresters need operational guidance to achieve stable economic incomes; and foresters want to reform the current forest logging quota system so that they can have timber's disposal and earning rights. According to the analysis results, this paper makes the following policy recommendations: (1) legislatively guarantee the issuing of forestry right certificates should be legislatively guaranteed; (2) national financial support is needed; (3) financial reform efforts should be increased; and (4) the forest logging quota system needs improvement.

Game analysis of subject behaviors and policies of Yichun state-owned forestry property right reform. Cao, Y. (*Northeast Forest University, China*), Han, L. (*Northeast Forest University, China; cyklk@sina.com; whitney.han@163.com*).

On the basis of a spot research on the Yichun state-owned forestry right reform experiment bureaus (fields), this paper constructs a game model, and makes a quantitative analysis of the game situations between stakeholder behavior of the state-owned forest right system reform and issue policies of the forest property right certification. Research shows that: when the forestry reform households (forestry workers) need money urgently, they will apply for mortgage loans and transfer standing trees to raise funds if the Government issues forestry right certificate; they will be taken cut the immature trees to raise funds if the government does not; when the forestry reform households (forestry workers) do not need money, they will cut only mature trees to receive the greatest economic benefit regardless of whether the Government is issuing forest right certificates. In a word, the two-side game results show that no matter whether the forestry reform households need funds urgently or not, issuing forestry right certificate can maximize the interests of state and families. Finally the paper presents policies and proposals to further improve the forestry property right reform.

Managing forests with communities: an effort towards sustainable forest resources and livelihoods in Kuningan District, Java. Damayanti, E., Prasetyo L. (*Bogor Agricultural University, Indonesia; e11yn.d4mayanti@gmail.com; lbprastdp@yahoo.com*), Masuda, M. (*University of Tsukuba, Japan; masuda@sakura.cc.tsukuba.ac.jp*), Wachyuni, M., Puspawati, D. (*Bogor Agricultural University, Indonesia; nina_ekowisata@yahoo.co.id; desca_puspa@yahoo.co.id*).

Deforestation has become a major issue in the developing countries in the tropics. One of many efforts to reduce pressures on forests that was developed in Java in 2001 was a program of Managing Forest with Community (*PHBM*). Implementation of this program is different in each district. Kuningan Districts is among the first that practiced this program. This study is aimed at knowing how *PHBM* in Kuningan District affects forest conditions and livelihoods. Household surveys were conducted in villages with high rates of deforestation and reforestation, based on the study of Prasetyo *et al*. (2009). Participation of people in forest management (patrol, nursery, planting, maintenance) under *PHBM* programs were mostly on a voluntary basis because they have been aware of the benefits they will gain in the future. There has been an understanding among these people that the forest and forest land is common property which are managed by the State Forest Corporation (Perhutani). Approval of patrols by the forest official showed that the people recognized Perhutani as forest management institution and the officials as the managers.

Equity and tenure regime in community-based forest management (CBFM) in Nueva Vizcaya, Philippines. Gevaña, D.T. (*Seoul National University, Republic of Korea; wuweidix@yahoo.com*), Dizon, J.T., Pulhin, J.M., Cruz, R.V.O. (*University of the Philippine Los Baños, Philippines; josefina_dizon@yahoo.com; jpulhin@yahoo.com; rexcruz@yahoo.com*).

The study determined the CBFM participants' perception of equity, assessed the relationships between the participants' characteristics (gender, educational attainment, economic status and type of membership) and perceptions of CBFM goals (improved living condition and forest condition), and described the differences in the perception of equity and CBFM goals in the two tenure regimes namely: CBFM Project in Banila and Co-management Project in Barobbob, Nueva Vizcaya. The study employed a household survey and key informant interviews. Results of the intra-community study revealed that equity across gender, educational attainment, economic status and type of membership in the People's Organization (PO) generally exists in the sharing of leadership roles, livelihood opportunities, PO services, access to forest-based resources, sharing of cost and responsibilities in community forestry activities, and in the implementation of CBFM policies in the two tenure regimes. Similarly, CBFM goals were also noted to have improved along with the perceived equity on these dimensions. There were few significant relationships distilled between the participants' characteristics, perception of equity and CBFM goals. Likewise, there were also significant differences in the participants' perceptions of equity and CBFM goals. These findings highlight both the strengths and weaknesses of each tenure regime.

Local people in the state forest in Indonesia: a case study in Gunung Kidul district, Yogyakarta Province. Herawati, T. (*Forest Research and Development agency, Indonesia; tuti_hera_wati@yahoo.com*), Wijayanto, N. (*IPB, Indonesia; nurheniw@gmail.com*).

This research seeks to explain socio-cultural condition of local people in relation to land tenure reform of the state forest area in Indonesia, specifically in district of Gunung Kidul-Yogyakarta Province. It uses a qualitative approach to study people's perception about changes in land status and their bundle of rights (based on theory of Ostrom). People had used the land for 32 years as proprietors, until 2007 when the Ministry of Forestry of Indonesia launched a program called Hutan Tanaman Rakyat or

Smallholder Forest Concession. The program gives local community special access to utilize state land for developing plantation forests. Through this program, the position of local communities changed from being proprietors to authorized users that imply the existence of some binding rules. The study showed that people were enthusiastic with this change of status. This situation is very interesting from a socio-cultural perspective that merits further analysis. The study concluded that the Kingdom tradition of Yogyakarta is a very important factor in this obedient culture, and that there are implications for policy-making at the national level, that detailed rules for the local people in Yogyakarta in relation to plantation forest program must be site specific.

Farmers' cooperatives: a solution to the conflict between economic scale and individual household incentive in the forest tenure reform process? Hu, X., Zuo, T. (*China Agricultural University, China; huxinping@cau.edu.cn; zuoting@cau.edu.cn*).

The forest tenure reform process in China has decentralized many rights to forestlands, returning them to rural communities and individual households. The Contract Responsibility System came about following the successes of the Household Responsibility System in agricultural sector was implemented in collective forest areas of south China to provide incentives for forest farmers to engage in forest operation and production. But the difference between forestry and agriculture means that benefits from forest more depend on the economic scale, which is difficult to meet in individual forest management and operation. This research examines the conflict between economic scale and individual household incentives, assess the role of forest farmers' cooperative (FFC) in forestry development, and analyze incentives and effectiveness of FFC by questionnaire survey, interviews and qualitative analysis of collected data. A inception survey about FFCs has been carried out in south China. Its findings show that FFC could be an effective solution to the conflict between forest economic scale and individual household incentives, but limitations and difficulties exist in the development of farmers' cooperative at present. This research will provide constructive suggestions for the governance and development of FFC in China.

A study of management and protection of ecological forests after the reform of the collective forest property right system. Ke, C., Haili, W., Yinli, Z. (*Shenyang Agricultural University, China; chenkeyaya@163.com; haili_wang16@126.com; yinlizhai@163.com*).

This study considered two counties, 16 villages, 228 households, and 133 ranger ships in which a random sampled questionnaire was used in Liaoning province to acquire a comprehensive understanding of relevant circumstances about the mode, compensation willingness and ranger ship's behavior towards management and protection of ecological forest after the reform of collective forest ownership. A united mode of ecological forest's management and protection was designed. The result of ecological forest's management and protection has been affected partly by compensation level. By measuring the compensational standard through CVM, and reasonable criteria should be 283.03 $RMB \cdot hm^{-2} \cdot a^{-1}$. Given the positivity of ranger ship, it explores a reasonable salary of ranger ship should be 1,225.09 RMB/month through the opportunity cost theory. As a result, it designs a set of united mode of ecological forest's management and protection which sees every village as a unit and takes interest of forest peasant, ranger ship and government into consideration, aiming to harmonious development between the forest care and economy. The research suggests how to distribute the ecological forest's compensation between peasants, ranger ships and the forestry management departments. Finally, policy proposals on the united mode of management and protection are proposed.

Assessment and analysis of forest farmer cooperatives in collective forest areas of China: the case of Longquan County, Zhejiang Province. Li, L., Shen, Y., Li, M., Huang, W., Jiang, X. (*Zhejiang Forestry University, China; llycds@163.com; shenyueqin-zj@163.com; limingfeng@zjfc.edu.cn; 382167915@qq.com; 36199335@qq.com*).

Collective forests predominate in southern China, and contribute significantly to rural livelihoods. Since the 1980s, forest farmers have become relatively independent producers, and their status and incomes continue to increase. However, the small-scale farmers are at a disadvantage in forest management and have been unable to meet the requirements of market. Forestry Farmers Cooperatives (FFCs), seen as an important way to develop small farmer's forestry to modern forestry economy, have developed. This study used the survey data on 140 households, involving 78 members and 62 non-members of 4 FFCs in Longquan, along with SWOT analysis, Likert-scale and problem-trees. The FFCs are: (i) organized by *homo habilis* or business; (ii) developing fast although they were at an early stage; (iii) promoting quality and increasing price of forest production. Thus FFCs play a significant role in promoting forestry efficiency and increasing farmers' income. However, problems include: (i) inadequate governance of FFCs, (ii) operation of FFCs is not normal, and improved instruments are needed, (iii) lack of information services, lack of FFCs knowledge for farmers; (iv) the available policy not matching the forest farmers' needs. Supporting policy options that help the development of FFCs in China are proposed.

A study on economic valuation and compensation of eco-forest services in Fujian where forest tenure reforms are in place. Li, Y., Kong, X. (*Renmin University of China, China; liyuhui416@yahoo.com.cn; k-xz@263.net*), Sun, J. (*Ministry of Agriculture, China; newcarol@163.com*).

Although Fujian Province is the leading forest tenure reform area in China with many achievements, there remain some challenges. One great challenge is the huge gap between the compensation, WTA data and economic valuation of eco-forests which has a negative impact on the Eco-forest service supply. This paper uses a willing-to-accept method, research results from Costanza (1997) and data from field surveys in Yongan, Fujian to evaluate this gap. The result shows that the farmer's willing to accept for compensation is 18.75RMB/Mu, while the compensation from government is only 5RMB/Mu and the economic valuation is 33168.75 RMB/Mu. On basis of these result it can be concluded that: the reason why the current compensation from government cannot stimulate the farmers to supply Eco-forest service is low compensation; the most efficient way to stimulate the farmers is increasing the compensation from government; increasing finance resources to increase the compensation could involve international cooperation, ecological tax, marketization of forest carbon-sink services, and other ecological payments.

The conflicts among various stakeholders emerged and solution to the conflicts during in collective tenure reform process. Liu, J., Sheng J., Li, K. (*Renmin University of China, China; liujinlong@ruc.edu.cn; shengjianfeng@gmail.com; 381783353@qq.com*).

The goal of collective forest tenure reform is to develop forestry and increase income of the farmers. And the transfer of forest land use rights seems to be an inevitable result. However the gap between the rich and the poor might be enlarged as has happened historically, which would be a violation of the original intention of the reform. A study on the conflicts emerged during in the reform at Hengxian country, Guangxi province has been undertaken. The result show that: (i) policy makers haven't paid enough attention to respect the rights of the farmers in the local areas where Forest Tenure Reforms are holding; (ii) non-standard contracts for the transfer of forest property right present a hidden danger; (iii) the increase in forest rents has stimulated the right to dispute the dominance of the forest; (iv) forest property right dissension has led to a series of social and economic consequences in local areas which is a threat to the development of forestry. The study concludes that there is a need to rationalize forest land use planning, ensure the participation of the farmers, consider multi-functional efficiency of forests, and a need for legal protection in relation to the transfer of forestry land.

Applying NFP to revising the "Harvest Quota Code" in support of collective forest tenure reform in China: a case from Sanmin Prefecture. Liu, J. (*Renmin University of China, China; liujinlong@ruc.edu.cn*), Wang, H., Pan, M. (*Sanmin Prefectural Forestry Bureau, China; smszyz@163.com; smszyz@163.com*).

With the support of FAO and State Forestry Administration, a national forestry programme (NFP) has been implemented to formulate a new harvest quota code in Sanmin Prefecture of Fujian province. Following intensive training on NFP, a multidisciplinary team including local officials, representatives from various stakeholders, and policy experts and academics conducted a field survey using participatory approaches and tools in selected villages. Stakeholders including small scale foresters, community based enterprises, forester associations, and private industrial sector were consulted. The team formulated a tentative proposal for revision of the "Harvest Quota Code of Sanmin Prefecture of Fujian province" and distributed it to various stakeholders for comment. The project's final activity, a public hearing, involved all stakeholders and called for comments on this tentative proposal through website, posters and other means. The final version of the harvest quota code has been implemented smoothly and replicated in other regions in Fujian province. This case demonstrated that it is essential to apply NFP approaches and tools in reform relevant policy and legislative framework to support collective forest tenure reform.

Forest tenure reform in China: a case study of local transformations and recognition of different stakeholders in Hengxian county, south China. Luo, Y. (*Beijing Forestry University, China; lyfcl@163.com*), Liu, J. (*Renming University of China, China; liujinlong_jl@hotmail.com*), Zhang, D. (*Beijing Forestry University, China; zhangdahong591120@163.com*).

Forest tenure transformations in the local villages in southern China are attracting an increasing number of stakeholders. Can forest tenure reform policies benefit the people who live in the forest? This article examines how stakeholders perceive the reforms, ways in which they can establish win-win mechanisms and what these changes will bring to the rural poor. This study was conducted in PingTang and BaoDing village, HengXian County, GuangXi province, in southern China during 2009. The study methods included participatory observation, interviews, semi-structured questionnaire surveys, round-table stakeholder discussions, combined with information deriving from situational analysis and case studies to explore the research questions. Our study found that stakeholders have different perceptions and needs for forest tenure reform. These different perceptions lead to various actions and game behaviors which will reconstruct forest tenure in the local village. Meanwhile, with various stakeholders competing in the game process, the rural poor are vulnerable to suffer exclusion from the natural wealth around them and increase poverty. Finally, though there are differences, stakeholders in the heterogeneous villages can also establish participatory consultation and benefit-sharing mechanisms through more communication and trust building.

Make the vulnerable groups benefit from using rights transfer under the unchanged collective ownership. Zhao, L., Liu, J. (*Renmin University of China, China; zhaolixia@cau.edu.cn; liujinlong@ruc.edu.cn*).

The ongoing forest tenure reform entrusts production and management of forest land to individual farmers, while the nature of collective ownership remained unchanged. Users of such land could transfer, lease and mortgage the land using rights within the tenure. But much less attention has been paid to the vulnerable groups before, during and after the using rights transfer. There are three kinds of typical vulnerabilities: by age, by gender and by wealth. The vulnerable groups rely on scattered plots of forests for their daily subsistence, non-cash income, and insurances may not provide them with equal access to information, market and other services. When shocks occur, they more likely to give up their operating rights at lower prices and unfavorable terms. Once they lose their forestland, they lose social support from the others, since the forestland is a traditional capital in local communities for mutual help (like labor exchange, credit, and even matrimonial ceremony), self-help and support for old-age. Through analysis of ethnographic records from one typical village, this research explores the possible solutions at the community level and concluded relevant policy recommendations.

H-06 Human dimension solutions to difficult forest problems

Organizer: Taylor Stein, *University of Florida, USA, tstein@ufl.edu*

Protecting and sustaining public lands: is legislation enough? Anderson, D. (North *Carolina State University, USA; dorothy_anderson@ncsu.edu*), Enzler, S. (*University of Minnesota, USA; senzler@umn.edu*).

Legislation at the federal level is required to permanently sustain public lands for the benefits they provide to people and society. Chief among these benefits is the protection of ecosystems and their services. But, is legislation enough to sustain these benefits? In 1994 the Clinton Administration concluded that the United States' legal authorities and environmental protection programs are ill suited to protect the health of the nation's ecosystems. The 2005 Millennium Ecosystem Assessment reported unprecedented degradation of ecosystems and their services and its adverse effects on human health, security and welfare. Simple observation of the condition of U.S. public lands suggests that legislation is limited in its ability to protect ecosystems unless it is accompanied by social change. To be effective, social change must be at a scale and magnitude large enough to be considered a social

movement and must result in overcoming political blockage that denies citizens input to public land managers' interpretation of legal mandates. This paper examines the Mono Lake Ecosystem (California) and the Everglades Ecosystem (Florida) and the role law is playing to change the political and social systems necessary to protect these ecosystems. It further suggests how communities might use law to protect ecosystems.

Re-casting difficult forest management problems: stakeholder insights on motorized recreation in state administered public lands. Asah, S. (*University of Washington, USA; stasah@uw.edu*), Bengston, D. (*U.S. Forest Service, USA; dbengston@fs.fed.us*), Nelson, K., DeVaney, L. (*University of Minnesota, USA; nelso468@umn.edu; deva0052@umn.edu*).

Effectively solving difficult forest management issues often depends on understanding the diverse attitudes and conflicting perspectives of multiple stakeholders involved in those issues. This study examined All Terrain Vehicle (ATV) use in Minnesota (MN) state forests as part of MN Department of Natural Resources efforts to better understand and sustainably manage ATV use. ATV use in MN state forests is highly controversial and characteristically intractable. We used Q methodology, a social science research technique, to reveal the structure in the cacophony of conflicting stakeholder perspectives. The core of this method involves stakeholders deliberatively ranking statements, selected from all that is said about ATV use in MN, according to a given condition of instruction. This approach allowed stakeholders to provide an organized narrative of their perceptions of the problem and to indirectly negotiate with other stakeholders. By allowing ATV stakeholders to speak for themselves, Q methodology helped identify common attitude structures, exposing unknown or unspoken agendas linked to the problem. By defining these structures and revealing unrecognized agendas, a more coherent understanding and consequent resolution of the seemingly intractable conflict is made possible. We demonstrate and discuss the importance and implications of social science research approaches to sustainable forest management.

Volunteering for novel landscapes or historical analogues? The dilemmas of public involvement in restoration ecology in a context of climate change. Buizer, M., Ruthrof, K. (*Woodlands and Forest Health of UWA and Murdoch University, Australia; m.buizer@murdoch.edu.au; k.ruthrof@murdoch.edu.au*).

For social and environmental reasons, restoration ecologists and volunteers have become increasingly collaborative. Restoration activities being undertaken include seed collection, planting of seedlings and monitoring. Simultaneously, at a theoretical level, restoration ecologists are debating the changing meaning of ecological restoration in the context of climate change. The main question is whether to 'restore' a site to what it had historically been, or whether it should be 'novel'. In view of this, we carried out a case study (including in-depth interviews, analysis of the restoration literature and participatory observation) to understand how volunteers have framed and explained their restoration activities. We found a chasm between the theoretical debate and the ways in which restoration practitioners and volunteers perform restoration. 'Novel', in their activities, is not an absolute, but a mix of 'old' and 'new'. The articulation of a historical analogue may be a necessary condition for public involvement but the question is how this, simultaneously, articulates problems of public involvement. We argue that the theorists and practitioners of restoration ecology need to be transparent about the filtering process taking place at the crossroads of their theorizing and practices, in order to avoid false notions of the uncertain outcomes of volunteers' engagement.

Stakeholder awareness underpins successful control of forestry pests: a *Sirex* woodwasp case study. Hurley, B., Slippers, J., Wingfield, M. (*University of Pretoria, South Africa; brett.hurley@fabi.up.ac.za; jana.slippers@telkomsa.net; mike.wingfield@fabi.up.ac.za*), Dyer, C. (*Institute for Commerical Forestry Research, South Africa; colin.dyer@icfr.ukzn.ac.za*), Slippers, B. (*University of Pretoria, South Africa; bernard.slippers@fabi.up.ac.za*).

Sirex noctilio is one of the most serious invasive pests of pine. In South Africa, there has been a national effort to control *Sirex*, which has included increasing awareness of the pest amongst the local forestry community. In this study, we considered the impacts that the arrival of the pest and the awareness campaign has had on perceptions and knowledge of *S. noctilio*, as well as other forestry pests, amongst members of the forestry community. For the data collection, a survey questionnaire was developed and used in telephonic interviews. Results of the study showed that the Sirex awareness campaign had increased awareness of forestry pests in general. However, basic knowledge regarding the identification and symptoms of specific pests, such as *S. noctilio*, was poor. This will negatively influence monitoring efficacy. Traditional paper-based media and personal contact contributed most to enhanced awareness. Electronic media were less effective and improvement would require a more focused effort. It was of concern that private farmers and contractors, as well as non-English and non-Afrikaans speakers, were less well informed about forestry pests. Clearly, a fragmented landscape in terms of ownership and language, presents challenges for effective communication of forestry pest threats in South Africa.

Effect of education on the adoption of wildlife management practices by family forest owners. Johnson, J. (*Oregon State University, USA; jim.johnson@oregonstate.edu*), Rasamoelina, M. (*World Wildlife Fund, Madagascar; mrasamoelina@wwf.mg*), Hull, B. (*Virginia Tech University, USA; hullrb@vt.edu*).

In the U.S. there have been many established programs to assist family forest owners with managing their lands to better provide both economic and ecosystem services to the public-at-large. We conducted a survey of 3,435 family forest owners in Virginia to determine the effect of voluntary educational programs, offered through the Cooperative Extension Service, on the adoption of a suite of wildlife management practices. Respondents were classified as not having attended any educational programs, having attended minimal programs, or having attended shortcourses offered through the Virginia Forest Landowner Education Program (VFLEP), designed specifically to motivate landowners to adopt woodland and wildlife management practices. There were significant differences in the rate of adoption at the 0.10 level between the three educational categories. Forest owners who attended a wildlife management shortcourse adopted practices at a rate of 71%, while those who attended both a wildlife management and a woodland management shortcourse adopted at a rate of 85%. Logistic regression analysis showed that the probability of adoption of wildlife management practices ranged from 45 to 91% for forest owners without a forest management plan, to 74 to 97% for those owners with a forest management plan.

Reexamining the conceptual structure of place attachment. Jun, J., Kyle, G. (*Texas A&M University, USA; jjun@tamu.edu; gtkyle@ag.tamu.edu*), Absher, J. (*U.S. Forest Service, USA; jabsher@fs.fed.us*).

To varying degrees, most research has noted that place attachment involves three qualities: affect, cognition, and practice. From these three elements, Kyle et al. (2004) operationalized place attachment in terms of four dimensions: affective attachment, place identity, place dependence and social bonding. While this multidimensional conceptualization suggests that human-place bonding is largely a product of these four abstract elements, identity theory suggests that self-related component (i.e., place identity) is central and is an antecedent of these others (Burke, 1991). Thus, in this investigation, we adapted identity theory to reassess structure of Kyle et al.'s (2004) conceptualization of place attachment. Specifically, we hypothesized that place identity predicts the other facets of place attachment (i.e., affective attachment, place dependence, and social bonding). This model was tested using data collected in two spatial contexts; San Diego (residents surrounding Cleveland National Forest, n = 729) and Los Angeles (residents surround Angeles and Los Padres National Forests, n = 929). Structural equation modeling (SEM) using LISREL was conducted to examine the hypothesized structure of place attachment. Our analysis illustrated that the effects of *Place Identity* on three facets (Place Dependence, Affective Attachment and Social Bonding) were significant and strong – offering support for our re-conceptualzation.

Understanding forest recreation visitors' behavioral intentions. Li, C.L., Tu, Y.C., Feng, F.L. (*National Chung Hsing University, China-Taipei; CXL345@gmail.com;laurien12@gmail.com; flfeng@nchu.edu.tw*).

Forest recreation provides both psychological and physical health benefits. Forest recreation also provides visitors low density experience. Evidence shows that crowding is one of the determinants of visitors' behavioral intentions. In addition, marketing factors, such as service quality, satisfaction and past experience, are important to influence visitors' subsequent behaviors. On the other hand, taking from the perspective of cultural anthropology, I argue that behavioral intentions are also influenced by values. The purpose of this study was to explore possible factors affecting visitors' behavioral intentions. In 2009–2010, the visitors to Huisun Forest Station in Taiwan were surveyed using an on-site sampling approach. Overall, 400 usable questionnaires were obtained. The results showed that values, service quality, health benefits, past experiences as well as crowding, satisfaction, and behavioral intention indices were acceptably reliable measures. Multiple regression analysis was used to test the predictive power of these factors on visitors' behavioral intentions. The finding revealed that the multiple regression model was significant at the 0.001 level, and the model R-square equaled 0.42. The discussion and implication of study findings in forest recreation management are provided.

Socio-economic impacts of the forest industry crisis in northwestern Ontario: involving local communities in developing key strategies for transforming the forest industry. Palmer, L., Shahi, C., Smith, P. (*Lakehead University, Canada; clpalme1@lakeheadu.ca; cshahi@lakeheadu.ca; pasmith@lakeheadu.ca*).

Forest industry has been the backbone of the local economy in many remote locations in Canada. While the forest industry, which focused on commodity products such as pulp, paper and lumber, thrived until the early part of this century, in recent years it has faced a major downturn that has resulted in extensive mill closures and unprecedented job losses to the forest industry workers. This study examines the economic and social impacts that have resulted from the forest industry downturn in northwestern Ontario (NWO) communities in Canada. NWO comprises a vast boreal forest region and has both municipal and Indigenous (First Nations) communities. The study utilizes both qualitative and quantitative approaches based on open-ended interviews with a range of participants from 9 municipalities and 41 First Nation communities in NWO. The study participants include community leaders (mayors, chiefs, council) and key informants familiar with the forestry situation (loggers, former mill workers, lands and resources staff, and economic development officers). The role of government and local organizations in assisting through the crisis is also examined. The study results have been used to formulate policy recommendations to develop a long-term economic vision to support sustainable local communities and local forest ecosystems.

Ensuring the sustainability of Mt. Makiling forest reserve through an enduring academe-civic organization environmental education partnership: an assessment. Rebugio, E. (*University of the Philippines Los Banos, Philippines; erlindarebugio@yahoo.com*), Tan, E. (*San Pablo Colleges, the Philippine; iemtan23@gmail.com*), Almendral, F. (*Rotary Club of Makati-Legazpi, Philippines; fgalmendral@yahoo.com*).

The Mt. Makiling Forest Reserve, Laguna, Philippines is an internationally renowned forest ecosystem. World acclaimed scientists had documented its biological richness. It is a field laboratory and experiment station of the UPLB College of Forestry and Natural Resources. It functions as an important watershed to surrounding communities and an outdoor recreation area to local and Metro Manila population. Like other important forest ecosystems in the Philippines and in Southeast Asia, Mt. Makiling is continuously threatened by various forces of forest destruction partly due to the lack of public awareness and appreciation of its values. This paper highlights assessment results of 16 years of continuing partnership between the University of the Philippines Los Banos and the Rotary Club of Makati-Legazpi, an outstanding civic organization in Metro Manila in undertaking forest conservation and environmental education among the youth as a strategy in the conservation, protection and sustainable management of the Mt. Makiling Forest Reserve. The most significant thing about this partnership is that it has endured without the binding effect of a formal agreement that usually characterizes other collaborative relationships but only through a genuine commitment among partners to the nobility of its cause, the sustainability of an invaluable forest resource.

Integrating place attachment into outcomes-focused management. Stein, T., Kil, N., Holland, S. (*University of Florida, USA; tstein@ufl.edu; ecoparkmgt@hotmail.com; sholland@ufl.edu*).

Forest recreation and tourism researchers have strived for decades to identify and measure the diverse positive outcomes (e.g., benefits) of recreation. This research resulted in the outcomes-focused management (OFM) framework designed to assist forest managers in providing opportunities for visitors, communities, economies, and environment to benefit from recreation and tourism. Researchers have criticized this process as being too "production" focused and claimed that emotional and symbolic *attachment* to places was overlooked in the outcomes approach. This study incorporated the concept of *place attachment* into the

OFM framework. Visitors to the Ocala National Forest, Florida, USA were surveyed to identify their demographics, trip characteristics, place meanings, attainment of desired experiences (i.e., outcomes), and attachment to the forest. Structural equation modeling was used to examine the relationships between the constructs. Results demonstrated age, the number of days in the forest over the last year, and the length of association with the forest increased place attachment and improved recreation experiences in the forest. Natural settings tended to increase attainment of desired experiences, satisfaction and attachment. As respondents attained desired experiences, they seemed to be more satisfied with the recreation settings. Attainment of natural, social, learning, or fitness experiences, appeared to foster place attachment.

Socioeconomic impacts of forest production on the local economy in the Ucayali region, Peruvian Amazon. Ugarte-Guerra, L. (*International Potato Center, Peru; j.ugarte@cgiar.org*), Ramos, N. (*UNALM, Peru; ramosrx@yahoo.com*).

The objective of the study was to evaluate the economic contribution of forestry activities on the Peruvian region of Ucayali. A methodology approach was designed to evaluate the economic impact at the regional scale over a 10-year long period, analyzing and identifying the relationships among key macroeconomic indicators and forest production. The analysis of this impact was carried out from both statistical and qualitative perspectives. The study revealed that National Gross Domestic Product (GDP), per capita GDP, numbers of new business start-ups (entrepreneurship), exports rates, tax collection for central government, and decrease of the poverty and extreme poverty of Ucayali are highly correlated with forest production during the period analyzed, and that other social aspects and economic activities such as formal employment rates and the human development index (HDI), have no clear correlation with regional forest production. Positive socioeconomic impacts of forest activities are limited because a high percentage of these activities are not formal. Sustainable development policies are outlined for Ucayali region based on this study.

An exploration of factors shaping setting substitution behavior among visitors to a natural area. Yoon, J.I., Kyle, G. (*Texas A&M University, USA; jeeinyoon@tamu.edu; gerard@tamu.edu*), Absher, J. (*U.S. Forest Service, USA; jabsher@fs.fed.us*).

Using data collected from the Sumter National Forest in South Carolina, U.S.A., we examined the relationship between campers' motivation, place bonding, and the willingness to substitute recreational sites. The previous literature suggested that the meanings recreationists ascribe to recreation settings provide insight on their motives for place interaction and attachment to the setting. This work also shows the degree to which recreationists' are attached to specific sites informs their willingness to substitute comparable leisure settings. We hypothesized recreationists' attachment to selected recreation settings would result in less willingness to substitute. Our analyses offered a partial support for the hypothesized model. We also compared the model across the two groups: people who have visited the camping area for less than 3 years and for more than 3 years. For people who have less visitation history, their place bonding was driven by motivations—family cohesion, enjoyment of nature, and social activity. For people who have more visitation history, place bonding was predicted by motivation for the enjoyment of nature and solitude. For both groups, their willingness to substitute their recreational place was negatively influenced by familiarity with the setting and positively associated with the place identity dimensions of place bonding.

Posters

Does wildlife *en*courage or *dis*courage outdoor recreation among different ethnic groups in Danish society? Jensen, F.S. (*University of Copenhagen, Denmark; fsj@life.ku.dk*).

Like many other Western societies, Denmark is becoming more ethnically diverse. The most recent population forecast indicates a doubling of citizens with non-western backgrounds, to 12% in the year 2050. Until now, it is unknown how outdoor recreation is practised among our new citizens. More specifically, what role does wildlife play in outdoor recreation? A mail-back questionnaire sent to 1,217 adult Danes in 2007–2008 was used to assess the impact that wildlife has on nature visitation for different segments of the population (including citizens with non-western backgrounds). Relatively more citizens with non-western background indicated that disgust or fear of different wildlife species has prevented nature visits, as well as fear of commonly encountered farm and hobby animals in the countryside. I addition, fewer people stated that wildlife is an important reason for visiting nature. Finally, a relatively poor knowledge of the rules of access to different nature types was revealed. The results indicate that lack of familiarity with (new) nature/wildlife prevents nature visits for citizens with a different frame of reference (i.e., Danes with non-Western backgrounds). A targeted information and education effort can play a key role here – e.g. through the established ranger and nature school systems.

Management eidos of nature reserve and sustainable conservation of biodiversity. Jin, Y.H., Li, S. (*Chinese Academy of Sciences, China; jinyh@iae.ac.cn; helloandwelcome@163.com*), Piao, Z. (*Research Institute of Changbaishan, China; piao_1777@sina.com*).

There are more than 1,300 nature reserves of the forest ecosystem type in China, and 28 nature reserves have been become the International Man and Biosphere Reserve system. With sustained economic development, people's culture and leisure demands will increase more and more, and nature reserves are facing a growing burden of human disturbance in China. How to analyse and to treat properly, and to handle the relationship between conservation and development and utilization of different types of natural resources in protected areas, these issues bring forward a higher demand and problems to nature reserve managers in China. Through the establishment of a new management eidos of nature reserves, it is more important than ever to establish harmony relations gradually between man and nature, and to further enhance people's awareness of nature conservation. Therefore, there should be a new awareness of nature reserves, that these places are not only a sanctuary for wildlife and a valuable repository of biodiversity, but also an ecological barrier to humans. Nature reserves are not only the most important green ecological engineering and an objective existence of natural ecosystems, and but also provide the natural reference system for the restoration of degraded ecosystems.

Economic impacts of restricting motorized recreation in the U.S. national forests: a case from the American southwest. Kim Y.S. (*Northern Arizona University, USA; ysk@nau.edu*).

The U.S. Forest Service and National Forest System contribute social and economic environment by providing places for outdoor recreation. On many national forests in the U.S., motor vehicles are used for a number of recreational activities, as well as for other administrative and commercial activities. The U.S. Forest Service published final travel management regulations governing off-highway vehicles and other motor vehicles on national forests and grasslands in 2005. In order to comply with the new Travel Management Rule, each national forest has to restrict motorized travel to designated roads, trails, and areas. The U.S. Forest Service and motorized recreation user groups tend to paint very different pictures of the economic impacts generated by motorized recreation on national forests. Here I present the social and economic contexts of the motorized recreation uses on the Coconino National Forest of the American southwest. Regional economic impacts of the motorized uses were estimated in two different ways and the sources of differences in the estimates were examined. Overall, motorized recreation activities on the forest contributed about 0.2% to 1% of labor income, and about 0.1% to 0.3% of total number of jobs to the regional economy of three counties.

Impacts of community forestry on conservation and livelihoods in the biological corridor of Nepal. Lamsal, R.P. (*Ministry of Forests and Soil Conservation, Nepal; ramplamsal@gmail.com*).

The concept of community forestry is not new. The challenge is to convert this concept into reality and make it acceptable to poor and disadvantaged groups when forest management is focused at improving the habitat of large wild mammals. This study assesses the impacts of a community forestry programme in Khata corridor of Bardia, Nepal. The study is descriptive in nature and based on the primary information obtained from a sample of 30 community forest user groups and secondary information from the Terai Arc Landscape Programme. Recognizing that not all outcomes are beneficial, both positive and negative impacts are outlined. The achievements identified are: effective and efficient conservation of forest, biodiversity, wildlife and their habitat; reduced poaching and increased wildlife movement; increased supply of basic forest products; and increased availability of environmental services. Similarly, the communities have developed a strong sense of ownership; established an inclusive community institution; developed local leadership; incorporated gender issues; and implemented integrated programme involving poor and disadvantaged groups for livelihood improvement. However, conflicts due to wildlife depredation, marginalization of very poor forest-dependent households, and issues of equity still need to be addressed.

Implicit attitudes of forestry publics toward the forestry profession in the province of Laguna, Philippines. Paras, F., Rebugio L., Pulhin J. (*University of the Philippines Los Banos, Philippines; fdparas@gmail.com; lucrebugio@gmail.com; jpulhin@yahoo.com*).

The study is an ongoing research that aims to determine the implicit attitudes of randomly selected individuals from four clustered groups of forestry publics: local peoples' organizations, non-government organizations, small-scale private forest industries, and foresters themselves, toward the forestry profession. To measure implicit attitudes, there were two methods used: the Implicit Association Test (IAT), which determined the implicit attitudes of the respondents and the Picture Story Exercise, which determined their implicit motives. An explicit survey was also administered to compare the implicit attitudes with the explicit attitudes of the respondents. This exploratory study on the socio-psychological conditions in the minds of the different publics would provide a new perspective of how foresters and other environmental professionals can improve upon their public image for the development of the future of the forestry profession.

Recreational services as an opportunity for small forest holders: case study from Slovakia. Sarvašová Z. (*National Forest Centre, Slovakia; sarvasova@nlcsk.org*), Moravcik M. (*National Forest Centre, Slovakia; moravcik@nlcsk.org*).

Case study deals with incomes diversification in small non-state forest enterprise in Veľký Klíž, Tríbeč Mountain, Slovakia. In total 786 ha of forest and pasture land is shared owned by 600 owners. Low timber price results from world economic crisis should be compensated by additional economy activities of forest enterprises, e.g. application of new products or services. Case study analysis is focus on introduction of recreational services as a new opportunity for landowners to stabilize their annual incomes. Innovation in forest sector is crucial point for sustainable development and improvement competitiveness especially in less favoured rural areas. The political support in form of different programs on European Union, national and regional level seams to be important for alleviation of poverty risk in rural mountain regions. Forest owners or mangers are oriented on practical information on support measures available through actual policy programs. Political support for diversification activities is an essential factor for smallholder forestry and its sustainability from economy and social point of view.

H-07 International developments in the administration of publicly-funded forest research: challenges and opportunities.

Organizer: Gordon M. Hickey *McGill University, Canada, gordon.hickey@mcgill.ca*

When peer-reviewed publications just won't do! Meeting the information needs of today's natural resource managers. Bartuska, A. (*U.S. Forest Service, USA; abartuska@fs.fed.us*).

Several years ago, the U.S. Forest Service Research and Development branch was challenged by the management oversight institution of the U.S. federal government, the Office of Management and Budget, to demonstrate that our science was relevant and being used by the public we serve. The quality and quantity of our science, based on the traditional metric of number of publications, was not in dispute. We decided to establish a Customer Satisfaction Index, where data were gathered by reaching out to more than 10,000 "users" with a set of questions. The results reinforced that the quality of our science was very good, and the credibility of our scientists was excellent; however, the data also revealed that our information was not easily accessible or

user-friendly. We have begun to make *science delivery* as important a goal of our organization as doing good science, including structural institutional changes and targeted funding. We have also explored the potential for *participatory research* as a mechanism to engage decision-makers in defining the questions and in designing and assisting in the analysis of scientific study. Finally, we have begun analyzing the most effective pathways for improving knowledge transfer, including developing career pathways for specialists in science delivery.

Do the beneficial impacts of Australian Cooperative Research Centres outweigh the transaction costs? Reflections on two decades of triumphs and trials for the CRC for forestry. Duff, G. (*CRC for Forestry, Australia; gordon.duff@crcforestry.com.au*).

The Cooperative Research Centres (CRC) program is designed to strengthen the links between publicly funded research organisations and end-users. The CRC for Forestry has been in operation since the start of the CRC Program in 1991. There are currently 48 CRCs in Australia, covering sectors including manufacturing, information technology and communications, mining and energy, agriculture and other primary industries, environment, and medical science and technology. Advantages of the program include the ability to capture critical mass in research, development, education and extension across a wide base of research providers such as universities, commonwealth and state agencies, and to direct these resources to strategic issues facing particular industries and other sectors. Strategic research can be planned with time horizons of seven years or longer, and CRCs include a strong research training component. Active maintenance of national networks and a research culture with strong end-user focus are also key features of the program. The CRC for Forestry is recognised as a successful example, with a strong track record of research impact. This presentation will discuss the pros and cons of investing in the CRC model in terms of benefits to the Australian forestry sector.

Canada's Sustainable Forest Management Centre of Excellence: a 15-year experiment in publicly financed research partnership. Fyles, J. (*McGill University, Canada; james.fyles@mcgill.ca*).

The Sustainable Forest Management Network Centre of Excellence (SFM-NCE) was a university-based, research organization supported jointly by the Canadian federal Centres of Excellence program and provincial and federal government agencies, private companies, Aboriginal organizations and NGOs. The SFM-NCE evolved from a research program directed mainly by university researchers publishing in academic venues, to a research and knowledge exchange program receiving significant direction from users. Evolution was driven largely by the recognition that traditional academic approaches to research were not well suited to generating outcomes that could be implemented in policy and practice. A research process was developed in which teams of researchers and users were involved throughout the research cycle from initial problem definition to final dissemination. Active knowledge exchange among research team members became a key mechanism to keep research on track and ensure uptake of results. Priorities and reward structures within academic and non-academic organizations often worked against effective research collaborations. Investment of time and funding to facilitate the engagement of researchers and users became a crucial part of the program. The SFM-NCE partners perceived the model as being effective in delivering value found in relationships developed as much as in the research results per se.

International developments in the administration of publicly-funded forest research. Hickey, G. (*McGill University, Canada; gordon.hickey@mcgill.ca*).

This paper discusses the natural tension that exists between the 'purchaser' (the decision-maker) and 'provider' (the researcher) of publicly funded forest-related scientific research in different jurisdictions. Drawing on the latest scholarship in the field of science management and policy, this paper prefaces the Congress session titled *International developments in the administration of publicly-funded forest research: challenges and opportunities*. Issues that are addressed include: (1) funding pathways (including public and private partnerships) that enable forest research; (2) managing decision-maker and researcher satisfaction in publicly-funded forest research contexts; (3) measures of research success and relevance (i.e., scientific versus public impact factor); (4) Demand for inter- and trans-boundary governance and research; (5) external pressures on setting forest research directions; and (6) information pathways for improving knowledge transfer.

Strengthening forest research networking and cooperation in Europe: challenges and opportunities. Päivinen R. (*European Forest Institute, Finland; risto.paivinen@efi.int*).

In recent years, national financing for forest research in European countries has been under pressure. Despite this, some opportunities have been found in the research funding programmes by the European Commission. At the same time forests have been globally recognised as one of the key elements in mitigating and combating climate change. This paper discusses some of the prospects on the role of international cooperation in setting forest research directions and advocating funding for forest research in Europe. Examples including the European Commission initiative on Technology Platforms, and research networking and advocacy within the European Forest Institute addressing the issue of setting policy-relevant research agendas will be provided. The Forest-Based Sector Technology Platform is one of the thirty European Technology Platforms and gathers together the whole forest sector from forest producers to industries and forest product marketing, and other respective fields of research. The European Forest Institute is an international organisation with 21 Member Countries and has more than 120 member organisations, all aiming at strengthening forest research cooperation and information support for policy-making at a pan-European level.

Creative forest research: relevance at a time of global crisis. Pendlebury, J., Freer-Smith, P. (*Forest Research, UK; james.pendlebury@forestry.gsi.gov.uk; peter.freer-smith@forestry.gsi.gov.uk*).

The global economic downturn is severely restricting public expenditure on research at a time when the scientific issues to be addressed by the forestry sector are rapidly expanding. For example, issues such as adapting to climate change, managing forests to contribute to a low carbon economy, delivering more environmental services for less money when pest and disease problems are increasing is challenging conventional wisdom and forest management practice. The provision of innovative yet authoritative

research solutions to these and other problems requires flexibility and creativity especially when set against a background of the need to demonstrate value for money and policy relevance. This paper explores, through the use of selected examples, ways in which it may be possible to provide the public benefit and service required through adopting new business models, informed research commissioning, closer links with and involvement of policy makers, effective prioritisation, national and international partnerships and joint ventures. There is no panacea, but a judicious blend of options can reduce the organisational risk from declining investment whilst improving the relevance and quality of service to key clients and the public.

First experiences of the Chilean Native Forest Research Fund. Real, A., Saavedra, M.E. (*Corporación Nacional Forestal/ CONAF, Chile; alejandra.real@conaf.cl; maria.saavedra@conaf.cl*).

The promulgation of the *Native Forest Act* ends the long negotiations concerning the native forest in Chile. One of the characteristics of this law is the creation of the first, and only, research fund in the forest sector specifically dedicated to native forests. This Fund is an instrument focused on applied research related to the implementation of the Act, designed to generate the necessary knowledge not only for the continuation of scientific development but also for evaluating the Act and its application. This study presents the experience gained from starting up the Fund and emphasizes those aspects related to the creation of this legal instrument, the main actors who participate in determining the research outlines and information about projects to be financed, the practical aspects related to the administration of the fund, and the related processes of dissemination. The experience gained predicts high interest on behalf of the scientific community in Chile, which is not limited to forest scientists, because it is an exclusive space designed for forest ecosystem research including the biological diversity of the country. The experience also delivers lessons on participation and inclusion of citizens when setting research priorities.

Canadian Wood Fibre Centre: a national innovation pilot for forest sector transformation. Smith, G.K.M., Bruemmer, G. (*Natural Resources Canada, Canada; gusmith@nrcan.gc.ca; george.bruemmer@nrcan.gc.ca*).

In 2006, Canada's forest sector innovation system was restructured, aligning public and private research capacity to deliver innovations for a globally competitive 21st Century forest industry. In a new partnership model, the Government of Canada contributed critical capacity through the Canadian Wood Fibre Centre (CWFC) to the integrated research programs of FPInnovations. The Fibre Centre comprises 66 staff from eight locations across Canada. FPInnovations combines privately funded research institutes specializing in pulp and paper, solid wood products, and forest engineering. With the addition of the CWFC's biological and ecological expertise, FPInnovations is equipped to deliver innovations along the full forest value chain that connects markets, products, manufacturing and the supply of wood fibre. Results include better targeting of research to meet industry needs, strong collaboration with provinces and academic research organizations, and increased investment in R&D. While CWFC's research framework helps integrate programs within FPInnovations, a knowledge exchange strategy facilitates the adoption of innovations. Success measures are used to demonstrate the impact of the CWFC in enabling Canadian industry to shift from a volume maximization business model to a new value optimization paradigm. The new model is not without some challenges, which are discussed.

H-08 Contribution of political theory to policies for sustainable use of forest resources

Organizers: Dodik Nurrochmat, *Bogor Agricultural University, Indonesia; dnrochmat@yahoo.com*; Maria Brockhaus, *CIFOR, Indonesia, m.brockhaus@cgiar.org.*

Theories for forest policy analysis: a systematic and longitudinal overview. Arts, B. (*Wageningen University and Research centre, the Netherlands; Bas.Arts@wur.nl*).

This presentation gives an overview of political and policy theories which are currently used in the sub-discipline of forest policy analysis, and evaluates trends over time in the use of different theories. The aim is to consider whether the sub-discipline of forest policy analysis deviates from the "mother discipline" of policy sciences in general, and if so, how and to what extent. The data are retrieved from the scientific literature database SCOPUS and covers the time frame of 1995 to 2008. While presenting the theories used, the presentation also offers a systematic overview of theories applied in forest policy analysis. This overview might be helpful for researchers in order to: (1) identify an appropriate theory once one conducts a specific research project; or (2) position his or her preferred theory in the literature as a whole. The analysis shows that the current top 3 theories used in the forest policy sub-discipline are: (a) policy network approach, (b) (neo)institutionalism and (c) social-constructivism. The longitudinal analysis further shows that the advocacy coalition framework, no. 1 in the late 1990s, has lost ground in the sub-discipline. This outcome is more or less in line with developments in the "mother discipline".

Strangers among trees: policies and politics for foreign residents in northern Bolivian forests. De Jong, W. (*Center for Integrated Area Studies, Kyoto University, Japan; wdejong@cias.kyoto-u.ac.jp*).

This paper analyses the case of Brazilian residents in Bolivia's tropical forest borderlands, as a case to explore theoretical frames that support forest policy formulation. While border crossing in tropical forest regions is quite common, its implication for forest policies has yet little been explored. The paper relies on a number of theoretical concepts, the most important of which are territorialisation and frontier development theories. These concepts and theories are used to explore the presence of illegal immigrant in northern Bolivia forest regions and relate their presence to forest policy formulation and implementation. Borderland conditions impose a higher need to increase state administration, property rights and the rule of law in borderlands. Protecting territorial integrity and national sovereignty are key strategies of a government's legitimatization and this is reflected in the forest policies that are formulated for the northern borderlands. Neither in the Bolivia case nor elsewhere have serious efforts been made to incorporate foreign residents into a pro-poor forestry agenda, even though such policies are now common in most tropical

forest countries. Borderlands and illegal immigrants impose exceptional conditions that affect the policy agenda, including forest policies.

Power and authority in government decision-making: implications for sustainable forest management. Hickey, G. (*McGill University, Canada; gordon.hickey@mcgill.ca*).

The concepts of power and authority are central to decision-making, both at the individual and organisational levels of society. Over the past twenty years, governments have been actively pursuing reform in their regulations to encompass values and management strategies that are consistent with the principles of sustainable development. However, the ability of bureaucratic decision-making processes to deliver meaningful solutions is severely challenged by the temporal and spatial complexities associated with sustainability-related policy implementation. In the context of the environment, failures in government decision-making processes have been highlighted by numerous studies. One reason given for this situation is a poor strategic understanding of how the existing relationships between power and authority in the different (often overlaying) jurisdictions of government are impeding or supporting the environment and sustainable development objectives of society. This suggests a need to improve our understanding of the multi-jurisdictional interdependencies that exist and how the expression of power and authority within a particular government influences the efficacy of forest-related decision-making overall. This paper discusses the different dimensions of power and authority in the context of control and considers the implications of this for successful forest and environment-related regulation.

Administrative forestry investment and its impact on activity in Japan. Nose, M. (*Research Institute for Humanity and Nature, Japan; nose@chikyu.ac.jp*).

Of late, the demand of timber has been decreased year by year, affected by economic decline. Historical trends of administrative forestry investment should be evaluated to establish a basis for future forest policy strategies. The objective of this study is to follow the levels of investment in both silviculture and road construction from 1960 to 2006, comparing these data with forestry GDP (Gross Domestic Products) in each prefecture based on available statistical data. Administrative forestry investment has been maintained at a fixed level in proportion to total amount during between 1960 and 2006, with a percentage share from 1.0 to 1.5%. On the contrast, forestry GDP has decreased continuously from 2.4 in 1960 to 0.08% in 2006. As a result, the investment hasn't been effective from an economic perspective, and the value of forest stands and timber have also declined during this period though the forestry activity is relatively steady in some prefectures and creates employment to some extent. In the future, the administrative investment should pay attention to the demand sector and be focused on specific local areas to ensure viability of forestry.

Green fiscal policy in the Indonesian forestry sector: options to transform political theories into practice. Nurrochmat, D.R., Ekayani, M., Hadianto, A. (*Bogor Agricultural University, Indonesia; dnrochmat@yahoo.com; metieka@yahoo.com; adianto_ipb@yahoo.com*).

Sustainable forest management does not relate only to the technical aspects, but also needs to be supported and could be achieved among other by green fiscal policies. Therefore, it is a pivotal task to formulate green fiscal policy schemes to address sustainable forest management through synchronizing legal basis, income accounting system, and tariffs in forestry sector. Amendment on fiscal balance law is a must since it promotes indirectly, over-exploitation of nature resources. Under the existing fiscal balance law, the local authority tends to maximize regional income by exploiting nature resources over a sustainable level. It means that the existing fiscal balance failed in preserving nature resources from over exploitation practices and tends to emphasize only on maximizing economic growth by scarifying nature resources. Accordingly, to ensure sustainable forest management, it needs new schemes to reform fiscal policies towards more comprehensive, fairer, and more respect to environment. This study examines some options to transform political theories into practice by improving the national income accounting system, amending fiscal balance law, and recommending set of schemes to implement green fiscal policy in forestry sector by promoting legal instruments to regulate payment for environmental services, purchasing land use right, and liability rule.

The importance of cultures in the development and implementation of forest policy management. Ramamonjisoa, B.R. (*University of Antananarivo, Madagascar; bs.ramamonjisoa @ essa-forets.org*).

Forest ecosystems are increasingly recognized for their roles in climate change and environmental services, including provision of forest products. However, deforestation and forest degradation continue throughout the world, despite the implementation of conservation and sustainable management programs, and development of law enforcement and/or incentives measures to reduce forest loss and degradation. The evaluation of associative and community capacity by social scientists has concluded that community management models may be effective because of communities' predisposition to the conservation of natural resources, including forests. However, following a culturalist approach, this theory can be refuted. Analysis of oral tradition (tales, legends, proverbs, speeches . . .) is a culturalist approach that allows unraveling of perceptions and experiences. Through observation of socialization by families in Madagascar, we have been able to capture the true local perceptions of the forest that justify its use. Use of forest resources is not justified solely by economic or social incentives. Other cultural incentives related to ancestral religion have important influences how people use forest land. The conclusions of these studies are used to define new methods of integration of local knowledge in policy management of forests.

Congo Basin forests and climate change: between discourse and institutional analysis. Somorin, O. (*Center for International Forestry Research, Cameroon; o.somorin@cgiar.org*), Brown, C. (*University of Guelph, Canada; hcpbrown@uoguelph.ca*), Sonwa, D. (*Center for International Forestry Research; d.sonwa@cgiar.org*), Arts, B. (*Wageningen University, the Netherlands; bas.arts@wur.nl*).

The potential role of the Congo Basin forests as the "second lungs of the earth" in the global carbon budget is currently receiving both scientific and political attention. With a complex triad of safeguarding the livelihoods of its multiple dependent-societies, contributing to national economies, and the emerging "carbon-driven conservation" through REDD; the forest is finding itself in a

new global debate. This paper seeks to theorize and analyze the current policy discourse and institutional dynamics around the Congo Basin forests under the changing climate. For discourse analysis, we use the Policy Arrangement Approach as an analytical framework. The framework is shaped in terms of policy discourses, actors and coalitions, resources and power and rules of the game. For institutional architecture, we combine the cross-cutting themes of the Earth System Governance and insights from neo-Gramscian and governmentality perspective: 1) the nature of power and influence; 2) the dynamics between structure and agency; 3) the relationship between state and non-state actors; and 4) the rationalities and practices of governance. Analysis of in-depth interviews from Cameroon, CAR and DRC show that central to discourse and institutional analyses is the pragmatic interaction of the duality of structure (rules and norms) and agency (actors).

Posters

A study of effective utilization program of the forest certification system for private forest owner. Choi, S.H., Woo, J.C. (*Kangwon National University, Republic of Korea; skkarima1@nate.com; jcwoo@kangwon.ac.kr*).

The forest certification system, which has significant meaning in the context of ecosystem management, is a forest supervision system involving non-governmental organizations. The system evaluates whether forests are managed sustainably according to criteria and indices required for forest certification, which include environmental, economic and social aspects. According to its 5th forest plan of the Korea Forest Service is moving forward towards the policy goal of enlarging the area of certified forest to 300,000 ha, including National Forests, by the year 2017. However, forest management through forest certification is not widely practiced until now in Korea, because of lack of understanding about forest certification and its management requirements. Therefore, this study investigates certified forest areas in Korea, comparing the conditions before and after certification. It also analyzes the actual efficiency of forest certification, and presents alternatives for maximizing the effect of forest certification.

Proposal for the direction of forest landscape policy in Korea by importance-performance analysis. Kim, J.J., Kang, M.J. (*Korea Forest Research Institute, Republic of Korea; jjkim@forest.go.kr; navyzzang@gmail.com*).

The purpose of this study was to provide information that could be used to improve implementation of forest landscape policy in Korea. For this assessment, the Importance-Performance Analysis (IPA) was adopted. In-depth investigations were conducted involving local government officials working in various forestry sectors. The total number of respondents was 232 persons, of whom 105 provided effective responses to questionnaires that were screened using the IPA method. According to our analysis, a total of 15 aspects, or properties, of forest landscape policy were emphasized. Among these, the property of *Need to be Kept up Good Work* was classified into four components: strong driving will of the Korea Forest Service (KFS) for landscape policies, of local governors and of local officials, and legal and systematic supports by the KFS. Furthermore, the property of the *Need to be Concentrated Here* was also classified into four items: supply of the information and data such as guidelines to improve forest landscape condition, budget support of KFS, forest owner's consent to the forest landscape work, and the optimum level of officials' number in forest sector.

Study on the awareness of local officials towards forest landscape policy in Korea. Kim, J.J., Kang, M.J. (*Korea Forest Research Institute, Republic of Korea; jjkim@forest.go.kr; navyzzang@gmail.com*).

This study aims to survey the current awareness of local officials towards forest landscape policy in Korea. Inquiries involving 105 questionnaires related to forest landscape policy were sent to local officials. From the survey, we found out that their recognitions on the landscape law legislated in 2007, and their plans for the landscape based on the law, were insufficient. Most of the respondents replied that they were considering the forest landscape when conducting forest practice. Their suggestions of main business techniques for forest landscape management were as follows; promoting forest theme parks, urban forest and village groves, tending of forests through thinning and pruning, and operating forest management along major roads and rail roads. Also, they proposed that management of forest landscape could be connected to the development of ecologically healthy forests, to improving tourism resources, and to the improvement of local image. Forty-six percent of respondents indicated that forest landscape management did not apply to the whole forestland but to more particular forest areas such as around trails, village groves and tourist attractions.

A compative study on forestry household economy survey between Korea and Japan. Lee, S.Y., Park, D.G. (*Korea Forest Research Institute, Republic of Korea; leeferas@korea.co.kr; pdk5920@hanmail.net*).

Forests in Korea represents about 64% of total area in the country and forest resources have continuously increased in terms of their growing stocks and biodiversity in recent decades. Understanding structure and characteristics of forest ownership and management is useful for establishment of national forest management plans and to develop competitive forest industries using existing forest resources wisely. The first Forest Household Economy Survey was done in 2004 to provide basic data for the establishment of forest policies and the improvement of forest management by analyzing trends in forestry household economy and changes in forest management patterns in relation to changes in the economy of society as a whole. It also helps to understand status of forest owners by size, regional distribution, and forest management practices. The objectives of this case study are to do comparative analysis on the Forest Household Economy Survey in Korea and Japan with respect to the survey systems used and the contents, and to introduce a flexible and cost effective survey system.

Changing membership in the traditional community forest management systems in Japan. Yamashita, U. (*University of Tokyo, Japan; utaco@chikumagawa.jp*).

With the decline in timber value and a decrease in silvicultural operations in unmanaged forests, changes in traditional community forest management system (*Iriai*) have been taking place in Japan. Strict rules to manage Iriai forests have been loosened in response to a decrease in the exploitation of forest resources and transformation of local communities. In particular, new arrivals to local communities have had impacts on the characteristic of clearly defined membership of the Iriai rights-holders. This study analyzes how the Iriai rights-holders have responded to the increase in new arrivals into their communities. Case studies were conducted in the hamlet forests which have yet to be modernized in their ownership in Nagano Prefecture, Japan. As

a result, two types of behaviours were observed. In one case, Iriai rights-holders accepted new arrivals to become members of the Iriai right-holders with or without conditions. In the other case, Iriai rights-holders did not accept newcomers on any condition. It was revealed that the economic value of the Iriai forests, the number of new arrivals into the local community and the persistence in traditional customs have effects on the behaviours of Iriai rights-holders.

H-09 Future of forests—responding to global changes

Organizer: Gerardo Mery, *Finnish Forest Research Institute/IUFRO, Finland, gerardo.mery@metla.fi.*

Forest health in a changing environment. Alfaro, R. (*Natural Resources Canada, Canada; ralfaro@pfc.forestry.ca*), Battisti, A. (*University of Padova, Italy; andrea.battisti@unipd.it*), Carroll, A. (*University of British Columbia, Canada; allan.carroll@ubc.ca*), Fleming, R. (*Natural Resources Canada, Canada; Rich.Fleming@nrcan-rnc*), Hantula, J. (*Finnish Forest Research Institute, Finland; jarkko.hantula@metla.fi*), Hennon, P. (*U.S. Forest Service, USA; phennon@fs.fed.us*), Lanfranco, D. (*Universidad Austral, Chile; dlanfran@uach.cl*), Lilja, A., Müller, M. (*Finnish Forest Research Institute, Finland; arja.lilja@metla.fi; michael.mueller@metla.fi*), Ramos, M. (*Universidad Austral, Chile; mar.ramos@postgardo.uach.cl*).

Accelerated rates of change in the earth's atmosphere resulting from global warming will have profound effects on future forest distribution and composition, as well as on the organisms that live and depend on the forest. It is anticipated that through increased stress, trees will become more susceptible to insects and diseases. At the same time, changes in temperature and precipitation regimes will cause alterations in the life cycle of insects and diseases -increasing their host range and virulence- and making them important drivers of change in forest ecosystems. In addition to these effects, forest health is threatened by invasive species. Accelerated global trade will increase the likelihood of cross-continental introduction of insects and diseases, plants and animals alien to native ecosystems, causing transformation and economic loss already stressed by global warming. Forest resistance to climate-induced forest health decline can be increased by a number of measures, which include increasing forest complexity and assisting forests to migrate and adapt to the change. Complex decision-making systems may need to be developed to assess climate risk and forest health impacts. Forest pest management can play a role in mitigating the effects of climate change on forests and society.

Ability of institutions to address new challenges. Cashore. B. (*Yale University, USA; benjamin.cashore@yale.edu*), Galloway, G. (*CATIE, Costa Rica; galloway@catie.ac.cr*), Puente, M. (*Fundación Esquel, Ecuado; makitti@yahoo.com*). Cubbage, F. (*North Carolina State University, USA; cubbage@gw.ncsu.edu*), Humphreys, D. (*Open University, UK; D.R.Humphreys@open.ac.uk*), Mc, Dermot C. (*Oxford University, UK; constance.mcdermott@ouce.ox.ac.uk*), Maryudi, A. (*Göttingen University, Germany; maryudi76@yahoo.com*), McGinley, K. (*U.S. Forest Service, USA; kathleenmcgcol@gmail.com*), Temu, A. (*ICRAF, Kenya; a.temu@cgiar.org*), Katila, P. (*Finnish Forest Research Institute, Finland; Pia.Katila@metla.fi*).

This article reviews the current state of knowledge regarding the most promising institutional configurations with which to addressing new and enduring forestry challenges. Our substantive interests include the complex role of forests as emitters and sequesters of carbon, the water cycle, the role of forest in poverty alleviation and the promotion of responsible and sustainable forest management. Our purpose is not to provide definitive answers, but to assess the current state of knowledge, and to help focus the next generation of scholarly and practitioner efforts. To accomplish this review we make two conceptual distinctions. First, we focus our attention on understanding when and how institutions might earn long term support from a range of forest stakeholders and civil society. Second, we argue that governance/political science conceptions of institutions must be expanded to include more explicitly educational and scientific institutions that create knowledge and produce the technical expertise critical for policy implementation and problem amelioration. Such an integration is a prerequisite for promoting capacity building to which a range of scholars and practitioners have devoted significant efforts but to which, the evidence indicates, often fall short in achieving stated objectives.

The Amazon forests at the crossroads: pressures, responses and challenges. De Jong, W. (*Kyoto University, Japan; wdejong@cias.kyoto-u.ac.jp*).

The Amazon basin and its rich forest has inspired much debate about its natural treasures, potential for economic development and the rights of its populations to exclusive benefits. This debate started in the 1970s and has not stopped since then. The presentation is based on "The Amazon Forests at the Crossroads: Pressures, Responses and Challenges", a paper that points out some of the dominant key social, occupational and political dynamics of lately. It reviews a number of the threats that affect forests and forest related livelihoods: cattle ranching, soy bean production, logging, infrastructure expansion, and the oil and gas industry remain the major culprits. These sectors have changed over the years and have adapted to a new economic, political and social climate. The chapter subsequently reviews the responses over the last years to address those threats. Important progress has been made in institutional overhaul, land tenure reform, decentralized government and deregulation and incentives to support sustainable forest use, in particular the newly emerging REDD initiatives. The final part of the paper makes a balanced assessment of conflicting interests, persisting threats and responses that have achieved positive outcomes, while old and new challenges continue to need much attention.

New strategies and approaches to address global changes in forestry. Galloway, G. (*CATIE, Costa Rica; galloway@catie.ac.cr*), Mery, G., Katila, P. (*Finnish Forest Research Institute, Finland; gerardo.mery@metla.fi; pia.katila@metla.fi*), Alfaro, R. (*Natural Resources Canada, Canada; ralfaro@pfc.cfs.nrcan.gc.ca*), Varjo, J. (*Finnish Forest Research Institute, Finland; Jari.Varjo@metla.fi*), Kanninen, M. (*Center for International Forestry Research, Indonesia; m.kanninen@cgiar.org*), Lobovikov, M. (*FAO, Italy; maxim.lobovikov@fao.org*).

This paper brings together new strategies and approaches to respond to global drivers of change and challenges impacting both forests and interrelations between forests, society and the environment, including global environmental changes, global changes in

markets, investments and technology, societal drivers affecting forests and inter-sectoral drivers. Response to these drivers of change requires innovation at the policy level and proactive participation by a diverse array of institutions and stakeholders in collaborative policy implementation. Of particular importance is the collective ability of institutions to create an enabling environment that favors sustainable forest management and that is capable of adapting to change over time. Owing to the complex nature of these challenges, integrative and systemic approaches are required that bring together organizations and stakeholders from different sectors of society that interact with forests and have an impact on them. These approaches require leadership and technical support of professionals with skill sets not often fostered in traditional forestry education. In summary, this article will highlight policies and institutional arrangements and changes that need to be introduced in forestry education and research agendas to respond to global drivers of change.

Global drivers of change and new challenges affecting forests. Katila, P. (*Finnish Forest Research Institute, Finland; pia.katila@metla.fi*).

Important drivers of change affect forests and forestry globally. These include environmental changes, changes in technology, markets, and investments, and societal changes. Many of the drivers originate from outside the forest sector, e.g. from agriculture and energy sectors, and the increasing complexity and dynamics between sectors. Climate change is an important driver of change affecting forests and other natural resources and thus livelihoods and sustainable development. Mitigation of climate change and adapting to it pose new challenges to forestry. At the same time globalization of economic and financial activities is leading to changes in forest product markets and investment. Forests are crucial for rural livelihoods but increasing urbanization and urban centred consumption and production activities are essential drivers in the long-term ecosystem changes. The attitudes to and perceptions of forests are also changing reflecting the changes in forest values. The interactions and complexities between and within the different changes affecting forests and forestry create considerable challenges. To address them requires more holistic and intersectoral approaches at local, regional and global levels.

Forests and adaptation to climate change: challenges and opportunities. Locatelli, B. (*CIRAD-CIFOR, Indonesia; bruno.locatelli@cirad.fr*), Thompson, I. (*Natural Resources Canada, Canada; ian.thompson@nrcan.gc.ca*), Brockhaus, M. (*Center for International Forestry Research, Indonesia; m.brockhaus@cgiar.org*), Buck, A. (*IUFRO, Austria; buck@iufro.org*).

Climate change is an important driver of changes in forests. As many forests are likely to be affected by climate change and its associated disturbances and many forest-dependent societies may be consequently affected, adaptation is needed for reducing the vulnerability of forests. New challenges arise from the need to understand the vulnerability of, and means of adapting, forest and forest-dependent people to climate change. Forests have also a role to play in the adaptation of broader society to climate change, as they provide diverse ecosystem services that contribute to human well-being and reduce social vulnerability. For this reason, forests should be considered in planning the adaptation of the society beyond the forest. Ecosystem-based adaptation, an emerging approach to adaptation, offers opportunities for forest and forest dependent people as it recognizes their role in providing ecosystem services for the society and supports the conservation or sustainable management of forests. This presentation gives an overview of climate change as a driver of changes in forests, the challenges and opportunities of adapting forests and the use of forests for adaptation, as well as the associated policy issues.

Future of forests: responding to global changes. Mery, G. (*IUFRO, Finland; gerardo.mery@metla.fi*), Alfaro, R. (*Natural Resources Canada, Canada; ralfaro@pfc.cfs.nrcan.gc.ca*), Katila, P. (*Finnish Forest Research Institute, Finland; pia.katila@metla.fi*), Galloway, G. (*CATIE, Costa Rica; Galloway@catie.ac.cr*), Varjo, J. (*Finnish Forest Research Institute, Finland; Jari.Varjo@metla.fi*) Lobovikov, M. (*FAO, Italy; maxim.lobovikov@fao.org*), Kanninen, M. (*Center for International Forestry Research, Indonesia; m.kanninen@cgiar.org*).

A synthesis of the latest output of IUFRO-WFSE, the book "Future of Forests – Responding to Global Changes" will be presented. This collaborative effort is involving researchers from multiple disciplines from throughout the world. The book focuses on global drivers of change and challenges impacting forests and forestry. Critical analyses on a number of topics related to global environmental changes such as climate change, biodiversity conservation, and forest health are provided, as well changes related to markets, investment and technology. Societal drivers affecting forests and inter-sectoral issues are also analyzed. A number of case studies serve to illustrate how society and institutions are striving to respond to the aforementioned drivers of change at different scales in diverse parts of the world. Special emphasis is placed on policies and institutional arrangements being pursued to address new challenges and how global and regional policies goals translate into tangible progress in sustainable forest management at the local level. Drawing on experience to date and perceived growing complexity of the forestry sector, policy and institutional arrangements are proposed, as well as conclusions about the profile of new professionals to meet crucially current challenges affecting forest, society and the environment.

Posters

Fire risk under changing climate in the southern U.S. Goodrick. S., Stanturf, J., Liu, Y.Q. (*U.S. Forest Service, USA; sgoodrick@fs.fed.us; jstanturf@fs.fed.us; yliu@fs.fed.us*).

Most forests in the Southern United States are affected to some extent by fire. Changing climate and land use will affect fire risk. As part of a larger effort to project future forest conditions, we examined the likely changes in fire risk using the Southern Fire Risk Assessment System (SFRAS) to evaluate current fire risk by sub-region and evaluated wildfire risk under future climate scenarios for areas of changing land use and population growth. Five sets of model runs of SFRAS produced maps of the Wildland Fire Susceptibility Index for (1) baseline of current land cover, climate and fire occurrence; (2) changed land cover, current climate and fire occurrence; (3) changed climate, current land cover and fire occurrence; (4) changed land cover and fire occurrence, current climate; and (5) changed climate, land cover, and fire occurrence. Within each change scenario, we display results at decadal intervals for 50 years. We used a cellular automaton program to allocate cells to new cover classes and changed climate by developing new percentile weather conditions under the new climate scenarios. Fire occurrence change used

relationships between demographics and urbanization to simulate human ignitions; we assumed frequency of lightning ignitions remained the same.

The future of forest and forestry statistics in Japan. Yamamoto, N. (*Forestry and Forest Products Research Institute, Japan; n.yamamoto@affrc.go.jp*).

The Statistics Law in Japan was proclaimed through the unanimous approval in Parliament, and was enforced completely in April, 2009 on May 23, 2007. This new Statistics Law unifies Statistics Law enforced in 1947, and Statistical Reports Coordination Law enforced in 1952, and revises both. Sixty years after World War II, the basic law for a statistics system in Japan was revised radically for the first time. From now on, along with "the fundamental plan about maintenance of public statistics" based on regulation of Article 4 of Statistics Law, statistics in Japan will begin afresh. With these changes in the statistical system in Japan, changes in forest and forestry statistics system is also changing. In this paper, the trends in forest and the forestry statistics system in recent years will be reviewed, and the changes, challenges, and outlook under national statistics reform will be discussed.

H-10 Wood and forest culture: yesterday's lessons and today's impact

Organizers: Howard Rosen, *U.S. Forest Service, USA, hrosen@fs.fed.us*; Young Woo Chun, *Kookmin University, Republic of Korea, ychun@kookmin.ac.kr.*

Historical wooden structures for forest utilization and cultural heritage in Italy: conservation strategies in sustainable forest management. Agnoletti M. (*University of Florence, Italy; mauro.agnoletti@unifi.it*).

In Italy forests have been utilized for the production of timber at least since Roman times. The most important area for this activity is probably in the north east of Italy. The area was dominated by the Republic of Venice from the 11th century to 1796. One of the strengths on which the power of Venice was based was the efficiency and the high technical level of the organization of the timber industry, upon which shipbuilding depended. Water powered saws, already used in the 9th century, were the most important elements of the system. A survey carried out in the north east of Italy has shown their distribution and their technical features. The conservation of these structures has been included in the rural policy strategies supported with the funding of the European Common Agricultural Policy. The role of cultural values related to forestry is recognized also at the European level by the Ministerial Conference on the Protection of Forests in Europe (MCPFE). Several indicators have been proposed to assess them. The incorporation of cultural values in sustainable forest management at the global level is essential for current and future generations.

The importance of wood anatomy in the detection of imitation objects in museums. Asensi Amoros, V. (*Xylodata SARL, France; victoria.asensi@free.fr*).

Museums in the world have wooden objects belonging to ancient civilisations. Studies on woods used in ancient time were mainly based on classical iconographic and epigraphic sources completed by the archaeological material (specially for Egyptian, Roman and Greek cultures); however the comparison between those sources and microscopic wood identification shows some differences between them, or some points which need to be further investigated. When we have a wooden artifact, the only way to know the wood species used is microscopic identification. Each civilization chooses the wood depending on the availability of natural forest resources; as well on the physical and mechanical wood properties or the beauty of the material. For example, if an American species is detected in an alleged twelfth century B. C. Egyptian object, the object is an imitation. The same logic can be applied for each part of the world. Wood anatomy helps us to better understand some historical, economical and symbolic aspects relating to ancient civilizations. We can observe what kind of wood was used for a particular artifact and, for imported wood, we can follow the international trade from past to present.

Changes in the species of woods used for ancient and historic Korean architecture. Lee, K.H., Park, W.K. (*Chungbuk National University, Republic of Korea; bluesea044@hanmail.net; wood1957@hanmail.net*).

We investigated the changes in species of woods used for Korean ancient and historic architecture, from prehistoric excavated relics to existing wooden buildings in South Korea. In prehistoric periods, hardwoods were the major species. Oak woods dominated, but less important ones were *Juglans*, *Platycarya, and Castanea*. During the Iron Age and the Three Kingdom periods, oaks remained a major species (57%) and others included *Platycarya*, *Castanea*, and *Pinus* spp. The use of oak sharply decreased in the Koryo period, when pine (71%) and *Zelkova* (22%) dominated. In the early and middle Joseon periods, pines remained a major species; less important ones were oaks and *Zelkova*. In the late Joseon period, pine woods were used more than 80% of the time. In the late 19th century, a few boreal species such as larch and spruce were found, transported from northern Korea. Existing buildings in Korea are mainly from the Joseon period and a few from late Koryo periods, when mostly pine woods were used. In earlier times, broad-leaved trees such as oak and *Zelkova* were the major materials. The changes in building materials resulted from both climate and human impacts. The dry climate and disturbed forests induced more pines in the mountains.

Color changes in wood, paper and their components during natural aging and heat treatment. Matsuo, M., Yokoyama, M., Umemura, K., Kawai, S. (*Kyoto University, Japan; matsuomiyuki@rish.kyoto-u.ac.jp; myokoyama@rish.kyoto-u.ac.jp; umemura@rish.kyoto-u.ac.jp; skawai@rish.kyoto-u.ac.jp*).

This study aims to verify the usefulness of color for monitoring aging of wood and paper and to explain the mechanism of color changes during aging. Natural aging of wood and paper at ambient conditions produces significant changes in physical, mechanical, and chemical properties. Since color is one of the properties that changes during aging, color has been empirically

used as an aging index of cultural heritages and artifacts by restorers. Three types of samples were prepared for color measurement; (1) naturally aging wood and paper samples to examine color changes during natural aging, (2) wood and paper samples heated in a drying condition at various temperatures to explain natural aging process as thermal oxidation by using kinetic analysis, and (3) heated cellulose and heated wood samples whose components were gradually subtracted to examine the contributions of each component to wood and paper color changes. Successful kinetic analysis for wood color changes indicated that color changes of wood during natural aging is the results of thermal oxidation in ambient conditions. By comparing color changes of wood and paper samples with those of each component, for example, color changes of cellulose contributed to those of wood and paper.

Interaction between forest resource use and social systems: a case study of the Solomon Islands. Miyauchi, T. (*Hokkaido University, Japan; miyauchi@let.hokudai.ac.jp*).

This presentation explores the relationship between the use of natural resources and social systems based on a field research begun in 1992 on Malaita Island, the Solomon Islands. The various uses of natural resources among the local people are described, in particular seminatural resources, i.e., resources that are neither domesticated nor wild. Varioius seminatural resources create stability in the community. The importance of the concept of "seminature " is also explored. The study also found that the various uses of these resources are linked with social systems, particularly land ownership. In Malaita, land is owned collectively by clans, and the use is governed by flexible regulations. Without this system, people would be confined to a small area and would not have access to the larger areas, so they could not enjoy the various natural resources. The link between the various uses of natural resources and common property systems is crucial to the sustainability of nature and society. Based on the Malaita case study, a model is presented relating the linkage between the use of natural resources and social systems. The model explores sustainability of natural resources through the interaction between human/nature relations and multi-layered social institutions.

Manufacturing techniques for wooden coffins the in Joseon Dynasty. Park, W.K., Kim S.K., Kim Y.J. (*Chungbuk National University, Republic of Korea; wood1957@hanmail.net; kskksk8181@hanmail.net; fairy@cbnu.ac.kr*), Lee H.C. (*Korea National Arboretum, Republic of Korea; leehc1012@hanmail.net*).

The study was carried out to analyze tree-ring dates of coffin woods (84 coffins in 53 graves) in the Joseon Dynasty and their manufacturing techniques. These coffins were dated from early 16th to late 19th century by tree rings. The species of coffin woods was exclusively hard pines, most likely, *Pinus densiflora* (Japanese red pine, 'sonamu' in Korean). Two types of coffins were found; double wood coffins with a plaster cover and one wood coffin with outer plaster-made mold (a so-called 'outer coffin'). The former type seems to precede the latter one which became predominant after the 16th century. The lengths of coffin woods were random, indicating an order-made instead of a ready-made coffin. However, the thickness of coffin woods was dependent upon the social class of buried people, i.e., thicker for the higher-class people. One or two fist-shaped heads was the primary method for connecting side and end panels. Varnishing with oriental lacquer and black paint made from charcoal mixture were detected by IR spectroscopy. The black-powder layers under the seven-star holed panel on which the corpse laid were identified mostly as wood charcoals but in a few cases as charred or raw straw (rice).

Evolvement of wood culture in the United States. Rosen, H.N. (*U.S. Forest Service, USA; hrosen@fs.fed.us*).

Wood Culture is an interdisciplinary science area which provides a better understanding of the use and social aspects of wood from a cultural perspective. In the United States (U.S.), there has been a rich history of forest products use since the early settlers in the 17th century. Forest products have been a major strategic asset and are critical to the social, economic, and ecological well being of the United States. U.S. history includes trees removal for farmland and significant production of timber products, such as log homes, train trestles, fences, and bridges. There is a rich culture in art, literature, poetry, and drama that developed as a result of an emphasis on forest products. The U.S. is a wood oriented country, ranking third of all countries in volume of standing forest timber. Abundant forest resources and prudent forest management have allowed U.S. industry to make wood the single largest material resource of industrial production. Approximately 330 million metric tons of wood is harvested annually in the United States, which is by far the world's largest industrial timber-producing nation. The focus of this presentation is on the rich history of wood culture in the U.S. and the use of forest products in the development of the country.

India's forest culture – can age-old traditions of forest management be guidelines for the future? Seeland, K. (*ETH Zurich, Switzerland; klaus.seeland@env.ethz.ch*).

The legacy of India's still persistent forest culture has ventured into a new phase in which its age-old traditions are challenged by social and environmental changes. This process causes friction between the 90 million forest dwellers and the mainstream society. At present in India there is a dilemma of economic development and the preservation of natural resources and cultural values. The tribal life-world of some tribal ethnic groups of Orissa (India), among which the author's research team has done extensive empirical social scientific research, shows that it is basically established from various interconnected dimensions of space, knowledge and values. These dimensions are perceived and integrated in an overall spiritual perspective. The tribal culture is established by each phenomenon or social process which refers to them. The paper describes tribal forest perception and management concepts and examines them under societal and political conditions of a modern nation state. Socio-political interactions between forest-dwelling tribes and the local non-tribal population as well as the forest administration are taken into account and suggest solutions for future developments in the renewable natural resources sector of India.

Wood and forest culture in Brazil. Tomazello Filho, M. (*University of Sao Paulo, Brazil; mtomazel@esalq.usp.br*).

The wood and forest culture of Brazil represent a strong connection with the history of the country, whose name is derived from a traditional tree species, Brazilwood, *Caesalpinia echinata*, heavily exploited by the early settlers. The presentation aims to review this history of wood and forest culture in Brazil. Since the indigenous population with ancient traditional knowledge has combined with modern society and new technological advances; the culture of wood and the forest is strategically linked to economic, environmental, historical, and social issues. Currently, forest plantations of eucalyptus and pine species occupy large

areas providing industry with wood for wood products. The new forests landscape and wood supply of unknown tree species require adaptability, especially related to cultural and technological aspects of the society. Furthermore, an initiative has been advanced to preserve the tropical forests and to protect the indigenous populations and traditional forest inhabitants. Among these, are the recognition of ancient customs directed at the rational exploitation of forests, the use of non-timber products, sustainable forest management, and the demarcation of indigenous reserves. Our society is continuously receiving information on environmental education and the importance of consumption of timber products originating from managed forests or reforestation.

The stability of fundamental cultural values among indigenous people of North America. Trosper, R.L., Bateson, K., Singh, M., Chandran, A., Barnes, J. (*University of British Columbia, Canada; ronald.trosper@ubc.ca; kebcree@hotmail.com; monikaxing@gmail.com; ajithchandran@yahoo.com; littleboxes@gmail.com*).

Having been exposed to great pressure to adopt the values of the settler societies in North America, many indigenous people have tenaciously maintained their fundamental values regarding their relationship to land. This assertion can be checked using the Q method to elicit opinions from a community considering land use policies. Although the mix of opinions varies in different communities where the method was used in Canada in the 21st century, those views remain broadly consistent with attitudes revealed by other means, namely that respect for the land is very important. We found slightly more variability in the forms of expression in a community whose ties to the land had been under great challenge; in that community, some preferred to express their ties to the land in spiritual terms, while others were more secular. The Q method would appear to be a useful approach which allows communities to express their views in novel ways, allowing attention to subtleties in the midst of general agreement. By distinguishing views by gender, age, or political office, one can determine how views vary within a community. We conclude that the Q method is a useful method for evaluating opinions.

Overview of integrated wood protection in the conservation of wooden artifacts of historical significance. Unger, W. (*University of Applied Sciences Eberswalde, Germany; wunger@fh-eberswalde.de*), Unger, A. *(University of Applied Sciences Potsdam, Germany)*

In this paper we discuss the advantages and disadvantages of different integrated wood protection materials and methods in the field of conservation of wooden artefacts. *Wood conservation* consists of the protection of wood of historic and/or archaeological importance. The profession has a long history for academies of arts and for skilled restoration professionals. *Wood consolidation* is one component of wood conservation. *Wood preservation* includes the protection of wood against deterioration using chemical agents or by other means including *wood modification*. *Integrated wood protection* encompasses all measures designed to permanently prevent the damage or destruction of wood and wood-based materials by insects, fungi, marine borers, and bacteria. Measures relating to building technology are selection of wood species resistant to bio-deterioration and construction methods which protect wood from moisture accumulation and adverse weathering effects. Physical methods to preserve wood include the application of heat and cold treatments and use of electromagnetic radiation such as microwaves and gamma rays. Chemical methods involve the use of preservatives or fumigants. Biological methods include the biological control of insect infestations and other such methods for wood protection. In Germany, our institutions are actively involved in wood conservation using the various technologies available for integrated wood protection.

Memorable and sacred trees in the Czech Republic: causes of the loss of natural and cultural heritage during the 20th century. Woitsch, J. (*Czech Academy of Sciences, Czech Republic; jiri.woitsch@post.cz*).

Inventories of memorable trees in Bohemia were published in the early 20th century. An inventory made in 1908 recorded 165 trees and parts of the forests. Today the Czech Agency for Nature Conservation registers 3,136 memorable trees. The veteran trees are considered to be extraordinary because of their growth or age. They constitute dominant features of the landscape and commemorate historical events or various legends and fables that were considered magic and sacred. The analysis of the inventories from the beginnings of the 20th and 21st century proved interesting and informative. The inventory from the year 1908 served as the basis for this research. Early data on the trees were compared with all subsequent inventories; the biological development of plants was monitored (e.g. height, age, causes and time of death). For certain trees the postures and knowledge of local inhabitants were traced, including the folklore presentations, religious, ritual practices, etc. The results of the analysis of a documented sample of the Central European environment show an uneven pace of the destruction of trees in various regions, changes of the attitudes of local communities to nature, and loss of traditional religious behaviour.

Wood culture activities in China and the wood education movement in Japan. Yang, P. (*Kumamoto University, Japan; yangping@educ.kumamoto-u.ac.jp*).

As an ecologically-friendly and renewable resource, wood has contributed to human civilization and the advancement of mankind. As examples of these contributions, the adoration of wood culture in China and promotion of wood education in Japan are worth examining. As a leading proponent of a comprehensive wood culture, The International Wood Culture Society (IWCS) is dedicated to exploring the value and usage of wood from a cultural perspective to advance human experience, knowledge, wisdom, and inspiration of wood. IWCS has had success in organizing international conferences and local exhibitions in China, establishing a website, and publishing a magazine. Such efforts provide guidance in scientific applications and daily effective uses of wood and advocacy for a harmonious relationship with nature, which will ultimately have the ideology and practice of wood culture make a positive impact on our lives for generations to come. In Japan, wood education is a national strategy to produce new green consumers who will appreciate wood products indefinitely. A methodical education process emphasizes stepwise activities of feeling, assembling, and creating by using wood not only in schools but also in communities in collaboration with other groups. These regional wood cultural and educational activities are expected to spread world-wide.

Culturo-social forestry derived from the cultural services of trees and forest ecosystems. Yi, C.H. (*Korea University, Republic of Korea; yicheongho@korea.ac.kr*), Chun, Y.W. (*Kookmin University, Republic of Korea; ychun@kookmin.ac.kr*).

From the ecosystem service perspective of the 21st century, trees and forests are one of the best providers of "cultural" ecosystem services to humanity. These important ecosystem resources, which have long provided fuel and products, have been drastically

reduced in developed countries, while the regulatory ecosystem services or environmental functions of forests have recently become more important in global social consciousness and behavior. This explains the current high level of emphasis on culturo-social and environmental values of forests. The perception of trees and forests as complex naturo-cultural resources and the use, protection and management of trees and forests for culturo-social purposes have ancient origins and should be approached from the pre-modern cultural logic of past ages. Culturo-social forestry with abundant cultural logic derived from human-forest interaction is different from the modern production forestry practices in which almost no cultural sense is observed and the end products of logged wood and pulp are normally pursued solely for their economic value. A good case of modern urban South Korea in culturo-social forestry was developed in the 1990's; it is also a good example of pre-modern to modern modes of human-forest interaction.

Eighteen-year-fir trees and forest management in the Dong community in China. Yuan, J. (*Guizhou College of Finance and Economics, China; yuanjuanwen@yahoo.com*), Wu, Q. (*Kaili Cultural Institute, China; wuquanxin@hotmail.com*), Xu, Z. (*Guizhou College of Finance and Economics, China; xuzhuyan2006@sina.com*).

This paper documents the 18-year-fir tree (daughter fir) forest management by the Dong ethnic group in Guizhou province, China. Eighteen-year-fir tree management is part of the traditional Dong culture to manage the forest, which means that 100 fir trees are planted when a baby is born and these trees will be cut for preparing the child's marriage after 18 years. The Dong people treat these fir trees as nurturing the children, so trees are replaced every 18 years. They treat a tree as a human being and think a tree has a spirit and cannot be damaged deliberately. They have a harmonious view of nature and people. Although the Dong's forest management practice is unique and is very different from modern forest management technology, it is still accomplished in a sustainable way. This paper documents its history, ecological function, and the sustainable management of this traditional culture and presents some documented cases. The paper also describes the strict forest management regulations of the Dong people to keep the forest sustainable. Generally, this traditional forest culture has a positive effect on forest management.

Posters

Forest culture in Korean ceremonial occasions. Kim, K.W., Lee, Y.H., Lee, H.S. (*Kookmin University, Republic of Korea; kwkim@kookmin.ac.kr; shineryh@kookmin.ac.kr; adoo77@hanmail.net*), Kim, J.J. (*Korea Forest Research Institute, Republic of Korea; jjkim@forest.go.kr*).

This research focuses on the examination of trees and forests that are found in basic ceremonial occasions of the Korean people. These are the ceremonies that a human being will go through at least once in his life. In the ceremony of the coming of age, a straw hat and bamboo are closely bound up together. *Lespedeza bicolor*, *Gossypium indicum*, and charcoal are used in the marriage ceremony. There is also the marriage ceremonial table which includes *Castanea crenata*, *Zizyphus jujuba* var. *inermis*, *Pinus densiflora*, bamboos and *Camellia japonica*. In the ceremony for a funeral, *Salix koreensis*, *Juglans mandshurica*, *Juniperus chinensis*, *Cryptomeria japonica*, *Pinus densiflora*, *Paulownia coreana* and bamboos are used. The ceremony of ancestral worship that takes place during a festive day, such as in *Chuseok*, the Korean Thanksgiving Day, and on Korean New Year's Day, which is also known as the tea ceremony, because this rite of the memorial for ancestors was traditionally a ceremony that tea was offered to the ancients. That is why *Thea sinensis* is used in this ceremony. Finally, for the ceremony of delivery, *Pinus densiflora*, pine forest and *Paulownia coreana* are known to be used.

The main causes of village grove loss in Korea and their relative importance. Koo, J.C., Cho, J.H., Youn, Y.C. (*Seoul National University, Republic of Korea; sele78@snu.ac.kr; paransubak@hanmail.net; youn@snu.ac.kr*).

We can think of a village grove as a traditional heritage, since a village grove is built and managed by traditional knowledge closely related to the lives of the villagers. Previously in South Korea, there were 189 village groves, but today only 37 village groves remain. The remaining village groves are now faced with significant loss. Previous research shows greater pressure for land use causes more village groves to be lost. This research attempts to apply a binary logit model to identify the main factors explaining this loss. In this research, the dependent variable is the village grove's existence. Independent variables are divided into three categories; physical, functional, and social characteristics. All the data is collected by literature review and GIS analysis. The result indicate that a village grove which has various functions (e.g., a ritual ceremony), a community for managing, and a legal restriction for land-use change was not easily lost. This result suggested that to rehabilitate a village grove, the land should be owned publicly.

Estimation of wood fuel use in some villages of Ilam province and the reasons for its decrease. Naji, H.R. (*Ilam University, Iran; hrn_16hrn@yahoo.com*), Fathy, H. (*Ilam Province, Iran; hfathy20@yahoo.com*).

Forests are important for their fundamental economic and social roles. This research was carried out in Aseman-Abad region in the west of Iran, in 18 villages with a total population of 14,036. Our objective was to investigate ways to better use the region's forest resources sustainably and improve the lives of villagers and nomads. Three questionnaires were prepared to assess the rate of wood consumption by families and villages, in order to provide practical programs to address the wood fuel resource needs. Our results show that the average rate of fuel consumption per capita is 27.5 kg and 159 kg per family, whereas the annual growth of forests is about 350 to 400 kg per hectare. Therefore a village, with one hundred families needs 15,900 kg wood fuel per year, in addition to to the amount used to fix houses, huts, hutches, stables and pens. Altogether, 385,908 kg of wood (1.8×10^{12} cal) is consumed for household energy in the 18 villages. To substitute for this, 147,595 kg of liquid gas would be needed. Existing alternative energy sources in the region are large volumes of organic matter (for biogas) and rural forestry. Growing forest plantations are a future possibility.

Koreans' traditional knowledge on village site modification through forestation. Park, B.W. (*Kangwon National University, Republic of Korea; pakbw@kangwon.ac.kr*).

Field surveys and bibliographic research were undertaken to better understand traditional Korean thought and behavior with respect to village site selection. Traditionally, Korean kept '*Bae-San-Yim-Soo*' (a site facing a river and opposing mountain) as the

fundamental principle when selecting a village site. However, because it was not easy to find such an ideal site, they would often select a less favored site and modify it to create as nearly as possible '*Bae-San-Yim-Soo*' conditions. There are many ways to modify the site, but the most frequently used modifications were mounding and forestation. Between the two, the most favored was to adjust the site through forestation, which would allow the less favored site to improve its condition and become as close as possible to the principle, '*Bae-San-Yim-Soo*'. Some of the favorite species of trees used for this method were the pine tree, in the coniferous category, and native deciduous trees of the area. The forestation not only made the site closer to the principle, but also provided 1) safety by screening out the view from the outside, 2) comfort by controlling microclimate of the site, and 3) charm by providing pleasing scenery.

Factors for the success of forest restoration and their historical roots in the traditional knowledge of Korea. Shin, J.H. (*Korea Forest Research Institute, Republic of Korea; kecology@forest.go.kr*).

There are many factors contributing to the success of forest restoration in the Republic of Korea. The first one is socio-economic stabilization and political leadership, particularly the President's strong interest and enthusiastic involvement in the restoration project. The second one is voluntary public participation, and third one is implementation of forest protection policy. There are also other factors including modernization of forestry techniques and international assistance. The top three factors have their historical roots in the traditional knowledge of Korea. Throughout Korean history, all successive kings supported greening of the land, especially in the capital city, and gave priority to managing forest mountain and water (治山治水) in many national dealings. The historical root of voluntary public participation can be found in numerous examples of traditional village groves in Korea. There is also considerable historical evidence related to implementation of forest protection policy from both government and private sector. This kind of evidence can be found abundantly in both historical documents and oral tradition. The historical roots of the success in the use of traditional knowledge in Korea are unique in that confirmation of community spirit is abundant.

Forest resources management supporting the traditional "Culture of Wood" in Japan. Yamamoto, H. (*The University of Tokyo, Japan; yama@k.u-tokyo.ac.jp*).

Timber-frame building is a symbol of Japan's "Culture of Wood" which makes use of renewable natural resources for construction. Compared to that of the West, construction in Japan is fundamentally different in that it incorporates a unique recycling system of timbers. Today the world faces a global issue of limited natural resources. In searching for a more suitable solution, this Japanese tradition of timber-frame building could guide us to an important future course so that not only Japan's buildings but also its forests, with its rich natural reservoirs, remain intact. Ninety percent of cultural buildings designated by the Japanese government are made of wood of which nearly half have roofs made of materials derived from biological materials. Due to the perishable nature of these materials, traditional buildings tend to be affected by rain and wind. Therefore, scheduled maintenances and restorations of these buildings must be continued into the future. About 30–40 percent of building parts are commonly replaced and at times requiring complete dismantling. To insure proper maintenance schedules, it is important to keep quantities of wood for repairs. A system to obtain these stocks on a long-term basis is essential.

Religious groves in Korea: their origins, types, management, and current status. Youn, Y.C., Lee, E.H. (*Seoul National University, Republic of Korea; youn@snu.ac.kr; norannamu@snu.ac.kr*).

Village groves in Korea differ in their origins, objectives, types, and forms of management organizations. Many have been lost since the colonial period of Japanese Imperialism. A number of factors are considered to have caused the loss of village groves in Korea. This study explores the trends of village grove loss and assesses the management conditions of village groves in Korea. This study surveys three regions of Korea: Gwangwon-do, Gyeongsang-do, and Cheolla-do. Sample groves were selected from inland regions and coastal regions. Inland regions were sub-divided into mountainous and flat regions. The sites of village groves were also grouped into urban and rural settings. The management status of each village grove selected was investigated in relation to their history, tree or stand composition, the utility of groves to the villagers, and the managerial organization. Mail survey, personal interviews and literature reviews were employed. The research addressed two main questions: 1) What are the key issues threatening the existence of the village grove? 2) What are the main features benefiting residents of the village?

H-11 Improving forestry education: innovative views of students and teaching staff

Organizers: Michaël Rivoire, *International Forestry Students' Association, France, michael.rivoire@gmail.com*; Siegfried Lewark, *University of Freiburg, Germany, siegfried.lewark@fobawi.uni-freiburg.de.*

Combining formal forestry education and extracurricular activities to improve students' knowledge and skills. Bari, F., Satyasari I. (*International Forestry Student Association, Indonesia; febrielbari45@yahoo.com; asia.ika.ifsa@gmail.com*).

Over 12 million hectares of natural forest are lost every year. This indicates the unbalances among utilization, protection, and preservation. Therefore youth are needed as the agent of change to implement better forest management. They will inherit the consequences of the current and historical mismanagement of forest resources. Unfortunately, current forestry curricula are not always adapted to these requirements. Undergraduate forestry students need the media to enrich their formal education. Therefore extracurricular activities should be made available in order to improve students' knowledge and skills. An example of this is the shares initiative learning system that was implemented by Department of Forest Resources Conservation and Ecotourism (DFRCE) in the Faculty of Forestry of Bogor Agricultural University in Indonesia. Besides following their formal education, the students of DFRCE can be actively involved in profession extracurricular activities through HIMAKOVA, a club in which students are divided into specific group related their interests. The annual big event conducted by HIMAKOVA is Environmental Conservation Study. The study is held in different National Parks every year. This writing is arranged by analyzing the impact of combining the formal education and HIMAKOVA to the students' knowledge and skill.

Educating managers for sustainable tropical forestry: the Sarawak experience. Bigsby, H. (*Lincoln University, New Zealand; bigsbyh@lincoln.ac.nz*).

Forest and logging managers are now being called on to deal not only with profitable forest operations, but as well, to deal with difficult environmental and social issues, and take their organizations through forest certification. As a result, developing the appropriate skills to successfully manage a logging operation that meet the goals of sustainable forestry has become an important requirement for managers in the forest sector. To meet these skill needs, the Sarawak Timber Association and Lincoln University in New Zealand have collaborated to develop an innovative postgraduate degree for managers in the logging industry. The degree is designed for working managers with all subjects being offered in a modular structure of three intensive one-week block courses where students attend a mix of lectures and field exercises in Sarawak. Between the intensive block courses students use an extensive set of written and online course materials that will be used for self-study or completing projects. The paper outlines the structure of the degree and analyses the results of this type of programme in terms of developing the necessary skill mix for the timber industry in Sarawak.

Diagnosis of the level of pedagogical preparation of forest engineering teachers in Colombia. Catalina, M. (*Universidad Distrital Francisco José de Caldas, Colombia; cata007201@gmail.com*).

In Colombia, forest engineering teachers are not obliged to receive preparatory pedagogical and teaching training in order to develop basic or advanced material for course work. An example of this can be found at the Universidad Distrital where only 5 out of the 32 "profesores de planta" (full-time university employees) are specialized in education and teaching. This directly affects learning and lowers the academic level of students because it does not allow the development of efficient and innovative teaching tools and methodologies. To solve this problem, we evaluated students and teachers by asking them to what extent they consider the academic efforts harmed by the lack of applied teaching methodology, and if the teachers were willing to attend preparatory pedagogical workshops. We also carried out a statistical analysis on the national level, where we studied the degree of pedagogical knowledge of forestry engineering teachers. The main result of our study was that the pedagogical problem is a general one among these teachers and that it exists at all faculties in the country. For this reason we suggest to develop workshops dedicated to the pedagogical preparation of forestry teachers, who would be required to attend these workshops before holding their courses.

Enhancing the capabilities of cutting-edge staff through training and capacity building: policy and implementation initiatives. Chandrappagari, S. (*Andhra Pradesh Forest Academy, India; suvarnac@yahoo.com*).

The Andhra Pradesh Forest Department (APFD) is an organization comprising of over 8,000 regular employees with cutting edge staff playing a crucial role in forest protection and management through community involvement. Frontline staff undergoes formal forest training at different levels for developing their technical and professional competencies. However, the training is organized in a routine manner following age old guidelines and syllabus with no significance attached to training by the department other than linking it with promotion eligibility. This paper attempts to bring out gaps in various relevant training activities taken up for frontline staff duly taking into account the Andhra Pradesh Forest Academy database, group discussions and personal interviews held with focus on gender, age and educational qualifications. The study reveals issues like induction training not taking place, outdated syllabus and examination structure, no specific focus on gender and vision. The conclusions include making training an integral part of all activities of APFD irrespective of funding source, more investment in training to ensure long term vision and continuity in efforts, modifying syllabus as per current requirement, imparting induction training, gender mainstreaming, sensitization of higher level officials for training their staff and developing future training strategies.

Linking research and teaching in the education of forest engineers at the National Amazonian University of Madre de Dios, Perú. Correa, G.H., Vela, L. (*Universidad Nacional Amazónica de Madre de Dios, Perú; biologo.geo@yahoo.com; cibdamdd@yahoo.com*).

In the region of Madre de Dios, the biodiversity capital of Peru bordering with Brazil and Bolivia, UNAMAD University was established ten years ago. Since 2005, the future professional foresters who study forest and environmental engineering and attend courses in plant physiology, genetics, pathology and forest entomology, have been increasingly urged to search, read, interpret and display papers of journals, as well as develop short descriptive or experimental research during the academic period of four months, with the respective tutoring, which is something that has not been institutionalized before. The experience shows that up to now the students have gained a wider perspective of their professional field; they know different sources of compiled information, mainly through the Internet; they are trained in designing and effecting research work; they have a better knowledge of English; and they even present some of their papers at scientific congresses, which increases their competence. This is considered a successful experiment as this strategy of teaching-training has also been included by many teachers in their respective courses as a counterpoint to the passive education which does not link updated information with research.

Strengthening the academic atmosphere of undergraduate education in the Department of Forest Products, Faculty of Forestry, Bogor Agricultural University: lessons and good practices learned from a six-year academic improvement project. Karlinasari, L., Hermawan, D., Massijaya, M.Y., Darmawan, W. (*Bogor Agricultural University, Indonesia; l_karlinasari@yahoo.com; dhht@ipb.ac.id*).

Through two kinds of competitive grants received from Directorate General of Higher Education, the Department of Forest Products (DFP) in Faculty of Forestry of Bogor Agricultural University has implemented a six-year academic improvement projects aiming at improving the academic atmosphere of undegraduate education. Following a reformed undergraduate curriculum at the University, i.e. new major-minor curriculum system, which has been in effect since 2005, the department has designed stimulating programs under the project such as student centered learning (SCL), reserach grants for undegraduate thesis, improvement of English language skills and promotion of link and match with relevant stakeholders. In general, results of self-evaluation showed that academic atmosphere at the DFP have been significantly improved and enhanced. In particular, the positive progress is shown by the following indicators: i) shorter length of study (from > 50 months to 48 months), ii) increased

GPA (GPA from 2.70 to 3.00), iii) increased number of research collaboration with stakeholder by almost 50% and iv) higher number of scientific publication (n = 1.2 papers/staff /year). However, some weaknesses have also been identified and will be discussed in relation to the lessons learned and good practices obtained from this six year project.

Furthering professional development in higher education of forestry and marketing. Kettula-Konttas, K. (*University of Helsinki, Finland; kirsi.kettula-konttas@helsinki.fi*), Clarkeburn, H. (*University of Sydney, Australia; h.clarkeburn@econ.usyd.edu.au*).

Besides mastering the scientific knowledge in his or her area of expertise, a graduating student should also have the general skills that a professional needs in working life. There is a wide consensus about the need for these key skills in working life, but the current higher education does not seem to further these skills well enough. This paper introduces applied drama as a promising tool to simulate real life situations and problems in the classrooms, and thus enable to train professional skills already before entering the working life. The target group consisted of students of forest ecology and forest economics and marketing participating in two courses taught through either applied drama or blended learning. Research data were collected from learning journals and questionnaires. Learning journals were analysed qualitatively and the questionnaires quantitatively (t-test). The results indicate that applied drama can bring a sense of real life and real life problems to the classroom, and thus it can further professional development by giving experiences that resemble working life experiences. These findings offer to the higher education of forest sciences a novel tool to integrate classroom teaching and practice.

Innovation through WELAN, the new world-wide e-learning academy for natural resources, forestry and wood science. Lewark, S. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*), El-Lakany, H. (*IPFE, Canada; Hosny.ellakany@ubc.ca*).

The concept of WELAN has been developed by higher education specialists from IUFRO, IPFE and forestry faculties of six universities as a worldwide e-learning academy, in order to use the potential of e-learning for improvement of higher education. WELAN will promote, facilitate, organize and run e-learning courses in scientific education and further education in the fields of forestry and wood sciences as well as management of natural resources. WELAN will also explore approaches of open learning resources, i.e. courses available without tuition fees. Activities of WELAN will start with the development of recommendations for administrative regulations including course formats, course delivery, credit recognition, accreditation, tuition fees in order to allow students from different universities as well as companies to have access to e-learning course information and to the courses of the collaborating universities and get their credits gained easily recognized independent their affiliation. Following this the development and offering of courses and course package under the umbrella of WELAN is aimed at, for organization and funding to be divided in separate projects with defined course packages. Thus in a growing and comprehensive system essential parts of natural resources, forestry and wood science will be covered.

New inputs on the global action plan for forestry education. Ortvald Erichsen, E., Kaiser, F., Rivoire, M. (*International Forestry Students Association, Denmark/Germany/France; eva.ifsa@gmail.com; iufro.lo@ifsa.net; florent.ifsa@googlemail.com*).

In 2009, the International Forestry Students Association launched an important discussion on the future of forestry education. Beyond the vital importance of educating society about forests, concrete issues for forestry universities are raised through a Global Action Plan. More than assessing the problems that hamper a good education worldwide, this plan proposes actions and means of improvements, gathered in a few main goals. Financial means and adaptation of curricula are proposed in a synthetic manner. Presented as a draft calling for discussion, this document has already been presented to several professional organizations during international conferences. They widely support this action plan motivated by students and recognize the huge work that yet needs to be done. Here, we present an original view on this plan and its potential, one year after the first draft. Designed as a collection of interviews, this presentation is intended for (i) presenting the first outcomes of the plan, (ii) developing concrete ideas in specific regions and (iii) showing the discussion in an innovative format. This gives incentive in continuing the work on this promising plan.

Why are internsips, traineerships, and Ph.D.s important for forestry students? Öztürk, Y. (*Istanbul University, Turkey; yasemin.ifsa@yahoo.com*).

In this presentation, we demonstrate how important are the internships and exchanges during one's studies, based on a case study on forest education. We show that the internships that are performed in international organisations give significant results, because they give to students great opportunities to know forest science cooperation worldwide. Working with these organizations is a unique Professional experience for future careers. The experience of working in an international environment is enriching practical knowledge and skills. Coinciding with organisations' strategic goal of strengthening communication with students, one of the objectives of IFSA (International Forestry Students' Association) is to promote co-operation among forestry students and the Professional forestry sector. One way to achieve this goal is to establish partnerships with international organisations such as IUFRO. Here we explain (1) what the students need from international organisations and from donors, (2) what are the concrete outputs of working in a proffessional environment, and (3) what are the benefits in return for professionals. This presentation is based on concrete examples and results and gives innovative opinions on the developement of such exchanges for all students.

The dynamic and interactive structure of the International Forestry Students Association. Rivoire, M. (*International Forestry Students Association, France, iufro.lo@ifsa.net*), IFSA students (*IFSA, Germany; secretariat@ifsa.net*).

The International Forestry Students' Association was established in 1990 as a world-wide organization of local and national associations of forestry students. IFSA's vision is for global cooperation among students of forest sciences in order to broaden knowledge and understanding to achieve a sustainable future for our forests, and to provide a voice for youth in international forest policy processes. To achieve this vision, the association is made of different commissions, liaison officers with professional partners and 76 member associations in 48 countries, gathered into eight main regions. The different activities of IFSA make it working as a system. Here we built an original presentation of the structure of IFSA. More than a traditional descriptive poster,

this dynamic and interactive display (i) provides the underlying processes of the international association (ii) gives a graphical overview of the association and (iii) shows the links with professional partners such as IUFRO, FAO, EFI and IFISO. Communicating the structure and functioning of a whole association is a difficult task that is partly fulfilled by such a dynamic poster. It could become a new communication tool in the future.

E-learning tools and blended learning approach in continuing forestry education and knowledge transfer. Vančo, M., Sarvaš, M., Marušáková, L. (*National Forest Centre, Slovakia; Michal.Vanco@nlcsk.org; sarvas@nlcsk.org; marusakova@nlcsk.org*).

The paper introduces implementation of e-learning tools and didactical approaches chosen for their application in continuing forestry education in Slovakia. The e-learning tools and blended learning approach were tested within conditions of Eastern part of the European Union in the framework of project called "Transfer of Innovative Learning Techniques over Forestry Education". "Close-to-nature silvicultural approaches" and "timber classification and timber trade" were chosen as subjects for testing suitability of the innovative didactical approach. Experiences learned from this pilot testing are presented in this paper. Furthermore, the contribution describes specificity of conditions, which have a major influence on effectiveness of the particular e-learning tools: (i) educational culture of the target group – adult forestry professionals, (ii) level of their IT literacy, (iii) quality of internet connection in rural areas of Slovakia. Strengths and weaknesses of e-learning; as well as risks and opportunities for its utilisation in transfer of knowledge and experiences among forestry professionals are presented. In the end of the contribution, preconditions for successful utilisation of innovative didactical methods (but also for continuing forestry education as such) are summarized.

Posters

Public perspectives on the decreasing quantity and quality of forestry education in Borneo, Indonesia. Bahtimi Y. (*Lambung Mangkurat University, Indonesia; anonymous_tymy@yahoo.co.id*), Fierdaus W. (*Lambung Mangkurat University, Indonesia; wahyuni.fierdaus@gmail.com*), Risandi A. (*Lambung Mangkurat University, Indonesia; ifsa_lc_unlam@yahoo.co.id*).

Before 1998, forestry education in Borneo was something to be very proud of. But with changes in the Indonesian government's forest policies and logging permits that limit production forests, the number of high school students who intend to pursue forestry education has decreased. However Borneo forestry education has an important role, particularly in the empowerment of local communities, since Borneo is one of the three largest tropical forest areas after the Congo Basin and the Amazon. As Borneo's forest are continually decreasing, along with the human resources needed for forest management, which will affect the sustainability of regional development. A change in perspective of the people in Borneo towards a recognition of the importance of forests for sustainable development, water resources, and their role as carbon sinks. Forestry education also needs to be renewed so that future forestry students can make their contributions towards the sustainable management of our forests.

An overview to forestry education in İstanbul University. Butun, F.Y., Sarikaya, M. (*İstanbul University, Turkey; yagmurbutun@gmail.com; sarikaya.melih@gmail.com*).

Forestry education in our university (İstanbul University) began in 1857 as a 'Forestry Faculty'. The new forestry students of the faculty (second grade) conducted a survey regarding forestry education in our faculty. The survey involved undergraduate students from each of the four grades, graduate students, postgraduate students, assistants, professors and also with people who had earlier graduates from our faculty and have been working as foresters. When completed our survey results will give us a clearer picture of the quality of forestry education in our faculty. In addition it will give us the opportunity to improve this education by making some improvements, as we obtained permission from our dean for this. Like all students, we want to have a good, innovative, education, and to improve the forests of our country and the forestry profession through the education that we have been receiving in our forestry faculty.

An English language evaluation system in Cuba's forestry and agronomy engineering studies. Garriga Hernández, M.E., Romero Rio, F., Cuba Vega, L., Hernandez Lopez, I. (*University of Pinar del Río, Cuba; marige@fcsh.upr.edu.cu; francisco@uppr.cie.edu.cu; lidiacuba54@yahoo.es; Ihernandez@fcsh.upr.edu.cu*).

The objective of this poster is to show the results of investigation related to the learning evaluation process conducted in Pinar del Rio University, Cuba. This paper characterizes the students and the evaluation system developed, taking into consideration different alternative procedures and other techniques such as peer evaluation and the self evaluation in presenting their cooperative works. Improving the quality of future agronomy and forestry engineers has been the main concern of the pedagogical investigation in these specialities since 2005. Pictures of the students' creative work are presented to show the evaluation by means of a system of tools as seminars, portfolio, and communication almost exclusively in all contexts of the students' life. An inter-communication process was obtained during the evaluation process as the reflection of the evaluation functions used in classes, so the results of this investigation may be generalized to other disciplines within the university.

Strengthening forestry engineers' postgraduate education through English language instruction in Pinar del Río, Cuba. González, I., Cabrera, J.S. (*University of Pinar del Río, Cuba, iselys@fcsh.upr.edu.cu; jsilvio@fcsh.upr.edu.cu*).

The English language is one of the most widen used languages in the world, and knowledge of English leads provides access to updated information in science, technology and culture. Job-related needs have guided forestry engineers in Pinar del Rio to consult different forestry reference sources written in English; to understand and evaluate critically the extracted information, and to write abstracts for publications and presentations in international conferences for which the English language is required. This paper outlines the importance of combining the content related to their field of work and English language training by means of a English for Professional Purposes (EPP) diploma course as a means of helping postgraduate students to update their knowledge in forestry science. The process of course design followed the following methodological steps: needs assessment, program development, materials selection and students' assessment. Undoubtedly, developing EPP tasks related to the work field provided

useful tools for forestry engineers, and it constitutes a step forwards towards higher qualifications to face challenges in the implementation of sustainable forest management to enhance professional competence.

Building a better understanding into forestry: learning through paintings from Pinar del Río, Cuba. González, I., Cabrera, J.S. (*University of del Río, Cuba; iselys@fcsh.upr.edu.cu; jsilvio@fcsh.upr.edu.cu*).

Pinar del Río, Cuba's westernmost province, is well-known as a land of gorgeous and charming nature and is known as Cuba's Garden. It has two UNESCO Biosphere Reserves: at Rosario and and Guanahacabibes Peninsula, and has the greatest forestry heritage of the country, and scenic beauty which has traditionally inspired many painters through the generations. It is considered the cradle of the wider landscape painting movement in Cuba, a reality traced by its environment, by the tree as a symbol of life, time and culture. Unfortunately this has not been taken into account in forestry education. This paper discusses the value of landscape painting as and the expressive potential of art, as very motivating factors that can be used to teach and learn themes related to sustainable forest management. The arts can make vivid what words cannot, to symbolize what it is important, leading to deeper understanding, and to further education on conservation of the environmental legacy fr future generations from an artistic perspective.

Research on the establishment of network for activation of forest environmental education. Ha, S.Y. (*Korea Forest Research Institute, Republic of Korea; hashon@forest.go.kr*).

The aim of this study was the establishment of a network which links forest environmental education resources for greater activity and effective operation. It examines a network dealing with national and domestic forest environmental education, a network which is composed of participants, participants' resources, communication channels and ways of exchanging resources. The network could be divided into 4 types; educational information network, human network, education center network and educational business network. The operation of the program and creation of education facilities was considered to be the task of the Korea Forest Service, based on a survey of about 46 of forest policy-related education organizations and individuals. Potential users of network are needed for the effectiveness and the efficiency of a network. As for the network scale, a local and national scale is highly demanded. Also, there is a high demand for building a network that combines on-line and off-line systems, and one operated by the government. The study showed that the education center was based on a local need to revitalize the network. Workers engaged in forest environmental education center require training for their professional development.

Wood education in grade schools and colleges in Korea. Han, G.S. (*Chungbul National University, Republic of Korea; ilovewood@naver.com*).

Compulsory education in Korea extends from grade 1 to 9. To promote the understanding importance of forests in the global ecosystem and to increase awareness of wood culture for all citizens, the Korean Ministry of Education, Science and Technology modified the educational programs in 1997 for primary (1st through 6th grades) and middle (7th through 9th grades) schools. Since then, all elementary schools are required to teach a Wood Utilization course to 6th grade students; and all middle schools must teach a Wood Property and Wood Working class to 8th grade students. Since 2007 the Korean Forest Service has also provided primary and middle schools with additional assistance for teaching forest resources and wood utilization classes. There are eleven universities offering wood science and technology degree programs with 61 full-time professors. Current enrollment in the wood science and technology degree programs (including paper science) is 1,241 undergraduate and 139 graduate students. This report will focus on the forest and wood educational programs and activities in primary and middle schools.

The potential of forest education in general high schools in Japan. Inoue, M., Oishi. Y. (*Forestry and Forest Products Research Institute, Japan; imariko@ffpri.affrc.go.jp; oishi@ffpri.affrc.go.jp*).

Recently, educational activities in forests have attracted attention in Japan. Vocational schools and some high schools have already started teaching through practical experience in forests for environmental education and ESD. However, such activities have not spread into many general high schools, because the official guidelines for school teaching are not clear on the status of forest education. In this study, we analyzed the current systems for forest education in high schools. Firstly, a survey was carried out in high schools that conduct activities in forests. Secondly, the systems for conducting forest activities were analyzed. The results showed that forest education is carried out not only in forest or science special courses but also in general and regular courses. The special subjects that included forests were: the sciences, the environment, and physical education. The general subjects that included forests were biology and geography. Furthermore, there were "general learning" classes. The contents were varied, such as "forest resources," "natural environment", "nature experience", and "local culture". The purposes were also varied, including professional education, environmental education, regional learning, human education, and career education. In conclusion, if certain conditions are satisfied, forest education could become part of varied education in general schools.

Forest operations and work science in new international e-learning courses. Lewark, S. (*University of Freiburg, Germany, siegfried.lewark@fobawi.uni-freiburg.de*).

In industrialized as well as in small-scale forestry there is a continuing or even growing need of competences of professionals for Forest Operations and Work Science under different regional conditions. At the same time in these fields teaching capacity is reduced and relevant courses are taken from the obligatory core of forestry curricula in many places. These leads to the need of exploring the possible contribution of international e-learning courses, open for students as well as for professionals. They could help making better and joint use of scattered expertise and teaching resources. Some ideas about organisation, didactical aspects as well as contents will be presented, along with experiences from e-learning courses in the field of ergonomics and forest operations held at the University of Freiburg, Germany, and the University of Stellenbosch, South Africa. Stimulation and organisational frame for such courses, bundled in a course package on Forest Operations and Work Science could come from WELAN (World-Wide E-Learning Academy for Natural Resources, Forestry & Wood Science), which has been developed by higher education specialists from IUFRO, IPFE and forestry faculties of six universities presented elsewhere during the IUFRO World Congress.

Networks of higher education in forestry and related fields. Lewark, S. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*).

Improvement of higher education in forestry is in the centre of activities of the IUFRO education group (6.15). The education group is cooperating with a number of other networks and subunits of organisations devoted to improvement of higher education in forestry and related fields like SILVA Network, IFSA, IPFE, FAO, RELAFOR, ANAFE, WOCAN, which all have their special profiles and regional rooting. There is a general problem these networks experience: while many scientists from the universities in the networks are teaching and agree that improving education is of great importance, few are doing education research or are really active themselves beyond their own teaching. They may be prepared to attend an education session at conferences which they attend to participate in their own field of expertise, but they would seldom go for an education conference, where we always find the same handful of colleagues. Moreover few seem to be interested in didactical innovations, too many are still teaching on the basis of teacher oriented approaches, far from "the shift from teaching to learning". A promising way to engage more scientists in teaching networks and gaining didactical expertise is through international projects, for instance developing joint curricula. Examples are given.

New graduate analyses in Germany including graduates of forestry study programmes. Mühlsiegl, R., Lewark, S. (*University of Freiburg, Germany, reiner.muehlsiegl@fobawi.uni-freiburg.de; siegfried.lewark@fobawi.uni-freiburg.de*).

In many countries numbers of forestry graduates seem to have matched the needs of employment in the forestry sector for long time. Now we observe dramatic changes in the field of professional foresters. The Bologna process emphasizes the "employability" of the graduates as a crucial output of study programmes. The way to prove the extent of job success of graduates are is through graduate analyses. More and more forestry graduate analyses have been done in recent years as described at the annual conference of SILVA Network in 2008 in Copenhagen. In many cases they have been done in isolated processes with specially designed methods. In other cases forestry graduates have been included in university-wide enquiries, which are already done regularly by a few universities. Certainly both approaches have their merits in terms of flexibility, specificity and practicability. Most important of course is that they are done at all. The different approaches and methods of graduate analyses are discussed using examples from Germany. Then selected results are presented including fields of occupation, success and satisfaction with current jobs from recent graduate analyses at the University of Freiburg including forestry graduates from traditional diploma and new Bachelor study programmes.

Connecting universities with micro-, small-, and medium-scale forest enterprises to optimize the value chain. Pérez-Canales E., Pérez-Canales, G.A., Solís Moreno, R., Hernandez-Díaz, J.C., Aviña-Berumen, L.J. (*Universidad Juárez del Estado de Durango, México; pece@ujed.mx; pcgerardo@ujed.mx; rsolis@ujed.mx; jcirohd@ujed.mx; lavina@ujed.mx*).

The condition of forests and forestry in Mexico, similar to that of others countries, is a serious problem, with deforestation in recent years reaching 600,000 he per year, although now showing a downward trend. The causes are diverse, but can be summed up as an inappropriate forest exploitation and a neglect of the concepts of sustainability and integration of a rational and comprehensive forest value chain. In this context, Juarez University of Durango State (UJED), located in the state of Durango, Mexico in the region of the Sierra Madre Occidental, has developed an ambitious program to support the forest sector. The program's objectives are continuous improvement in the integration of the value chain, the application of high technology for genetic improvement of forestry, the use of new management systems, and GIS tools, and to produce a positive impact on the transformation of wood by integral industrialization, to give more value added to production, training staff of forest enterprises under paradigms of quality, design and production of wooden articles and furniture of world-class quality. Through this university- producers connection, we may help to make better use of our forests.

Professional training in the forest sector of Russia and the prospects for forest education development. Sanaev V.G. (*Moscow State Forest University, Russian Federation; rector@mgul.ac.ru*).

Questions of the rational forest use have become a concern not only at the national level, but globally. Sustainable forest management has been a priority for forest policy and the strategy of development of wood complex of Russian Federation until 2020. Russian forests contain more than a quarter of world's reserves of woody biomass and serve global environmental protection functions. One of the main objectives of the strategic development of the forest sector in the Russian Federation is maintenance of sustainable forest management to preserve and increase their resource-ecological potential. To achieve this innovative development and maintenance of professional expertise is necessary in forest management and the wood industry of Russia. Professional forest education development in Russia has a very long tradition, with higher professional forest education since 1803. Today in Russia, there are 60 state higher educational institutions and their branches.

Further education in the Slovak forest sector and cooperation between forestry research and schools. Sarvaš, M., Marušáková, Ľ., Vančo, M. (*National Forest Centre-Institut for Forestry Consultancy and Education Zvolen, Slovakia, sarvas@nlcsk.org; marušáková@nlcsk.org; vanco@nlcsk.org*).

Quality of education and further education plays a key role in economical and social development of rural areas not only in Slovakia but throughout Central and Eastern Europe. The current state of, and a target for, further education in Slovak forest sector are presented. We present the main strategic and programme documents related to further education in forest sector at European and national level, in particular, the EU Forest Action Plan and the National Forest Programme of the Slovak Republic. The most important results of a SWOT analysis for forestry further education are also presented. The system of further education at National Forest Centre—Institute for Forest Consulting and Education Zvolen (NFC-IFCE Zvolen, Slovakia) is presented from various viewpoints such as thematic content of education activities, age structure of learners and opportunities for cooperation at national and international level. Special attention is given to funding mechanisms (on European and national levels) for further education in the forestry sector in Slovakia. Finally, we present two projects which are directed towards cooperation between forestry research institution and primary and secondary schools.

Introducing citizens' forest surveys into forest environment education programs: the case of junior high school and university students. Yao, H., Kazuhiro, T. (*Kyoto Prefectural University, Japan; valenciaimar@hotmail.co.jp; tanakazu@kpu.ac.jp*).

Artificial (planted) forests in Japan have been widely abandoned for a long time for economic reasons, and these abandoned forests are associated with disasters such as soil avalanche and windfall damage. Amid growing recognition of the risks posed by abandoned artificial forests, forest volunteers who maintain forests instead of their owners have increased. In September 2000, Aichi Prefecture in central Japan suffered a number of serious sediment disasters in abandoned artificial forests. As a result, forest volunteers in this area started a system of citizens' forest surveys called "Forest Health Checks". These surveys require no specialized knowledge or tools, and are now spreading to other parts of Japan. In this study, we used these "Forest Health Checks" in a forest environment education program for junior high school and university students. The results showed that the program stimulated students' interest in forests and forestry and increased the number of students who have a positive attitude towards felling trees. Based on these results, we highlight some issues when introducing "Forest Health Checks" into forest environment education programs, and suggest solutions for these.

H-12 Cultural values and sustainable forest management: strategies and actions

Organizers: Mauro Agnoletti, *University of Florence, Italy, mauro.agnoletti@unifi.it*; John Innes, *University of British Columbia, Canada; john.innes@ubc.ca.*

Transferring cultural values into forest management: a survey of criteria and indicators in sustainable forest management and certification standards. Anderson, S. (*Forest History Society, USA; stevena@duke.edu*), Agnoletti, M. (*University of Florence, Italy; mauro.agnoletti@unifi.it*).

In 2005, an assessment of forest certification protocols showed that few aspects of cultural values in terms of cultural landscapes, including traditional knowledge and landscape history, were important components of the FSC, SFI or PEFC forest certification protocols. Since that time, guidelines for the implementation of "social and cultural values" in sustainable forest management were developed as a scientific contribution to the implementation of the fourth Ministerial Conference on the Protection of Forests held in Vienna in 2003 and published as IUFRO Occasional Paper No. 19 in 2007. Proposed actions and strategies for National Forest Programmes were defined. This paper will explore progress towards those ends during the last five years in the various protocols as well as current thinking of protocol representatives for the future. The aim will be to assess the likelihood of adopting and implementing strategies, actions, and indicators in each of the protocols. The author will also touch on the comparative challenges of considering local cultural values in forest management and protection strategies in developing countries with expanding efforts of land conservation in developed countries with regards to urban populations, especially the United States.

Attitudes towards nature adopted by Mexican colonial society: a contribution to the history of forests in Mexico. Ayala, M.L. (*Universidad de Guadalajara, Mexico; mlayala_99@yahoo.com*).

Changes in land use and the impact that mining, livestock and crops had on the forests and woodlands of colonial Mexico were observed and described. A large number of documents – laws, regulations, court cases, reports on economic promotion and scientific research – record attitudes to nature adopted by colonial society, and the points of view of those who were involved in cases of defending woodlands and forests. In these documents it is possible to note the way in which the subject of the environment is presented: i.e. whether the case is simply described, or, going to another level, an explanation is provided of the causes of the problem, or whether it proceeds to a third level involving scientific proof. It is also possible to trace the actions that were taken to solve the problems described, through the issuing of laws and regulations, imposing fines and punishments, or through the payment of compensation for damage, and to review how proposals for solving a problem were duly applied. My paper aims to present a panorama of the various attitudes the colonial state and society held towards their forests and woodlands. This way I hope to contribute to the history of environmental ideas.

The characteristics of sacred *dangsan* forests as cultural landscapes in Korea. Choi, J.U. (*Rural Development Administration, Republic of Korea; juchoi0530@korea.kr*), Kim, D.Y. (*Sungkyunkwan University, Republic of Korea; ydkim@skku.ac.kr*), Kim, M.H., Park, K. (*Rural Development Administration, Republic of Korea; kimmih@korea.kr; klpark@korea.kr*).

The forests used for *dangsan* rituals were established by local residents several hundred years ago. They have been disturbed in various ways, but they still remain in many rural villages where dangsan rituals are being held every year. Several dangsan forests have been designated as natural monuments by the Cultural Heritage Administration (CHA). Although the remaining dangsan forests represent Korean cultural landscape, they are not known well to the public. The locational and structural characteristics of dangsan forests was reported recently. The object of this study was to understand the beauty and function of dangsan forests including, *bibo* forests. Approximately sixty dangsan forests located in inland and seashore villages have been investigated since 1999, and we have participated in 15 dangsan rituals during this period. Dangsan rituals appeared to have played an important role to conserve dangsan forests. The dangsan forests show the historical importance of traditional (local and indigenous) knowledge in forest maintenance. The findings of this study suggest that the dangsan forests have the potential for development of rural communities and for the improvement of cultural and natural landscape in Korea.

Suspended between millennial conservation and modern cultural prosperity: the gulf between the Korean Buddhist temple forests and national park institution? Chun, Y.W. (*Kookmin University, Republic of Korea; ychun@kookmin.ac.kr*).

The Korean national park system, instituted 1967, has imposed ecological conservation requirements on the Buddhist temple forests that exist within some parks, revealing a gulf or gap between the cultural use of the temple forests and national park

conservation objectives. The forests owned by the typically millennial year-old Buddhist temples in famous mountains of Korea played the role of the both religious space for the monks and priests' religious disciplining, meditation, teamwork training and of the resource space from which famine foods, fuel-wood and timber material could be acquired. Now with the resource provision role almost gone, the modernized cultural role is still active as is exemplified in a variety of 'Temple Stay' programs for secular people's meditation practice. The land areas covered by the Buddhist temple forests in several mountain national parks designated by Korean government in modern times are considerably large. The Buddhist temple forests of Korea are the very place where the friction and conflicts are salient between the cultural values and the aesthetical and ecological values. Various strategies of resolution have to be pursued to address this problem.

A model for the use of traditional knowledge in sustainable forest management in the Kaska traditional territory in British Columbia and the Yukon. Crampton, D. (*Kaska Dena Council, Canada; crampton@arborecos.com*).

The 24 million ha Homeland or traditional territory of the Kaska Dena, represents one of the largest remaining forests of the northern interior of British Columbia and southeastern Yukon that has not been exploited for commercial use. The Kaska Dena recognise the need for a fundamental shift in the manner in which communities and our collective knowledge interact to manage the natural resources of our landscapes. The ecosystem-based forest management model developed by the Kaska Dena represents a unique opportunity for a First Nations people to combine their traditional knowledge and western science to sustainably manage both their communities and the vast boreal forest that surrounds them. This paper describes of Kaska Dena forest management model in which all resources, including ecological and Kaska traditional values, are given an equal weight and appropriate measures are taken to ensure that natural resources are managed in an ecologically sustainable manner. Planning in the Kaska traditional territory is the application of traditional knowledge as a unique layer of information combined later with scientific information. The scientific information is used to substantiate Kaska land use decisions made through the lens of traditional knowledge.

Contradictions between traditional and the commercial practices of Brazil Nut (*Bertholletia excelsa*) production by the Gavião indigenous peoples of the Brazilian Amazon. Felzike, L. (*Instituto Federal de Educação, Ciência e Tecnologia de Rondônia, Brazil; ledianeff@yahoo.com.br*), Imperador, A., Ott, A.M.T. (*Universidade Federal de Rondônia, Brazil; adrianaimperador@yahoo.com.br; ariott@unir.br*).

The Gavião ethnic group is composed of approximately 500 individuals who inhabit *Terra Indígena Igarapé Lourdes* in the Western Amazon Region, Brazil. Due to the inter-ethnic contact about 50 years ago, a desire for goods was created that was not previously part of this people's culture. They found in market practices an alternative source of income to purchase these goods. Driven by market demand, the main item sold is the Brazilian nut (*Bertholletia excelsa*), which the Indians had always used as food. Considering that intensive nut extraction brings about cultural and ecological impacts, this research study investigates the perception of Indians regarding the old traditional nut-collecting practices compared to the contemporary commercial extraction manner, using the ethnographical method. The Indians have observed a food reduction for seed dispersers and admit that it is hard to find Brazil Nut seedlings in the forest, and that this fact is related to the intense seed collection and its natural regeneration. Culturally, the insertion in the market economy changed the Gavião peoples' traditional way of life and increased Brazil Nut collection. Best practices should be incorporated in order to make this activity sustainable.

Public perception of Japanese rural landscapes and biodiversity through the evaluation of the "100 Japanese Rural Landscape" contest. Iwata, Y. (*Asia Air Survey, Japan; yki.iwata@ajiko.co.jp*), Morimoto, Y. (*Kyoto University, Japan; ymo@kais.kyoto-u.ac.jp*), Fujiwara I. (*Forests Culture Association, Japan; fujiwara-i2@asahi.com*).

The revaluation of rural areas is required for the future management of agricultural land and secondary forest, which are also related to the conservation of biodiversity in Japan. In 2008, a Japanese newspaper company conducted the "100 Japanese Rural Landscapes" contest which resulted in more than 4000 nominations from the public. These nominations were used to analyze public perception of rural areas. The nominated sites were given coordinates and combined with topographic datasets using GIS, and classified into landscape types using cluster analysis. A text mining tool was used to extract keywords, biological names and cultural services from the written nominations in order to investigate what aspects of rural landscapes are valued. The result showed that the majority of the nominations were for sites of Forest Type (forest 88%), followed by Mixed Type (forest 60%, paddy field 20%). Eight hundred and forty-three names of animals and plants were extracted, and more than 300 words associated with cultural services. These results showed that the public valued rich forests, the sense of other living organisms, history and traditions of the rural landscapes. The challenge for the future is how to incorporate this information to encourage better management.

Much more than firewood and timber – the integrated use of woodlands in Tlajomulco, Mexico. Jimenez, E., Ayala, M.L. (*Universidad de Guadalajara, Mexico; ejimenez@cucea.udg.mx; mlayala@cucea.udg.mx*).

Tlajomulco, like the other indigenous villages around the city of Guadalajara, has undergone profound social, cultural and environmental changes. The needs of Guadalajara for food and housing brought about two great changes in land use: the first took place in the second half of the nineteenth century, when agriculture became the principal economic activity; and the other occurred in the second half of the twentieth century. This was when the city expanded over the lands, woodlands and waters of the surrounding villages. The few wooded areas left today are seen as spaces that are still "available" for urban growth. On the basis of a description and a map of the village of Tlajomulco from 1778, we show the ample use made since ancient times of woodlands in the zone: as well as timber, firewood and charcoal, a wide variety of produce was obtained. Knowing about the great wealth ensconced in the woodlands will not only have a positive influence on their conservation, it will also help to keep alive the cultural heritage that has given these villagestheir identity over the years of their existence.

Sustainable forest management and the safeguarding of its immaterial cultural heritage in the Alpine region of Europe. Johann, E. (*Austrian Forest Society, Austria; elisabet.johann@aon.at*).

Over millennia a diversity of forest management practices and traditional knowledge provided multiple goods and services for Europe's rural and urban societies. Within the last decades the retreat of agriculture and the replacement of renewable raw materials have deeply changed the relationship between society and forest resources. Thus, former well-known techniques and uses have fallen into oblivion. However, there is growing awareness from the part of international forest science and policy as regards the relevance of indigenous knowledge about forest utilization, as well as the need to take account of this knowledge in the development of political strategies. Europe is at the beginning of a working process were cultural and social dimensions of sustainable forest management are being integrated in the relevant policies such as MCPFE, and the Alpine Convention. The study analyses the interrelation of traditional forest-related knowledge and forest management in the history of the European Alpine region. It tackles conflicts and agreements and investigates what kind and to what extent traditional forest related knowledge and practices concerning nature and traditional craftsmanship are still alive. Options are also discussed through which way the renewal of this knowledge could contribute to the strengthening of rural areas.

Incorporating the cultural values of sacred forests in forest management. Kim, I.A. (*University of British Columbia, Canada; forestinae@gmail.com*), Mohs, G. (*Chehalis Indian Band, Canada; GordonWMohs@gmail.com*), Trosper, R. (*University of British Columbia, Canada; ronald.trosper@ubc.ca*).

The purpose of this research is to explore the case for maintaining a balance between economic development and social tradition in a forest-related culture. Many countries face challenges whether they should conserve forests or convert them for other land uses. We undertook a community-based participatory case-study with the Chehalis Indian Band, one of 610 aboriginal communities in Canada. Canadian aboriginal communities present colonial history, rich forest-related cultures, and a worldview of 'harmony with nature'. Ethnography and secondary documents (such as maps) are used to generate an in-depth understanding of Kweh-Kwuch-Hum, a sacred mountain area used extensively by Chehalis spiritual practitioners, associated primarily with the Winter Dance Ceremonial. In 2005, severe logging practices on the mountainside facing the Chehalis community resulted in the Chehalis Indian Band proclaiming Kweh-Kwuch-Hum a '*Spiritually Sensitive Designated Area*' in July 2006. Through extensive negotiations between the Chehalis Indian Band and the Ministry of Forests and Range, an understanding was reached whereby a 5 kilometer square area of Kweh-Kwuch-Hum was designated a protected area for aboriginal cultural and spiritual practices, with limited areas designated for timber production.

The need for blending culture, traditional knowledge and capacity of the local communities in the sustainable management of NTFPs. Kinhal, G. (*International Center for Integrated Mountain Development, Nepal; giridharkinhal@gmail.com*).

The forestry sector is changing at a pace faster than its individual components can deal with effectively. The expectations from the forestry organizations in different countries have not only changed over the years but also have become competitive and complex. While forest management-related organizations are striving to cope with the requirements, their efforts seem inadequate and incomprehensible. Forest management is moving into a phase in which non-timber forest products (NTFPs) are gaining importance both in terms of providing sustenance and livelihoods to the local people and creating economic opportunities through trade and exports. Medicinal plants are major subset of the NTFPs. A novel methodology known as Community to Community Training (CTCT) has been tested and found to be useful for implementing an accelerated training and capacity building package for forestry staff and the local people under the Joint Forest Management regime, in India. It has been adopted in about 500 joint forest management societies in India.

The Satoyama treasure box: another meaning of Japanese cherries. Kuitert, W. (*Seoul National University, Republic of Korea; goedemorgen@snu.ac.kr*).

The botanic composition of the *Satoyama* forests in Japan have changed over the centuries, like any secondary forest under intensive human management. New species have introduced, others have disappeared. But the species themselves have also changed with the development of new varieties. This process is illustrated with the Japanese cherry. In Satoyama forests, regional varieties were developed because of human interest and selection pressure. *Prunus serrulata* var. *speciosa*, the Oshima-zakura, generally believed to have been brought from the Oshima islands for charcoal burning, and is now widely distributed along the coast. Two top varieties with spectacular flowers came to Kyoto, where ornamental selections of *Prunus serrulata* var. *spontanea*, the Yama-zakura, had entered earlier from the Satoyama forests of Yoshino, Nara. Two regional varieties came to Kyoto and created new hybrids, but it was in the Satoyama forests where selection pressure by local people who had used these plants for centuries created the earlier varieties. This presentation seeks to demonstrate that it is necessary to introduce the element of time and history when studying the future of Satoyama-like forests, and presents an urgent plea for dynamic and progressive management of Satoyama-like forests.

Some examples of traditional forest-related knowledge from Russian Siberia. Laletin, A. (*Institute of Forests n.a. V.N.Sukachev SB RAS, Russian Federation; slal@mail.ru*), Laletin, A. (*Friends of the Siberian Forests, Russian Federation; sibforest@akadem.ru*), Bocharnikov, V.N. (*Pacific Institute of Geography, Russian Federation; vbocharnikov@mail.ru*).

Natural conditions of the northern hemisphere' forests encouraged selection and accumulation of traditional forest-related knowledge (TFRK) specific to this area. This knowledge enabled survival of communities settling throughout the area. Daily routines of many indigenous communities from Siberia were shaped by surrounding vegetation and wildlife. The peoples depending on the nature for survival developed hunting rights which often included communication with spirits to ensure success in forest hunting. Siberia is situated in Asian part of Russia between Ural Mountains in the west and Amur River valley in the Far East. Siberia is inhabited by over 100 indigenous peoples. Each of them has a unique material and spiritual culture, finding expression in the traditional uses of natural resources, indigenous knowledge, and practical skills. Unfortunately, we are losing the indigenous heritage on conservation and sustainable use of biodiversity and forest resources due to a decline in traditional uses of forest-related resources and indigenous and community livelihoods, intensive use of natural resources, and urgent social and economic problems. We will report on the status of TFK in the region, to be published in a forthcoming state-of-knowledge report of IUFRO's Task Force on Traditional Forest Knowledge.

Sacred belief helps in conserving the Panchase forest, Nepal. Rajbhandari, M. (*Nepal Environmental Watch Initiative, Nepal; rmaneesha@wlink.com.np*).

Spread over 10–12 km^2, Panchase forest is an important block of forest in middle hills of Nepal. Its altitudinal variation, ranging from 1500 to 2517 m, provides wide range of habitat for different life forms. It harbors 300 plant species, including 100 NTFPs and 107 orchids and home for common leopard and Himalayan black bear. The five Panchase mountain peaks are sacred site for both Hindus and Buddhists. Politically, the forest is spread over three districts- Kaski, Syanja and Parbat. Managing whole block of forest has been very difficult due to controversial political boundary at the district level. It has created lack of clarity about ownership among the local people, and forest resources have gradually been depleting. But despite these boundary conflicts, local sacred beliefs have provided a strong support for conserving the sacred Panchase forest. The management of over 674 ha of peripheral forest area have been handed over to 13 community forestry users groups benefitting nearly 1500 households. With support from Nepal Tourism Board, a tourism management plan has also been prepared which identifies the important trekking routes, sacred sites and natural landscape. Managing peripheral forest areas not only provides livelihood requirement such as fodder, timber and fuelwood to sustain society, but also helps conserve the core forest area.

What is the future of "forest dynasties" in Russia? Teplyakov, V. (*Seoul National University, Republic of Korea; teplyakovv@gmail.com*).

Forestry is a profession unlike most others, connecting past, present and a future. Foresters use the results of the work of their ancestors and carry out forestry activities to establish forests for their descendents. This time linkage within one family whose members work in the same field over time is called in Russia "a dynasty". Russian forest dynasties became a widely spread phenomenon centuries ago. The Teploukhovs was perhaps the first well known family in Russia to create a dynasty of professional foresters covering more than a century of work in the forest sector starting in the early 1840s. Since that time many forest families in Russia have associated their lives with forest sector – forestry, forest operation, forest research and education. What makes them so dedicated to forest and its inhabitants? How will younger generations of foresters' families inherit a passion for the profession? How will the Russian government and society regard their experience? In this paper, some internal and external factors of this phenomenon are examined, and an attempt is made to set a research agenda.

Impact of ethnic community diversity on forest cover changes in the northern mountains of Vietnam. Thinh, N. (*Vietnam National University, Vietnam; anthinhhus@gmail.com*), Choen, K. (*Kookmin University, Republic of Korea; choenkim@kookmin.ac.kr*).

Mountains in northern Vietnam are mainly covered by tropical and subtropical evergreen forest. In these regions, there are more than 30 ethnic groups, most of which relied on shifting cultivation, resulting in high rate of deforestation until early 1990s. Although the 327 afforestation programs and 661 forestry projects have been carried out at the national level since 1994 have made notable progress in reforestation, ethnic groups have been a driving force affecting forest cover changes. This research carried out in a case of the Hoang Lien Son, a high mountainous region where the majority of six ethnic groups – the Mong, Dzao, Kinh, Tay, Giay and Xa Pho – are settled. Mixing of different ethnic groups was considered as resulting in ethnic community diversity that was estimated by Shannon-Weaver diversity index (SDI). SDI values vary from 1.0 to 3.49 in which, higher value shows higher ethnic community diversity. Results from examining forest cover changes by detecting three available satellite images (Landsat in 1993, 1999, and Spot-5 in 2006) point out that in spite of increasing in overall region, forest cover changes vary among areas where different local ethnic groups live. Moreover, multivariate analysis was used to examine effects of ethnic community diversity on forest cover changes.

Forest, local community and conservation of *Saroyama* landscapes in Japan. Vafadari, K. (*United Nations University, Japan; kazemv@gmail.com*), Nakamura, K. (*Kanazawa University, Japan; koji@kenroku.kanazawa-u.ac.jp*).

Japan's forestland, which covers approximately 70% of the surface area of the country, have played a significant role in formation of Japanese culture and traditional lifestyle. For many years, people have been able to manage forest resources efficiently and had learned how to live in harmony with other habitats of the forest. The collaboration of human and nature has created cultural traditional landscapes of "Satoyama" in Japan. Although the forests that were planted after World War II are finally ready for use, there is no motivation to cut the trees due to rather low price of the imported wood. In fact, the reliance of local communities on forestland resources has been decreasing due demographic situation and significant change in lifestyle. Furthermore the cycle of cutting, planting and tending of planted forests decidedly depends on these activities being carried out by the rural community in a sustainable manner. The local communities and cultures are gradually collapsing in rural Japan, which affects the functions that Japanese forests can serve. This paper discusses a sustainable way of using the forest as basis of rural tourism in order to generate direct benefits for conservation of the forestland itself and to revitalize of local communities.

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The role of holy places in biodiversity conservation and livelihoods of local people: case study of the Chetan commmuity in northern Iran. Avatefi Hemmat, M., Shamekhi, T., Etemad, V. (*University of Tehran, Iran; mohamadavatefi@yahoo.com; tshamekh@ut.ac.ir; etemad@nrf.ut.ac.ir*), Farhadi, M. (*University of Allameh Tabatabaee, Iran).*

This paper examines the role of sacred places in the Hyrcanian forest in Chetan village of Noorshahr county, in Mazadaran Province of northern Iran. Data were gathered through ethnographical research, semi-structured and non-structured interviews, and participatory observation during intermittently stays in the village over 15 months. A holy place (Emmamzadeh), situated on communal lands outside of the village, is part of the traditional system of local people's lives. Utilization systems governing sacred places and surrounding areas are often different from other communal lands. In addition to its spiritual and more obvious religious role, it has various protective, productive and economical functions. Owing to its sanctity, local people don't harvest natural resources around it, so trees and shrubs can be very old. It also provides safe habitat for wildlife because of traditional socio-cultural mechanisms which ban hunting. Local people use the area as a shelter during gathering edible and medicinal plants

and hunting in surrounding areas. We believe that the use of these local institutions provide rules for sustainable use of ecological resources according to traditional ecological knowledge, which should be appreciated in the development of policies for the conservation of both culture and the environment.

The social forestry program in Nglipar district, Yogyakarta, Indonesia. Dwi Hardhitya, D. (*International Forestry Students' Association, Indonesia; js_des_har@yahoo.com*).

Social Forestry is a method to manage forests implemented in several developing countries. The importance of the method increases nowadays because humans have become more and more aware of the need for sustainable forest management. "*Forestry is not about trees, it is about people. And it is about trees only in so far as trees can serve the needs of the people*" (Westoby, 1987). Social forestry programs aim to improve communities' welfare by involving people in forest management which will raise the awareness about importance and benefits of forest resources. One example of this is found in Nglipar district in Yogyakarta, Indonesia. Previously, communities around the forest had no authority over the forest, nor did they feel the benefits of these forests. To meet basic needs, forest encroachment occurred, and damaged forests were eventually transformed into barren land. After the government's social forestry program, forest rehabilitation has taken place and community life has improved. What is needed is to allow communities to produce, strengthen institutional capacity of the communities, build a good marketing networks for forest and non-forest products, increase the added value of production through home-building industry, and increase access to financial credits.

Utilizing cultural practices and venerated plants for forestry development in India. Gupta, A. (*Loreto Convent School Tara Hall Shimla, India; anuguptaevs@gmail.com*), Gupta, H. (*Forest Survey, India; hemantgup@gmail.com*).

Indian culture has accorded a position of great importance to trees and other components of the natural environment which are integral parts of social life. Worship of trees and plants has been a religious practice since hunting-gathering stages. There are a multitude of venerated plants and trees in Indian culture, a number of which have medicinal properties. To augment and sustain the pace of increasing the forest cover in India, it is time to to use strong motivating factors like mythology, religion, science, culture, and aesthetic values to strengthen the bond of people with trees. It is believed that the positions of 27 constellation and stars, 9 planets, 12 zodiac signs affect the life of human beings and have considerable influence on our surroundings and events. Each of these stars, planets and zodiac signs have been associated with trees, shrubs and herbs based on their composition and utilitarian value. This paper describes the list of plants associated with each constellation, zodiac sign and planet and provides a design and layout for establishment and development of sacred and religious groves of selected tree species along different conceptual themes to increase the public awareness and sense of responsibility, and for tree protection and recreation.

Recognition of cultural values as integral part of sustainable forest management: requirements of FSC certification. Karmann, M. (*Forest Stewardship Council International, Germany; m.karmann@fsc.org*).

Certification against the standards of the Forest Stewardship Council (FSC) is one way for forest managers in developing and in developed countries to demonstrate corporate responsibility in showing that their forests are managed including the respect for traditional practices of local populations and meaningful measures for nature protection. From the development to the implementation of FSC's international and national standards consultation and monitoring processes guarantee that in certified forest operations the biodiversity, the range of the economic values, and the quality of life of those people living in and from the forest are fully respected. The paper explains which tools, processes, criteria and indicators are developed by the FSC system to identify and to measure the management of the different values of forest landscapes. Examples from certified forests in Scandinavia, Central America and the Congo Basin demonstrates which impact the certification process has both on concessionaires and on communities managing forests, to manage their timber and non wood resources economically, while enhancing biodiversity and the cultural and social values of those people living in and from the forest landscapes.

A framework to analyze the game theory between local people, government and enterprises base on *Fengshui* forest from the aspect of heterogeneity. Liu, J., Li, S., Li, K. (*Renmin University of China, China; liujinlong@ruc.edu.cn; lisaibiao@126.co;m like20060726@163.com*).

Forests are endowed with cultural functions for local people. The *fengshui* forests are forest which provides people surrounding it mainly with cultural services but few goods. For certain people, it is a symbol but for others, just forest. Sharing the same cultural function, local people can protect fengshui forests voluntarily for the community, without considering whom it belongs to. However, when different interests and perspectives exist, local people will find it difficult to balance between development and fengshui forest protection. Such heterogeneity also exists between the local government and enterprises. Based on the theory of self-organization, collective-action and common-pool resources by Ostrom, we analyzed the heterogeneity among people in communities, local government and other stakeholders and their interactions when economic development conflicts with the protection of the fengshui forest. The tenure of fengshui forest is a key factor influencing the outcome. The fact is that communities are often trapped in the prisoners' dilemma, with the fengshui forest destroyed and the communication between local people and government broken. We present a framework to try to find ways out of the dilemma, and suggests a starting point for further research.

Traditional management strategies for the conservation of *Parkia biglobosa* and *Vitellaria paradoxa* in rural communities of Oyo State, Nigeria. Oyerinde, O.V. (*University of Technology, Nigeria; voyerinde@yahoo.com*).

Indigenous knowledge can offer insights beneficial for management in the face of global climate change. Traditional knowledge from indigenous cultures about two NTFP species was investigated in ten selected rural communities in Oyo State, Nigeria. *Parkia biglobosa* and *Vitellaria paradoxa* are notable NTFPs that are economically and socially important for local people in the study area. The trees are also important in improving soil fertility and in traditional medicine.Semi-structured interviews conducted with key informants and households provided knowledge about traditional management strategies for *Parkia biglobosa* and *Vitellaria paradoxa*, as well as signals of changes in local climate patterns and how these influence them. The key elements

and ideologies in the traditional management of the selected NTFPs were identified. They linked an increased climatic warming trend to delays in the fruiting of trees. Farmers deliberately maintain these trees on farms mainly for their fruits and nuts. 80% of respondents said that they are willing to plant these trees for agroforestry purposes on their farms. The study revealed vital information about the notable NTFPs that will serve as guide for their domestication and integration into community forestry.

The development of visions, strategies and activities for better management of Zagros forests in Iran. Shamekhi, T., Feghhi, J., Soltani, A., Mohammadi Kangarani, H., Feiz Norozi, A. (*Faculty of Natural Resources, Iran; tshamekh@ut.ac.ir; feghhi@yahoo.com; Arezoo.Soltani@fao.org; kangarani@ut.ac.ir*).

Research was conducted to formulate strategies, policies and activities for the Zagros forests in Iran. It was carried out for 3 periods of 20-years visions, mainly 5-years strategies and necessary activities for each strategy. Participatory methods were used and existing literature and resources related to policy-making were analyzed related to the current situation to prepare "The Question Book" which included propositions for visions, forest strategies and their activities. "The Question Books" were sent for 160 institutions or individuals among 12 groups of stakeholders. Those surveyed were asked to return the book after amending, completing and determining their priorities. Based on the analysis of results of this survey and review process, "The Question Book" with its revised visions, strategies and activities, was formulated. Then, to investigate the feasibility and appropriateness of the propositions, a meeting was held with experts. After this meeting, appropriate visions, strategies and activities were finalized and proposed. Our presentation explains the stakeholder participation process and the resulting adopted visions, strategies and activities.

H-13 An honest conversation about decentralization and forest livelihoods in a globalized world

Organizers: S. Denise Allen, Joleen Timko, Juan Chen, *University of British Columbia, Canada, sdallen@interchange.ubc.ca.*

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Common property regime and the household-level importance of forest income in Nepal. Chhetri, B.B.K., Overgaard Larsena, H., Smith-Hall, C. (*University of Copenhagen, Denmark; bbkc@life.ku.dk; hol@life.ku.dk; cso@life.ku.dk*).

Common property regime is now widespread in forestry throughout Nepal. This paper analyses the household-level importance of forest income in communities in the three main physiographic regions of Nepal. Data was collected in 2008/09 in 836 households using the approach engineered by the Poverty Environment Network (PEN): qualitative methods to gather contextual information combined with quantitative household-level interviews, including four quarterly surveys. Results show that the total household's income is explained by their capital assets and the size and composition of the household labour force and their occupation which also fluctuate considerably in different seasons. Fodder/grasses, firewood, timber and other non-timber forest products constitute the main source of forest-environmental income, most of which supports current consumption and constituted an average of approximately 20% of total household income. Forest income is highly variable and dependent on household characteristics, location and other socio-political factors such as market access and administrative activities of locally formed forest user groups. With rising total household income, forest dependency decreases; share of cash income from forest increases; and the share of subsistence income decreases. Forest income decreased community-level income inequality and poverty. The potential of using forest to further prevent and decrease poverty is discussed.

Promoting conservation-compatible enterprises in Papua New Guinea forests through fair trade. Thaung, T., Hurahura, F., Leisher, C., Lipsett-Moore, G., Peterson N., Cassells, D. (*The Nature Conservancy, Thailand, Papua, New Guinea, USA, Australia; tthaung@tnc.org*).

This paper discusses Fair Trade movement as a potential tool to help poor people who particularly live in and around the forested areas in Papua New Guinea. The Nature Conservancy began working in the Adelbert's mountain region of Madang Province in Papua New Guinea (PNG) in the late 1990s because of a serious threat from logging. The Adelbert's mountain region is one of the most biologically rich parts of PNG's extraordinary forests, but the government had placed much of the region under a Forest Management Agreement, meaning the logging rights could be sold by local communities to the highest bidder. There are many barriers for the rural poor to escape from poverty. One of them is that products of the poor are rarely fair traded. Finding a suitable market through a fair mechanism is a key bottleneck to having these products be more conservation friendly and pro-poor. Various ways to promote conservation-friendly products through fair trade are discussed in this paper. TNC helped support fair-trade certification for local cocoa and this paper revealed the challenges and progress of getting Fair-trade label and establishing Fair-trade Adelbert Cooperative Society in PNG.

H-14 Forest ethics and conflict

Organizer: Christian Gamborg, *University of Copenhagen, Denmark, chg@life.ku.dk.*

Demystifying the gap between theory and practice in planning natural resources management participatory processes. Brown, C.L., Emborg, J., Gamborg, C. (*University of Copenhagen, Denmark; cbrown@life.ku.dk; jee@life.ku.dk; chg@life.ku.dk*).

Conflicts, often involving deep values differences, have become an issue which professionals within natural resource management (NRM) have to deal with. In many places NRM decision-making has moved from top-down government-dominated approaches to inclusive public participation approaches. Consequently, NRM planners' are now learning participatory process planning skills on

the job. We see a gap between theory and practice in how NRM participatory processes are planned. This gap relates to the lack of discussion, practitioner-oriented publication and other mechanisms to support interaction between academic researchers and practitioners who strive to manage the new complexities associated with NRM planning. Bridging this gap is essential for NRM planners to simultaneously manage demands for effective public involvement and the "messy" dimensions of participatory NRM processes: uncertainty, complexity, and controversy. This paper reviews influential attempts within professional practice theories on how practitioners manage complexity and decision-making theories to bridge this gap. Research and experience suggest framing such value-laden conflict situations as mutual learning situations in order to make progress. This paper seeks to establish effective learning approaches to support experienced practitioners – working with conflict management, public participation and group decision making – to reach a higher level of performance in such situations.

Free, prior, and informed consent and sustainable forest management in the Congo Basin. Freeman, L., Lewis, J. (*Anthroscape, UK; luke.freeman@ucl.ac.uk; jerome.lewis@ucl.ac.uk*), Wiedmer, C. (*Society for Threatened Peoples, Switzerland; christoph.wiedmer@gfbv.ch*), Karmann, M. (*FSC International, Germany; m.karmann@fsc.org*).

In the Congo Basin industrial forest management is usually done without involving those people living in and from the forests. International human rights standards as well as the FSC certification system demand however that the local, in particular indigenous populations, can give or withhold their consent to activities affecting the areas traditionally used and inhabited by them. They have the right to be asked for their "free, prior and informed consent" (FPIC) before any activity is carried out. However, the implementation of this principle poses major challenges. Anthroscape and STP studied in concessions in the Congo Basin on what FPIC involves and how it can be implemented. The resulting document is, to date, the only publication showing how FPIC can be realized in the forest context. It identifies seven major elements crucial to a meaningful implementation (such as institutional capacity building, communication strategies, negotiation processes). The paper shows how FPIC is a tool for preventing and resolving conflicts and for defining and constructively regulating contractual relationships between forest companies and local populations, and thereby supporting FSC certification under complex conditions. The presentation invites to discuss some of the most up-to-date thinking on how to achieve socially responsible industrial forest management.

Aboriginal forest ethics and the shaping of the Laurentides Park (Canada): a longitudinal analysis of institutional access and decision-making dynamics. Hebert, M. (*Université Laval, Canada; martin.hebert@ant.ulaval.ca*).

A forested territory such as the Laurentides Park (Quebec Province, Canada) can be understood as an institutional fact that has evolved through time. Since its creation in 1895, the Park has been the object of several transformations. Its constitutive laws and regulations, the zoning and functions of its territory, the spectrum of "legitimate" stakeholders taken into account in the decision-making processes, as well as its purpose within the wider society have all been negotiated, contested, and reformulated at one time or another. Each of these nodal moments involved several competing (and sometimes overlapping) forest ethnics expressed by a diversity of actors interacting within fields of institutional power. Developing the notion of a discourse-based Institutional Access Analysis, the present paper will examine archival and ethnographic materials collected with the intent to document important shifts that have occurred in this process of social construction, as well as the specific ethical frameworks and actors that have influenced these institutional shifts. Special attention will be paid to the forest ethics of Aboriginal peoples and the processes by which they have, or most commonly have not, become institutional realities. The paper concludes by highlighting avenues for greater equity in institution-building processes.

Understanding wildlife management through value orientations: a Danish survey. Jensen, F.S., Gamborg, C. (*University of Copenhagen, Denmark; fsj@life.ku.dk; chg@life.ku.dk*).

Extensive habitat and species deterioration have been widely documented. At the same time public concern about wildlife management is on the rise, resulting in an increasing number of human-wildlife conflicts. A better understanding of basic human-wildlife relationships is required to facilitate development of wildlife management practices that are not only biologically effective but also ethically acceptable. In collaboration with Colorado State University, a set of items measuring wildlife value orientation types (Traditionalist, Mutualist, Pluralist, Distanced), as mail-back questionnaires to adult Danes in 2007–2008 (n = 2,475), tested how these four types are reflected in views on different wildlife management actions. The results of the survey indicate that most Danes can be characterized as Mutualists (42%). All four types approve of landowner compensation for dealing with forestry/deer conflict situations, but differ on the question of providing more hunting opportunities. Given a connection between wildlife value orientation and wildlife-related attitude/behaviour, there is probably less support for the traditional approaches to managing wildlife. A deeper understanding of the underlying values will help to clarify in what direction to change wildlife management strategies.

The ups and downs of forest fertilization in Sweden 1960–2009. Lindkvist, A., Kardell, O., Nordlund, C. (*Umea University, Sweden; anna.lindkvist@histstud.umu.se; orjan.kardell@idehist.umu.se; christer.nordlund@histstud.umu.se*).

Fertilizing forests with nitrogen is the forest management method that enhances wood production most rapidly in Sweden. Fertilizers had a breakthrough in modern forest management in the mid 1960s, grew during the 1970s, and then lost ground and stabilized at a low level in the 1990s. During the last five years the activity has increased again. In this study we investigate factors that have influenced these fluctuations. A specific task is to investigate to what extent they correlate with debates on environmental issues. Furthermore, conflicting ideas of various interest groups are analyzed. The study thus contributes to an investigation of the relationships between forestry and the environmental movement. As historians we work with traditional sources composed of journals, polemic books, interviews and governmental inquiries. The concept of fundamental ideas, inspired by the sociologist Johan Asplund, is utilized in the analyses. We see two conflicting fundamental ideas of the forest in our study: the anthropocentric conservationist view and the biocentric preservationist view. These approaches can be put into a larger complex of ideas with far reaching historical roots: the idea of progress and the idea of an ageing world. Will it ever be possible to bridge over these fundamental ideas?

Moral diversity and universalism in the world of forests. Saastamoinen, O. (*University of Eastern Finland, Finland; olli.saastamoinen@joensuu.fi*), Teplyakov, V. (*Seoul National University, Republic of Korea; teplyakovv@gmail.com*).

Sustainable Development and its forerunner in forestry, now Sustainable Forest Management, are globally agreed principles and values and as such representatives of moral universalism. Multidimensionality of sustainability – containing economic, ecological, social and cultural aspects – has brought a rich variety of new or less considered values, goals and beliefs into the discourses and practices of SD and SFM. Consequently, also moral diversity in the world forestry is growing. Are the trends for moral universalism and diversity conflicting? This paper argues that while conflicts between moral universalism and diversity may appear, these often provide useful lessons. The real threads for sustainable use of world's forests come from plain immoral conduct – individual, social or institutional – derived from uncontrolled greed, unaccountable power or blind fundamentalism, sometimes fed by failed social processes and structures, historical or contemporary. Ethics is black and white, but also shades of grey. Yet moral philosophy needs to offer a firm ground where political decisions on the ultimate boundaries for acceptable social and international behavior are drawn. The paper concludes that forest policy processes and institutions can benefit from ethical considerations and fostering moral communities (professional ethics) and morally reflective organizations (corporate social responsibility).

Conflicting demands for corporate responsibility and financial performance in the forest industry: quantitative analysis based on the global reporting initiative frame. Toppinen, A. (*University of Helsinki, Finland*), Li, N., Tuppura, A. (*Lappeenranta University of Technology, Finland; anni.tuppura@lut.fi*).

Forest industry companies have increasingly adopted Global Reporting Initiative (GRI) guidelines on their corporate responsibility (CR) disclosure to alleviate potential conflicts regarding their practices. Because statistical analysis on the role and impact of CR on the financial performance in the forest industry is missing, we use quantitative multivariate analysis based on extensive analysis of sustainability reporting of 66 major companies in 2006. The sample of firms is by iterative K-Means clustering grouped into proactively, neutrally and defensively oriented firms based on the classification of 81 original GRI indicators. Our main result is that in the forest industry, 82% of the major companies are following what could be called as a relatively defensive approach to CR, while proactive and neutral companies towards CR represent a clear minority in the sample (5% and 13%). Despite substantial differences between the groups in terms of average turnover or the number of employees, financial performance difference between proactive, neutral and defensive groups was small. In conclusion, the impact of varying contextual background factors seems to dominate industry performance over CR, and the lack of customer driven pressures to CR partially explains the slow diffusion of responsible business orientation in the forest industry.

H-15 Sustainable forest management (SFM) through innovative forest laws and environmental legislation

Organizer: Peter Herbst, *Austria, hp@net4you.at.*

Conflicts and partnerships between forestry and nature protection in Eastern Europe. Abrudan, I.V. (*Transilvania University of Brasov, Romania; abrudan@unitbv.ro*).

The objective of this paper is to identify and discuss the main conflicts and partnerships between traditional forestry and nature protection in Eastern Europe based on the analysis of forest policy, legislation, forest management planning and socio-economic context of the last decades. Nature protection became an important issue in the region after the fall of communism. At the same time political, legislative and institutional decisions regarding nature protection have been taken at global and European level, as well as at national level (new national nature protection laws and biodiversity conservation action plans). The nature of conflicts is determined by various factors such as: improper legislation and institutional frameworks, improper funding for nature protection, changes in forest ownership/difference between status of nature protection in state and private forest, difficult economic and social conditions. On the other hand, forest managers have had an important role in nature protection in Eastern Europe, contributing to the establishment of the first protected forests, definition and implementation of the forest protection functions etc. Balancing forest production and nature protection interests will remain in the future an important priority for the forestry sector in a region facing a rapidly changing political, economic and social context.

Implementation of a classification system of forest habitats in accordance with the Natura2000 standards in Georgia. Akhalkatsi, M. (*Tbilisi Botanical Garden and Institute of Botany, Georgia; akhalkatsim@yahoo.com*), Kimeridze, M. (*GTZ, Georgia; mariam.kimeridze@gtz.de*).

Georgia includes two separate mountain systems: the Greater Caucasus lying between the Black and Caspian Seas, and the Lesser Caucasus, which runs parallel to the greater range. Two thirds of the country's territory (69,700 km^2) is mountainous. One third is covered by forests, 70% of which are mountain forests extending from the lower montane belt up to the treeline ecotone. The classification of forest plant communities was done by A. Dolukhanov (1989). However, a different methodology used by the European and Soviet schools resulted in nomenclature. Natura2000 habitat directives based on CORINE biotope classification system provided a legislative basis for conservation of natural habitats in EU. To join this system it was necessary to conduct inventories and develop a new schema of habitat types according to Natura2000 standards in Georgia. We have undertaken a project to classify Georgian forest area to the habitat types, with the following results: 11 forest habitat types are identified to belong to the Forests of Temperate Europe biogeographical region; beech forest is represented by seven sub-types, two of which are characterized only for Georgia; and four of the six habitat types belonging to Mediterranean deciduous forests are typical only for the Caucasus.

An analysis of forest legislation in Turkey. Aydin Coskun, A. (*Istanbul University, Turkey; aynur90@istanbul.edu.tr*).

Natural resources, due to their basic requirements and structure, have features that affect human life directly. Preserving natural resources is becoming an extremely difficult task due to changing global balances and increasing over-utilization of the resources.

As a precaution, tools and methods for protection of natural resources are being developed on a global level and efforts for international cooperation and coordination are becoming increasingly intense. In this context, the principle of sustainability, which is expressed as protection-utilization balance, is becoming more and more popular. This approach, which foresees the more intelligent use of the resources, is based on the principle of providing for the continuity of the natural resources and meeting the needs of society. One of the main tools used for preserving this balance is legal regulation. The purpose of this study is to demonstrate the degree to which the protection-utilization balance is reflected in legislation by analyzing the main laws related to forest resources in Turkish environmental law.

The effects of legislation on forest for the future: sustaining society and the environment in poor and rich countries. Gulca, V. (*State Agricultural University, Moldova; vitalie.gulca@gmail.com*), Deal R. (*U.S. Forest Service, USA; rdeal@fs.fed.us*).

It is widely recognized that forests can provide significant contributions to poverty alleviation, rural development, biodiversity maintenance, and healthy forest ecosystems. However the area of net annual deforestation on the global level is still estimated at 7.3 million hectares per year (an area about the size of Sierra Leone). Further compounding the challenges of natural resource management, the world population has been estimated to reach 7.7 billion by 2020, with over 80% of population occurring in developing countries. Our research will assess different policy approaches that could be applied in future forests and we will evaluate both positive and negative effects of legislation and specifically compare and contrast these effects in poor and rich countries. We will develop some case study examples using both poor (e.g. Moldova) and reach (e.g. USA) counties and apply these approaches to other developing countries (e.g. India and Philippines). We will compare and contrast some of the effects of forest policy on rich and poor countries with specific suggestions to improve sustainable forest management. Finally, we develop some recurring themes and suggestions about the potential role of forest policy for future forests in both developed and in developing countries.

Public participation in forestry related decision making. Menģele-Stillere, L. (*State Forest Service, Latvia; ligamenstill@inbox.lv*).

It is important to involve public in forestry related decision making to ensure decisions based on the representation of all concerned interests. Public participation is one of the keystones in all environment related decisions. The involvement of all stakeholders in forestry related decision making process helps to move towards sustainable development. Legislation has important role to guarantee these rights for public, but environmental communication – to realize the public participation in practice, thus public participation can be seen as inter-sectoral issue. Rights of participation are defined in soft-law documents and guarantied in international, regional (EC) and national laws. The author analyzes the contents of the participation rights and realization of these rights in forestry sector, touching upon the theoretical and practical issues. The most relevant environmental law instruments for realization of the participation will be analyzed in this article. The analysis of participation in forestry related decision making in Latvia will be included in this article. The example of Latvia will help to identify problems of implementation of these rights on national level. The results of the article will include the conclusions about the improvements needed for successful understanding and implementation of participation rights in forestry sector.

Analysis of the newly enacted law for the protection of native forests in Argentina. Minaverry, C.M. (*Universidad Nacional de Luján and Universidad de Buenos Aires, Argentina; Clara.Minaverry@gmail.com*).

Recent legislation in Argentina (Law 26.331) establishes the minimum requirements for protection of native forests, although each Province in the country can add to these requirements but shall never establish new standards that are below the given standards. Essentially, this law requires that every administrative district carries out a survey of the existing native forests and categorizes them according to their "environmental value" and the "environmental services" that they provide. In view of the current situation in Argentina with regard to native forests, which has been qualified as state of emergency, given the grave degradation of ecosystems and the significant loss of biodiversity, there is hope that this law will be both effective and efficient. There is no doubt that the new law presents an opportunity to contribute, from the native forests sector, to the sustainable development of our society and that, consequently, the institutions in the scientific sector will assume maximum responsibility and play an active role in the pursuit of the goals set out in that law.

Contribution of comparative law to the sustainability of woodlands and forests. Pérez-Rocha, E. Pérez-Canales, E., Solís-Moreno, R., Pinedo-Alvarez, A., Hernandez-Díaz, J.C. (*Universidad Juárez del Estado de Durango, México; eperez@ujed.mx; pece@ujed.mx; rsolis@ujed.mx; apinedo@ujed.mx; jcirohernandez@ujed.mx*).

The study of forest law becomes even more important as we advance towards the application of the concept of sustainability and improvement in environmental and forest culture, and education. The rationale for analyzing the forest laws of several countries is to know how their normative documents deal with the topic of sustainability in the use and conservation of forests. The objective of our research is to assess the extent to which the forest laws of Latin American countries raise the topic of sustainability as an information resource for the enrichment of the General Law for the Sustainable Forest Development in Mexico. Because of the nature of this investigation, this research can be defined as a documentary, given the analysis and study of several documents on forest legislation. With regard to the analysis and study of the documents, it was done using the technique of study known as comparative law. When completed, we expect the study results will widen knowledge on the implementation of Comparative Law, as a legal technique applied to forest and environmental law, provide proposals for improvements to the Mexican forest legislation, and enhance knowledge of legal approach of sustainability of forests and woodlands in Mexico and Latin America.

Main tendencies in forest legislation development. Poliakova, L. (*State Forestry Committee of Ukraine, Ukraine; Lpolyakova@ukr.net*), Herbst, P. (*IUFRO RG Forest Law and Environmental Legislation, Austria; hp@net4you.at*).

Forest law in all European countries is underlain by one basic law (code or act) regulating forest relations at the national level. Law process themselves is permanent. Even countries with high levels of economic development amend forest legislation according to changing tendencies of development. It should be recognized that until now, there has been no single approach to formation of forest law. Its content, structure and scope are determined by historical development and traditions of lawmaking in

every particular country. A scheme was elaborated for analyzing content of forest code, provided brief comparative analysis of forest codes of 6 new EU country-members with underlining main changes and tendencies in basic forest law countries under analysis during the last 7 years. Provided analyses points out positive tendency of changing legislation. In general changes occurring in society and requirements of international agreements had significant impact to this process and explain main changes in forestry law keeping in mind not only availability of EU financial support but also general improvement of environment.

Property rights, land tenure and its relation to the sustainable use of forests. Puente Salinas, M. (*Sociedad Ecuatoriana de Derecho Forestal y Ambiental/SEDEFA, Ecuador; makitti@yahoo.com*).

The system of land tenure and ownership that exists in each country influences the ways in which forests as a whole are understood and managed. Consequently, they determines which constitutional standards such as the ones that exist in Ecuador, Venezuela and Bolivia, and that talk about different "forms" of ownership, are relevant at the time of formulating schemes of sustainable management of forest resources. An analysis is suggested which shows, with an outlook to the future, under which scenarios could forest management combined with new forms of land ownership become an effective tool both for forest conservation and poverty alleviation for the people who live on the land. For this analysis, the legal elements and characteristics are identified which are typical of each type of ownership, hand-in-hand with the environmental, economic and social functions that the ownership right shall fulfill in the framework of the so-called "Latin American neo-liberalism". This will make it possible to identify the key issues that shall ensure that the legal institutions contribute effectively to the sustainable management of forest resources.

The implications of the FLEGT voluntary partnership agreement in Ghana for forest communities' livelihoods and poverty alleviation? Ramcilovic, S. (*European Forest Institute, Finland; sabaheta.ramcilovic@efi.int*), Saastamoinen, O. (*University of Joensuu, Finland; olli.saastamoinen@joensuu.fi*).

The European Union Action Plan on Forest Law Enforcement Governance and Trade (FLEGT) is the EU's response to the problem of illegal logging and associated trade. Voluntary Partnership Agreements (VPAs) are the main instruments for reaching this ambitious goal. VPAs are bilateral agreements negotiated between the European Commission and the timber producing countries (partner countries). The paper discusses the VPA, as a policy instrument, in terms of forest communities' livelihoods and poverty alleviation in Ghana. It builds on FLEGT and VPA policy documents and multi-stakeholder dialogue in Ghana, the available second literature and primary survey data. Setting firstly the scene of complex interrelations between illegal logging, law enforcement and livelihood; the paper next explores the concepts of livelihoods and poverty alleviation in the context of the VPA in Ghana. Then it presents the interests of main stakeholders in the negotiation of the VPA and how these interests have been accommodated in the finally agreed VPA. Finally, looking at the meaning of livelihoods in the context of VPA in Ghana and the focus of the final VPA, the paper discusses the VPA potential implications on forest communities' livelihoods and poverty alleviation.

Forest legislation as a tool for sustainable forest management in central Europe. Sulek, R. (*Technical University in Zvolen, Slovakia; sulek@vsld.tuzvo.sk*).

Forestry has recently achieved recognition as a global issue and sustainable multi-purpose forestry has become government policy in many countries. Forests were effectively managed for centuries in the region of Central Europe. Nowadays, the successful development of the forestry sector depends on the existence of an appropriate and effective legal and institutional framework that enables it to function efficiently. However, due to the recent social, political and economic changes, the legal and institutional framework needs to be revised and improved in order to resolve problems and meet new challenges as they arise. The main reasons for such changes include, in particular, increasing demand of society for public-beneficial forest functions and harmonization of public interests of the society and private interests of forest owners. In order to meet such requirements, the current forest legislation should be analysed and adapted to include modern and legislatively acceptable provisions on such issues as property and uses rights, management of forest resources as well as administration and control of forestry activities, including proper use of public financial sources.

Forestry and nature protection policy in the Czech Republic after political changes. Vasicek, J. (*Forest Management Institute, Czech Republic; vasicek.jaromir@uhul.cz*).

Using the example of the Czech Republic, this paper summarizes a survey of the basic problems which foresters have been facing since the time of transition to market economy. The most important forestry needs in the beginning of the 3rd millennium are mentioned as well as the challenge to avoid those solutions which could create other problems both in the short and the long-term future. The development of forestry and forestry policy and policy of natural protection since political changes in 1989 is outlined. Many of the problems faced in Czech Republic resemble those of other Eastern Europe countries after the transformation of their economies. The present difficult situation of forestry is similar in these countries, worsening with deteriorating economic conditions. The paper also describes problems which Central European forestry grapples with such as extremes of weather, which results in timber surpluses, low timber prices, and problems with marketing of products as well as challenges related to forest protection.

Forest policy: a property rights perspective. Zhang. D. (*Auburn University, USA; zhangd1@auburn.edu*).

In this presentation we demonstrate that all government forest policy (law and regulations, taxation, subsidies, landowner assistance, education) and forest practice/landowner ethics are about defining, enhancing, or limiting private or public property rights. Thus, forest policy development or policy-making process is about stabilizing, balancing and adjusting private and public property rights in the short- and long-run. It follows that understanding forest policy requires the comprehension of the theory, characteristics, evolution, incentive structure, and potential (intended and unintended) impacts of various property right arrangements. We also shed some light on the relationship between completeness of property rights and transaction costs and show that an increase in transaction costs limits the completeness of property rights. Once government objectives (such as sustainable forest management) are set, policy-makers need to pay attention to potential changes in property rights associated with

new forest policy development (or any innovative forest law and environmental legislation), especially their incentive structure and potential impacts. We provide examples of success and failure in forest policy around the world and suggest that modifying (sometimes in a subtle way) property rights can lead to sustainable forest management.

Posters

Development of criteria and indicators for evaluating validity of land use conversion in forest lands. Jeon, J.H., Park, Y.K. (*Korea Forest Research Institute, Republic of Korea; junjeon@forest.go.kr; parkkyu1@forest.go.kr*).

To avoid undesirable or imprudent land uses in forest lands, an evaluation system for validity of land use conversion was introduced in Korea. In this new system, a committee composed of experts, recommended by the Korea Forest Service, evaluates the validity for each case of conversion. It has been an issue for the current system that the evaluation criteria and indicators were vague and complicated, and none of criteria or indicators deals with ecological or environmental impacts on the conversion site. Thus, it is necessarily required to develop reasonable criteria and indicators. In this study, we developed a set of criteria and indicators (C&I) for evaluating validity of land use conversion in forest lands. For this purpose, we investigated the other evaluating systems for land use conversion operated by the government agencies in Korea. The developed C&I were categorized into 2 groups. One is the group of C&I related to the impacts of the conversion on the site, while the other group related to the activities of conversion or necessary restoration. Overall, there are 11 criteria and 23 indicators developed in this study.

Contribution of civil society to forest governance. Puente Salinas, M.C. (*Sociedad Ecuatoriana de Derecho Forestal y Ambiental SEDEFA, Ecuador; makitti@yahoo.com*).

One of the key elements of good management of forest resources is the empowerment of civil society with regard to its rights and the rights of nature. This can be achieved by a continuous education processes and an internalization of the rights and duties that every person has as a citizen. Such appropriation can have various forms; one of them is public reporting of violations and forest offences. For this purpose, the service called "Green Line" ("Línea Verde") has been set up for the civil society. It is a call centre that receives citizens' reports and forwards them to the appropriate authorities. In addition, it answers questions about related issues and advises its users on how to proceed when faced with a violation of forest rules. This service, the only one of its kind in Ecuador and unique to the region, seeks to strengthen forest governance by including participation of citizens as an element of surveillance and control within the framework of the constitutional state, the rule of law and justice. The collaboration of citizens and the knowledge of their duties underline the efforts made by the authorities to reach compliance with the law at all levels.

The impact of EU legislation on Slovak forestry sector. Sarvaš, M., Hrbáľ, P. (*National Forest Centre, Slovakia; sarvas@nlcsk.org; hrbal@nlcsk.org*).

The aim of this study is to evaluate the impact of European Union (EU) legislation on support to the forestry sector in Slovakia. Until Slovakia´s accession to European Union, support for forestry at the EU level was provided by the SAPARD Programme (The Special Accession Programme for Agriculture and Rural Development). Following accession of Slovakia to the EU, the support for forestry was provided through the sectional operating programme Agriculture and Rural Development 2004–2006, and for the current period through the Rural Development Programme 2007–2013 (RDP 2007–2013). The RDP 2007–2013 in Slovakia is based on Council Regulation (EC) No 1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EARD) and Commission Regulation (EC) No 1974/2006 laying down detailed rules for the application of Council Regulation (EC) No 1698/2005. These two regulations established the general rules governing Community support for forestry sector in EU member states. On the other hand the Commission Regulation (EC) No 1998/2006 on the application of Articles 87 and 88 of the Treaty to *de minimis* aid determines that support for forestry owners should not exceeding a ceiling of EUR 200,000 over any three-year period.

The relationship of Chinese laws and regulations to international forest certification. Zeng, Y., He, M. (*Zhejiang Forestry University, China; yrzeng@zjfc.edu.cn; heming79@163.com*).

China has many laws in place containing articles that are compatible with the International Labor Organization's (ILO) requirements. Although China has signed several, but not all, forestry-related international conventions (for example, Conventions 29, 87, 98 and 105 of the ILO have not been signed), China's national laws provide more than adequate equivalencies. For example, these national laws include: China's Constitution, Labor Law, Trade Union Law and 'Forest Certification in China – Forest Management' (a standard of the Forestry sector). Therefore, if a forest management unit complies with China's national laws, it will also with certainty meet the requirements of the ILO. Why is this important? China is now the 2nd largest importer of timber as well as an important producer and exporter of forest products. Forest certification plays a key role in the export trade of China's wood-based products. Both the Forest Stewardship Council (FSC) and the Program for the Endorsement of Forest Certification schemes (PEFC), two main international forest certification schemes, require forest management units to comply with laws. Both require compliance with international conventions.

H-16 Towards sustainable forest management and rural development in Latin America through appropriate forest policy instruments

Organizers: Santiago Barros, *INFOR, Chile, sbarros@infor.cl*; Vitor Hoeflich, *Universidade Federal do Paraná Brazil, vitorhoeflich.ufpr.iufro@gmail.com.*

Policy recommendations for Chilean dryland forest land-use planning. Echeverría, C., Schiappacasse, I. (*Universidad de Concepción, Chile; cristian.echeverria@udec.cl; ignacio.schiappacasse@gmail.com*), Urrutia, R., Cárcamo, M. (*Universidad Austral, Chile; rociourrutia@uach.cl; miguelcarcamo@uach.cl*), Smith-Ramírez C. (*Universidad de Chile, Chile;*

csmith@willnet.cl), Nahuelhual L. (*Universidad Austral, Chile; lauranahuel@uach.cl*), Newton A. (*Bournemouth University, UK; anewton@bournemouth.ac.uk*).

Conservation and sustainable use of dryland landscapes is central to livelihood development and poverty alleviation in diverse parts of the world. We assessed that conversion to agriculture and urban ground, and expansion of rangeland for livestock have led to a loss, fragmentation and degradation of dryland forests in Central Chile. We found that 38% of dryland forests have disappeared between 1976 and 2008. Such overexploitation has caused a serious decline in ecosystem services. In response to this dramatic situation, since 2007 the REFORLAN project ("Restoration of Dryland Forests in Latin America") has identified and promoted approaches for the sustainable management of dryland forest ecosystems. This goal was accomplished through a multi-disciplinary research approach that analyzed how restoration of degraded lands can be achieved in a way that will mitigate the effects of unsustainable land use practices. From the project's output and through a participatory process with relevant stakeholders, we generated policy recommendations to support development of national land-use planning strategies incorporating dryland forest restoration. This experience and recommendations could be relevant to other Latin American countries, and to other dryland regions around the world that deal with similar challenges and problems.

Critical paths for local capacity buildings in community forestry: the BOLFOR project experience in Bolivia. Guzman Gutierrez, R., Lehm, Z. (*CADEFOR, Bolivia; rguzman@cadefor.org; salem@entelnet.bo*).

In the past decade, Bolivia has experienced a significant incorporation of community forestry actors into the management of its natural capital. This created a need for a program for local capacity building on different organizational and thematic levels to ensure that communities gain technical knowledge, capacities, skills and tools to: manage their forests sustainably; face the market and participate in it; promote transparency in administrative management of use of resources that belong to the community; and to engage in local economic development. Against this background, the Community Forestry Project BOLFOR II has worked to enhance local capacities in indigenous communities in the Bolivian lowlands of Santa Cruz, La Paz and Pando, based on the experience developed over the past 15 years. The process of technical assistance has been systematized by defining critical courses of action with sequential activities in the following areas: socio-organizational, socio-political, forest management, administration, accounting and marketing, and financial aspects in community forestry operations. The results show that the process is proceeding at different paces, and that the necessary bases are being established for the native communities to manage their forest resources and their land and improve the quality of their lives by managing their forests.

A participatory model for sustainable forestry development based on community forestry in Mexico. Lujan, C., Olivas, M. (*University of Chihuahua, Mexico; clujan@uach.mx; jolivas@uach.mx*), Gonzalez, H. (*Forestry Consultant, Mexico; gzilda@yahoo.com.mx*), Kengen, S. (*Forestry Consultant, Brazil; skengen@terra.com.br*).

The participatory model was applied for sustainable forestry development in Chihuahua State, Mexico. The study was conducted in the Papigochi River watershed (600,000 ha) in the Northwest of Chihuahua State. It was based on commons property resources including forest *ejidos*. The natural resources are being degraded and the inhabitants are not able to satisfy their basic needs. The objective was to apply a participatory model for establishing a multidimensional strategy to approach sustainable forestry development. The model was based on the principles of participative democracy, holistic vision, and strategic thinking. The model included local people (indigenous and mestizos), Multi-search Conference for Participatory Planning, socio-cultural, economical, ecological and politico-institutional dimensions, and a hierarchical system of criteria and indicators to evaluate sustainable development. This case was graded as poor development. A multidimensional strategy was integrated into the participative strategic plan. Based on the preceding characteristics, this participatory model is the first of its kind (bottom-up decision process), and therefore, it is different from those traditionally used (top-down). This model allows promotion of a development policy responding to local peoples' needs. The model has flexibility and versatility. It can be replicated in diverse environments at regional, national and international levels.

Public policies as a contribution to forestry governance. Puente Salinas, M.C (*Sociedad Ecuatoriana de Derecho Forestal y Ambiental SEDEFA, Ecuador; makitti@yahoo.com*).

The new Political Constitution of Ecuador includes national planning and, consequently, public policies, as a key element of state management. This means that the concept of planning has become an obligatory standard for the country. Consequently, there is a need for establishing new standards and policies that work together in order to reach the goal of "sumak kawsay" (good life). There are different mechanisms for formulating these policies. One of them is the implementation of "emblematic" projects that show the line of action that is taken from the state side. There are concrete examples in Ecuador linked with the support of forest governance, namely the "Forest Partner" ("socio bosque") program and the "Yasuni ITT" initiative. The first one focuses on promoting a payment scheme for the conservation of forests that can be accompanied by sustainable management, and the second one refers to the non-exploitation of petrol that exists in a zone that is rich in forest resources. Both cases, although they are not formally called "public policies", represent the materialization of a vision, and they seek to be financed by national investment considering that the sustainable management and conservation of forests is a benefit for the global community.

Genesis of the Santa Catarina State Floristic and Forest Inventory in southern Brazil and the role of stakeholders. Vibrans, A.C. (*FURB, Brazil; acv@furb.br*), Uhlmann, A. (*EMBRAPA-CPAFAP, Brazil; alexandre@embrapa.cpafap.br*), Schorn, L., Sevegnani, L., Marcolin, M. (*FURB, Brazil; lschorn@furb.br; sevegn@furb.br; marcolin@furb.br*).

The Floristic and Forest Inventory of Santa Catarina (IFFSC) was conceived in 2003 in order to legitimize forest conservation and land-use policies and to review the state´s Red Lists. Begun in 2007 and to be continued in a five year cycle with 20% of the state's forests measured each year, a field inventory *strictu senso* assesses the genetic structure of endangered plant populations and the socio-economic importance of forest resources. The inventory's scope and methodologies were developed through workshops with the forest/environmental community (governmental, academic and enterprises), also by simultaneous discussion on design of the new National Forest Inventory (since 2006), crosscutting state and federal institutions like Brazilian Forest Service. The inventory is result of a long-term process to create awarness of forest as a strategic policy issue, motivated by:

prohibition of commercial timber logging in natural forests (since 1993), increasing dissatisfaction of the rural population, mostly smallholders; increasing importance of non-timber products (*Ilex*, mate tea; *Euterpe*, palmhearts); data-bases within global assessments and contracts like FRA and IPCC; pressure by international financial institutions acting directly/indirectly on local government, linking loans to concrete political actions based on actual/reliable data on the conservation status of forest lands in this biodiversity hotspot region.

Posters

Sustainable community forestry in Mexico: change, challenges and opportunities. Lujan, C., Olivas, M. (*University of Chihuahua, Mexico; clujan12@hotmail.com; jolivas@uach.mx*), Gonzalez, H. (*Forestry Consultant, Mexico; gzilda@yahoo.com.mx*), Kengen, S. (*International Forestry Consultant, Brazil; skengen@terra.com.br*).

In Mexico, the national forest policy considers forests and water as a national priority. This is supported by the Law of Sustainable Forestry Development and the 2025 Mexico Forest Strategic Program. Traditionally, forest management has mainly been focused on wood production, and the biodiversity has been affected in its components. There is a long tradition of forest harvestings through forest *ejidos* (common property land); about 80% of forests in Mexico lies within ejidos. Even though the ejidos are the owner lands, they have not obtained benefits based on sustainable development criteria. Ejidos have mainly harvested the forests for subsistence and they have limited capitalization. This is a reason why ejidatarios have not considered the environmental values and others services as a priority for their development. If ejidos are who live with the consequences of actions carried out in their communities, they must be involved in the decision making process (participatory democracy principle and participatory development models for designing, implementing and evaluating strategic projects). In summary, Mexico has started a structural process to address the efforts toward a new paradigm based on the philosophy of sustainable community forestry for achieving sustainable forestry development with vision-action in the long term.

H-17 Globalization and its impacts on the forest sector

Organizer: Piotr Paschalis, *Warsaw University of Life Sciences-SGGW, Poland, piotr.paschalis@wl.sggw.pl.*

Future forests in the making: global trends affecting Swedish forest use. Beland Lindahl, K., Westholm, E. (*Institute for Future Studies, Sweden; karin.beland_lindahl@framtidsstudier.se; erik.westholm.2framtidsstudier.se*).

This study explores international trends that may affect future forest use in Sweden. It is being carried out as an introduction to a major interdiciplinary research programme, "Future Forests", launched by the Swedish University of Agriculture, Umeå University and Skogforsk. This pilot study is based on a literature review and an interview suvey. Interviews have been carried out with key actors in, as well as outside of, Sweden. The informants include forest corporations and owners, consultancies, Swedish ministries and agencies, NGO:s, UN organisations and academics. The purpose is to explore actors' perceptions and expectations of the future as well as major trends affecting future Swedish forest use. The study suggests that important developments affecting Swedish forests and their future use are intimately related to processes in other systems. Therefore the "forest sector" must be disembedded and approached as an open system in interplay with other systems in a global context. Demographic and macro economic developments, changes in global energy supply and climate change/climate politics are key. How these trends will materialize will however depend on actors' visions and their capabilities to realise them. The outcome will thus reflect relations of influence and power.

The study of the effects of globalization on the economic viability of Lithuanian forestry. Mizaraite, D., Mizaras, S. (*Lithuanian Research Centre for Agriculture and Forestry, Lithuania; ekonsk@mi.lt; ekonsk@mi.lt*).

After the restitution of Lithuania's Independence in 1990, when the movement of resources, knowledge and technologies barriers were eliminated or reduced, the processes of globalization in all sectors of Lithuania, including forests, were accelerated. This study's goal is to analyze the effects of globalization on the economic viability of the Lithuanian forestry. The globalization factors analyzed included foreign direct investments, trade, adapted technologies and other innovations. Lithuanian forestry has been indirectly influenced by foreign direct investments mainly through the timber industry. The specific form of foreign investments is the support through EU Structural Funds. The main innovations have been adapted from high economically developed foreign countries: cut-to-length wood logging technology, technologies for biofuel production from logging residues, forest certification, etc. Lithuanian forestry has been economically viable during recent decades, with increases in the share of GDP of forestry, labour productivity and profitability. Forest destruction threats do not exist in Lithuania, and the social and ecological functions of forests have been maintained. There is a high potential to increase the forest GDP per worker in Lithuanian forestry when compared to highly economically developed countries.

Analysis of selected factors in the processes of globalization and their impact on global trends in forestry. Paschalis-Jakubowicz, P. (*Warsaw University of Life Sciences, Poland; Piotr.Paschalis@wl.sggw.pl*).

A synthesis of selected factors affecting forests and forestry on a global basis was made after the review of multilateral use of terms and definitions, describing the concept of standardized data collection and analysis of factors as well as use of multiple methods of data verification and obtaining an adequate level of accuracy. We analyzed references to the following subjects of global forests and forestry: role, place and importance of forests and forestry, and changes in forest resources in terms of their degree of naturalness and biological diversity of forests, changes in forest resources due to the introduction of forest plantations and fast growing tree plantations, climate change and the importance of forests in mitigating the impact of these changes, changes in the ownership structure of forests of the world and the labour market in the forestry sector, changes in the intensity of the functions performed by forests of the world. References to the extent of use of forest timber resources, non wood products wood

products market review, certification processes in forestry, research and education in the field of forestry at the university level were also included.

Posters

Future Forests – a Swedish interdisciplinary research initiative. Larsson, S., Tomas Lundmark, T. (*Swedish University of Agricultural Sciences, Sweden; Stig.Larsson@ekol.slu.se; Tomas.Lundmark@esf.slu.se*), Moen, J. (*Umeå University, Sweden; Jon.Moen@emg.umu.se*).

Climate change, globalization, and increased consumption of materials and energy lead to higher pressure on forest resources. The task of intensifying forestry to produce more timber, paper, and energy, while at the same time ensuring ecosystem services, such as biodiversity and recreation, is a complex one. Difficult decisions have to be made if we are to strike a balance between these demands. These decisions have to be supported by scientifically-based land-use strategies to deal with trade-offs on different scales. The vision of the recently started research program *Future Forests* is to take a significant step forward in this complicated task. The program has a long-term perspective (50–100 years), and consider changes in climate, as well as global and market development as major factors likely to influence forest management and forest landscapes in the future. The program constitutes a platform where researchers from natural sciences and social sciences, and practitioners from several sectors, can interact. Empirical research is combined with modeling, scenario analysis, and synthesis work. The program is a joint research effort of the Swedish University of Agricultural Sciences, Umeå University, and the Forestry Research Institute of Sweden.

Future forests – A scenario approach to the future. Moen, J. (*Umeå University, Sweden; Jon.Moen@emg.umu.se*), Larsson, S., Lundmark, T. (*Swedish University of Agricultural Sciences, Sweden; Stig.Larsson@ekol.slu.se; Tomas.Lundmark@esf.slu.se*).

We present a scenario analyses of possible futures for the Swedish forests and forest sector in 2050 which are being developed in the research program *Future Forests*. The scenario development follows four steps: 1) identification of external drivers, 2) identification of major uncertainties that need to be analysed through scenarios, 3) scenario descriptions, and 4) implications for policy. In step 1 we used an expert group approach where eleven important external drivers were identified. For each of these drivers we produced a literature review on recent and future trends. In step 2 we used the information on the drivers to identify two crucial uncertainties to be further analyzed. These were the degree to which renewable energy sources are incorporated in society, and the degree to which market mechanisms or international treaties dominate climate change adaptation and mitigation. In step 3 the four possible futures identified by the orthogonal uncertainties were described as narratives together with responses and implications for the Swedish forests. These futures will then be used as a basis for discussions with our stakeholders on policy options.

General Posters: Forests, Communities and Cultures

A study on the status and development of forest volunteer in Republic of Korea. Choi, I.H., Woo, J.C. (*Kangwon National University, Republic of Korea; inchoi@kangwon.ac.kr; jcwoo@kangwon.ac.kr*), Ueki, T.H. (*Shinshu University, Japan; tatueki@shinshu-u.ac.jp*).

This study suggests a development direction for forest volunteer organizations based on an analysis of the results of a survey of the public and forest volunteers that focused on the status and problems of forest volunteers in Korea. The origins of forest volunteers in Korea date back to the national reforestation movement of earlier decades, as a way for people to demonstrate their concern for environmental issues. The results of the 2008 survey, which included 26 organizations, indicate that forest volunteers are involved in a number of activities. These include: education on forest and culture (about 24%); forest work (about 20%; urban afforest movement (about 15%): forest publicity (about 13%); and environmental education (about 11%). The important development direction that were suggested from analysis of survey results included: strengthening education and publicity on forest volunteer; participant expansion through increasing group membership; diversity of participation program; activity funds of group; cooperation between groups; foster leadership of volunteers; identity establishment of non-government organizations. The survey results also highlighted the importance of moral standards for forest volunteer groups and transparency of funding activities.

Multifunctional forest perspectives and experiences in China. Liu, J., Li S., Zhang, Q. (*Renmin University of China, China; liujinlong@ruc.edu.cn; lisaibiao@126.com; qyzhang1018@hotmail.com*).

The concept of multifunctional forests (MF) has long existed in China and abroad. The relevant research abroad has been mainly about the tools of MF management and indicators fr its evaluation, but little theoretical research has been done in China. This essay proposes a system of MF which suits the Chinese situation based on the fruits of work abroad and practice and experience at home. Multifunctional forest management aims at win-win situations for stakeholders and the sustainable use of forest, with an ecosystem-level forest management perspective. MF in China is a broad system. The traditional ways of exploiting forest products should be changed. Other functions of forests, like cultural functions, are considered. Forest management at the ecosystem level is new for China and should be carried out in a proper way. The vulnerable people's interests should not be ignored and the forest must be used in a sustainable way, so that people and forest co-exist harmoniously. The paper provides suggestions for further research on economic evaluation of forest and the tools and methods needed to manage forest on the level of ecosystem.

Overview of 10 years' participatory forestry in China. Liu, J. (*Renmin University of China, China; liujinlong@ruc.edu.cn*), Yuan, Y. (*Wagenigen University, the Netherlands; juanwen.yuan@wur.nl*).

This paper documents the achievements of participatory forestry in last 10 years in China after the Chinese concept of participatory forestry was created. Participatory forestry was considered as a process and ideology that engages theory and methodology of participatory development into forest management and development practices. The various origins of the 5 components of this

connotation are analyzed including: 1) forest management should be part of integrated rural development strategy; 2) community members should actively participate in and benefit from in forest management; 3) policy, legislation and forestry administration fundamental bases should be adjusted to favor the development of "participatory forestry"; 4) 'social change' as a fundamental element of participatory forestry. As one of the discourses to promote sustainable forest management, the role and functions of participatory forestry have been analyzed. The achievement of participatory forestry in China in terms of research and development has been documented. Finally, this paper presented challenges of participatory forestry in China and recommendations on how to overcome these challenges.

Plan for the operational revitalization of mountain village in Korea. Seo, J.W., Jeon, J.H. (*Korea Forest Research Institute, Republic of Korea; knight01@korea.kr; junjeon@forest.go.kr*).

The aim of this study is to develop an operational program and propose a revitalization plan for Green tourism in mountain village for effective management and improvement of local incomes. Based on a definition developed in this study, Green tourism is divided into 4 types for the proposal of a revitalization plan. The study used a survey methodology involving 238 tourists to evaluate the citizen's demands in for Green tourism. Survey results revealed that the main advantages of Green tourism are the publicity of mountain village's value and the educational benefits for city people. Overall, the survey results indicated that the major opportunities for Green tourism in the future would be related to recreation and leisure activities. For the establishment of and operational program for mountain villages, the types and contents of the experience and requirements for human resources education have been analyzed. Plans related to marketing and networking have been suggested. On the basis of these, a customizing program has been developed by analysis of the resource status and income sources in 5 mountain villages.

Evolution of timber sale systems in the post-Yugoslavia Balkan region. Vlosky, R. (*Louisiana State University Agricultural Center, USA; vlosky@lsu.edu*), Glavonjic, B. (*University of Belgrade, Serbia; brankogl@rcub.bg.ac.rs*).

As the economies of the Balkan countries evolve, their forestry sectors are also in transition. In some countries, the forest sector transformation is close to meeting government objectives, while in other countries, the process has just begun. One challenge for Balkan countries is implementing effective wood sales systems. This presentation discusses results from research conducted on wood sale systems in the Balkan region and suggests recommendations for improvement. Timber sale systems in Balkan countries, with the exception of Romania, are undeveloped and burdened with numerous problems. These problems stem from a lack of legal, organizational and market structures and procedures as well as corruption. The authors believe that the role of international organizations such as FAO, UNECE, The World Bank, GTZ, USAID, and others is going to be significant in helping the region to develop and monitor timber sale systems. The most important recommendations for improving wood sale systems in the region is continuation of cooperation with international organizations and institutions, strengthening of mutual cooperation and accelerated changes in legislation and educational system, with the ultimate objective of reducing differences in wood sale systems among the countries in the region and increasing compatibility with EU demand countries.

Theme I: Forests, Human Health and Environmental Security

I-01 Healthy urban forests: healthy people

Organizer: William Manning, *University of Massachusetts, USA, wmanning@microbio.umass.edu*.

Nearby nature and human health: stress, social cohesion and physical activity as possible mediators. De Vries, S. (*Wageningen University and Research Centre, the Netherlands; Sjerp.deVries@wur.nl*), Van Dillen, S. (*Centrum Indicatiestelling Zorg, the Netherlands; Sonja.van.Dillen@ciz.nl*), Groenewegen, P. (*Utrecht University, the Netherlands; P.Groenewegen@NIVEL.nl*), Spreeuwenberg, P. (*Netherlands Institute for Health Services Research, the Netherlands; P.Spreeuwenberg@NIVEL.nl*).

Several studies have shown a positive relationship between the availability of green space in neighbourhoods and residents' health. This study focuses on the mechanisms through which greenery might exert its positive effect on health. Three mechanisms are investigated: stress reduction, stimulating physical activity and facilitating social cohesion. Altogether 80 neighbourhoods in four Dutch cities were selected. Data on the quantity and quality of streetscape greenery were collected by observations. Data on health and mediators were obtained for adults by mail questionnaires (N = 1641). Multi-level regression analyses, controlling for socio-demographic characteristics, revealed that both observed quantity and quality of streetscape greenery were related to perceived general health, acute health-related complaints, and mental health. In general relationships were stronger for quality than for quantity. Stress and social cohesion proved to be important mediators of these relationships. Total physical activity (PA) was not a mediator. PA that could be undertaken in the public space of the neighbourhood (green PA) was, to some extent. Attention is paid to the possibility that green elements have no special qualities other than that they help to make the neighbourhood more attractive, something that could also be achieved in other ways.

The effects of fragmentation on recreational experiences in urban woodlands. Hauru, K., Lehvävirta, S., Kotze, J. (*University of Helsinki, Finland; kaisa.hauru@helsinki.fi; susanna.lehvavirta@helsinki.fi; johan.kotze@helsinki.fi*).

Forests have restorative benefits and other positive impacts on human well-being. Urbanisation, however, causes habitat loss and fragmentation with possible negative effects on human health. The aim of this study was to evaluate the effects of fragmentation on people's experiences in urban woodlands. In particular, we studied effects of the forest edge on perceived restorativeness in Helsinki, Finland. On-site questionnaires were used to test the hypothesis that perceived restorativeness increases from the forest edge towards the interior. We showed that perceived restorativeness increased from the forest edge towards the interior irrespective of which urban setting (housing or a road) could be seen through the edge. Even though the experience was better inside the forest, perceived restorativeness was also relatively good at the edge zone. Several ecological studies have shown that the preservation of biodiversity and functioning of ecological processes are patch-size dependent. This research suggests that forest size affects recreational experience as well. Large woodlands are needed for high quality restoration but smaller patches are also important especially in densely built urban areas where large green areas have all but disappeared.

Nitrogen dioxide levels in urban tree canopies. Manning, W.J., Harris, T. (*University of Massachusetts, USA; wmanning@microbio.umass.edu; tbhaaris @psis.umass.edu*).

Nitrogen dioxide (NO_2) is the characteristic air pollutant of urban environments. It is the starting molecule in the photochemical oxidant cycle that produces ozone. Urban trees may function as sinks for NO2. Few efforts have been made to actually determine NO_2 levels inside tree canopies in cities. We measured NO_2 levels and temperature and relative humidity (RH) inside and directly adjacent to canopies of red maple (*Acer rubrum*) and London plane (*Platanus hybrida*) trees in Springfield, Massachusetts, USA for two growing seasons. NO_2 levels were consistently significantly higher inside tree canopies regardless of location. Temperature and RH levels were not significantly different. Fowler has suggested that nitric oxide (NO) emissions from soils under plant canopies would be oxidized to NO_2 inside plant canopies. The difference between the rate of NO emissions and subsequent oxidation to NO_2 and the rate of leaf uptake of NO_2 would result in an "effective canopy concentration point." When ambient NO_2 levels are high, canopies will act as sinks for NO_2, when ambient levels are low, canopies will act as sources of NO_2. This has not been demonstrated with trees. Current models for NO_2 uptake by trees may not be inclusive of these findings.

Environmental impacts of urban trees and their effect on human health. Nowak, D.J., Heisler, G.M. (*U.S. Forest Service, USA; dnowak@fs.fed.us; gheisler@fs.fed.us*).

Trees and forests in urban areas provide critical ecosystem services that enhance environmental and human health. These environmental services include impacts on air and water quality, global climate change and air temperatures, and ultraviolet radiation loads, all which have direct or indirect impacts on human health. Many of these environmental services have been modeled in numerous cities using locally collected field and environmental data, and the i-Tree Eco model (www.itreetools.org). In addition, environmental services have been measured in urban areas as part of long-term urban forest research programs. Results reveal that urban trees and forests can have relatively significant effects on multiple aspects of urban environmental quality. In the United States alone, urban trees and forests (urban land occupies about 3% of the U.S.) are estimated to remove over 700,000 metric tons of air pollution per year and remove over 80 million metric tons of carbon dioxide per year. This presentation will explore the latest research and modeling results from several cities around the world on these environmental impacts from urban trees and forests. The magnitude of the effects of urban trees on environment will be presented along with the associated implications for human health in urban areas.

Urban air pollution: role of tree response in air quality. Paoletti, E. (*IPP-CNR, Italy; e.paoletti@ipp.cnr.it*), Manning, W.J. (*University of Massachusetts, USA; wmanning@microbio.umass.edu*).

More than half of the world's population lives in cities. Quality of urban air is thus a topical issue. An important focus of research is on the role of urban forests in the formation and degradation of air pollutants. Trees in cities are confronted by a

variety of adversities, including air pollution. An understanding of how urban trees interact with pollutants provides useful information for planning their management and exploiting their potential benefits. As trees remove pollutants from the environment, their functional status undergoes certain changes. Thus, when we determine the health status of trees, we are also establishing an indirect indicator of the quality of the air. Tree response to air pollution affects the ability of urban forests to provide services to humans, such as water control, air quality control, cultural and social value, biodiversity protection. In this paper, we review: the main types of pollution affecting urban forests; the role of city trees as biomonitors of air quality; present knowledge about the role of urban trees in air quality control; and air pollution impacts on urban forest services.

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Korean urban forest monitoring: vegetation landscape characteristicsand biotope diversity assessment of 6 major cities. Kwon, J., Oh, J.H., Cho, J.H. (*Korea Forest Research Institute, Republic of Korea; alp96jk@forest.go.kr; jehoh@forest.go.kr; cjh544@forest.go.kr*), Cho, H.J. (*Korea Green Promotion Agency, Republic of Korea; jhh132@chollian.net*), Choi, M.S. (*Korea Forest Research Institute, Republic of Korea; hnarbore@forest.go.kr*).

Urban forests in South Korea have become isolated islands in urbanized matrices as the result of rapid urbanization. Most of these can be characterized as remnant forests. In this study, vegetation landscape characteristics of urban forests in six metropolitan cities were assessed. The classification of biotope types and evaluation for functions of forest structure were carried out, yielding two types of cell maps with raster data from 2003 to 2007. Numbers of biotope types classified according to the sub-community are approximately 15 communities up to 20 communities depending on the size of urban forests. The majority of biotope grades were dominating by lower rank grades which has low habitat value for wildlife. These results indicate that most urban forests in the 6 major cities are forests disturbed by man or still in the form of plantation forests which were planted during last century. Dominating species in sub-communities are *Quercus acutissima, Q. mongolica, Q. serrata, Robinia pseudo-acacia, Pinus densiflora* and *P. rigida*. The urgent issue associated with these urban forests is the mean size of the sub-community (approx. 1 ha), indicating less continuity of functional ecosystem roles.

Visitors' behavior patterns in urban forests. Lee, Y.H., Lee, S.K., Kim, K.W. (*Kookmin University, Republic of Korea; shineryh@kookmin.ac.kr; skfox76@hanmail.net; kwkim@kookmin.ac.kr*), Byun, W.H. (*Korea University, Republic of Korea; byun@korea.ac.kr*).

This study analyzes the visitors' behaviors and awareness in using forest by using the data from questionnaire targeted on Mt. Bukhan and Je-seok, to provide clear path towards a more effective administration and management tactics of urban forests. Though, Mt. Bukhan is a national park and the other is a forest in a city, there are no significant differences between the behavior patterns of the two sites. The results are as follows. Urbanites enjoy clean air and water, sounds of nature and beautiful scenery. They exercise in the mountains and visit 1 or 2 times in a week alone, or with family or friends. Mostly they stay for about 2 hours or more, enjoying mountaineering or walking. They expect the urban forest to provide opportunities for recreation and rest, and purify polluted air. They demand well-maintained trails, expansion of exercising and relaxing facilities, and various programs that guide people in experiencing the forest. They also show positive interest in fundraising for making private forests public, so that they can use those forests as recreational forests. As shown in the results, it seems that the forests should be managed effectively to act as recreational and relaxing sites for the urbanites.

Spatial distribution of urban forest in the city center of Curitiba (Paraná, Brazil). Lima Neto, E.M., Biondi, D., Bardelli-da-Silva, M.Y., Silva, A.R. (*Federal University of Paraná, Brazil; everaldo.limaneto@gmail.com; dbiondi@ufpr.br; myamamura@uol.com.br; anaraqueldasilva@gmail.com*).

Urban forest, comprised of green areas and street tree plantings, provide aesthetic benefits, and a better social climate for the quality of life. The efficiency of these benefits will depend on the location and density of forests in urban areas. However, the condition of vegetation in the central areas of cities is usually the poorest due to higher human impacts. The objective of this study was to analyze the spatial distribution of urban trees in central Curitiba, to underpin the planning of arborization of streets. The study area was divided into 3 sectors (I, II, III) where a census was made of street trees. The variables used in the study were: number of trees/hectare; identification and size of species. We identified 34 species, the most common being *Ligustrum lucidum* (21.3%), a tree of medium size, *Lagerstroemia indica* (16.7%), a small-sized tree, and *Melia azedarach* (11.32%), a large tree. The density of trees per hectare in sectors I, II and II were 4.47, 1.45 and 10.66, respectively. Sector II, characterized by more impermeable area and vertical construction, had the lowest density of trees. It is recommended that the arborization plan to revitalize the city increase planting of streets in sector II.

"Green Malaysia": an historical perspective. Maruthaveeran, S. (*Forest Research Institute Malaysia, Malaysia; sreetheran@frim.gov.my*).

The greening of urban Malaysia has focused primarily on beautification and has mainly been the province of horticulturists, landscapers, nursery workers, town planners and architects, with negligible inputs from foresters. Perhaps for that reason, the term "landscaping" has been used more widely than "urban forestry" by government and private institutions, politicians, stakeholders, academicians and the public. However, this does not mean that tree planting has not been given a priority in Malaysia's cities. This paper highlights the development of urban tree planting in Malaysia from a historical perspective and outlines some challenges and prospects for its continued development. The development falls loosely into three phases: the initiation of greening prior to independence; a more extensive greening programme in the 1970s, 1980s and 1990s; and the campaign for a Garden Nation of the past ten years. Over the course of this development, Malaysian cities have seen great changes in species selection, tree planting and tree maintenance, in other words a transition towards improved arboricultural practices. In the ninth Malaysian Plan, sustainable development and conservation of biological resources are emphasized. In line with this, big cities like Kuala Lumpur are establishing more urban parks for their dwellers.

Health benefits from wood interiors in hospital rooms. Nyrud, A.Q. (*NTI, Norway, anders.q.nyud@treteknisk.no*), Bringslimark, T. (*Norwegian University of Life Sciences, Norway, tina.bringslimark@umb.no*).

The presentation provides a theoretical basis for evaluating psychological effects of the use of building materials from wood. Empirical studies have documented that both active and passive experiences of nature may be beneficial for human health and well-being. The use of natural materials – such as wood – is expected to improve the user experience of designed environments. A study was conducted to evaluate psychological impact of different wood interiors in a hospital room was measured by using employees at a hospital as an expert group. An anonymous e-mail questionnaire was sent out to employees at a Norwegian hospital and the participants were asked to rate the pictures on twelve items describing the room. All the items in the questionnaire were taken from standardised measures related to preferences for both exterior and interior settings. The results indicated that it was the room with an intermediate level of wood that was the most preferred. This room was also rated as most *pleasant, natural, calming*, and *secure*, and as the least *boring* room. The results indicate that there are limitations to how much wood is preferred and provides some guidelines for how wood should be used in interior settings.

Estimation of heat island control effect on the urban forests. Yang, J.S., Kim, E.G., Kim, D.H., Shin, H.J., Park, S.B., Jeong, Y.O. (*Gyeongsang National University, Republic of Korea; yjs0605@gnu.ac.kr; egkim@gnu.kr; kdd221@gnu.kr; neoria@gnu.kr; ifwannayou@gnu.kr; ok99@gnu.kr*).

This study examines how urban forests can provide urban heat island relief as the function of Life Amenity Formation. For this study, total 126 of cities and counties were selected for study. We used regression analysis, using electricity consumption per person from July to August as dependent variable. There were 15 independent variables in our model related to metrological factors from July to August, land condition, income and electricity consumption type. Regression analyses were conducted using the statistical package SPSS 12.0K. Analysis results show that variables having a positive (+) effects on electricity consumption per person were electricity share for industrial use from July to August, the status of automobile registration per person, and GRDP (Gross Regional Domestic Product) per person, while urban forests within living area per person had negative(-) effect, with an R^2 of this regression model of 0.60. These results show that the increase of urban forests within living area as the function of Life Amenity Formation could be an effective countermeasure policy in relieving heat island effects.

I-02 Health benefits of forests

Organizers: Eeva Karjalainen, *Finnish Forest Research Institute, Finland, eeva.karjalainen@metla.fi*; Won Sop Shin, *Chungbuk National University, Republic of Korea*, *wonsop.shin@gmail.com*; Kjell Nilsson, *University of Copenhagen, Denmark, kjni@life.ku.dk.*

Assessment of the demand and consumption of herbal medicines in Ido and northwest Ibadan, Nigeria. Adebayo John, J., Oluwafemi, O.S., Bolarinwa, O., Omolade, A.J. (*Forestry Research Institute of Nigeria, Nigeria; talktobayo247@yahoo.com; oyamakin_femi@yahoo.com; oyeleyebolarinwa2003@yahoo.com; janetasaolu@yahoo.com*).

This study examined people's responses to demand and consumption of herbal medicines in Nigeria. It also assessed people's evaluation of the effectiveness of the existing medicines on the treatment of ailments and of encouraging forest products utilization for greener future in terms of healthcare delivery. Two Local Government Areas, namely Ido and Ibadan Northwest, were adopted for the study. Ido is characterized by rural populalation and Ibadan Northwest by urban population. Out of 500 questionnaires randomly administered to the households of the study areas, 481 (96.2%) were returned. Statistical analysis employed showed that people are beginning to understand the importance of herbal medicines in Nigeria as majority of the households used self-made, as well as locally and internationally made herbal medicines to treat various ailments. The major problems encountered by the respondents include right prescription and preservation methods. Over 85% of the respondents believed that forest related organization should be allowed to produce and supply herbal medicines in the society. It was recommended that Forestry Research Institutes in Nigeria should be encouraged in packaging their research findings on medicinal plants into products and make them available to the society for sustainable healthcare management and greener future of the nation.

Nearby nature for human health: evidence, theory, and implications. De Vries, S. (*Wageningen University and Research centre, the Netherlands; sjerp.devries@wur.nl*).

A review shows that in several north-west European countries (England, Denmark, The Netherlands, Sweden) a positive relationship has been established between the availability of green space near people's homes and their health, self-reported as well as in terms of morbidity and mortality. However, since correlation does not equal causation, more insight in the process behind this relationship is desired: how does it come about? Suggested causal explanations include: (a) improvement of air quality by filtering out fine particulate matter, (b) reduction of stress and concentration problems, (c) stimulation of physical activity, and (d) facilitation of social cohesion within the neighbourhood. The first question that will be addressed is the contribution of each of these mechanisms to the observed nature – health relationship. A second question is what type of green space will offer the greatest health benefits (and for whom), according to the mechanism at hand. Answering these questions will help to make more and better use of the salutogenic qualities of nearby nature, e.g. in public health and spatial planning policies. Some preliminary answers will be provided.

Forest recreation, psychological restoration, and health: some experimental and epidemiological findings. Hartig, T. (*Uppsala University, Sweden; terry.hartig@ibf.uu.se*).

Many surveys over the past decades have identified psychological restoration as an important motive for forest recreation. In more recent years, inquiry has looked beyond motives to consider how forest recreation might serve physical and mental health by promoting restoration. In this presentation, I will first give some background on psychological restoration as a family of processes

that mediate relations between environment and health. I will then present findings from recent experimental research on the mechanisms thought to be at work in restoration. This research has documented the emergence of relatively beneficial changes in emotion, physiology, and performance on attention-demanding tasks during time spent outdoors in a natural setting versus another, typically urban public setting. Finally, I will present findings from recent epidemiological studies that have considered how access to natural settings for recreation might serve health in the long run. These studies have been guided by the assumption that regular participation in restorative activities will over time help a person to avoid a variety of negative health outcomes. The results, obtained with longitudinal data, suggest that having access to outdoor recreation settings reduces the likelihood of outcomes such as depression and early death.

Elucidation of the molecular mechanism of the alleviation of atopic dermatitis by flavonoids by means of text mining method. Kushida, T. (*NalaPro Technologies, Inc., Japan, kushida@nalapro.com*), Takagi, T. (*Database Center for Life Science, ROIS, Japan, takagi@dbcls.rois.ac.jp*).

Flavonoids, secondary metabolic substances contained in bark, exhibit many biological functions such as, antioxidation, alleviation of atopic dermatitis and pollen allergy, antineoplastic effect, and hypertension prevention. However, the mechanisms of the multifunctionality of flavonoids have been largely unknown. In this study, we focused on the effect of the alleviation of atopic dermatitis from many biological functions of flavonoids to elucidate the molecular mechanism. We used the PubMed database to extract published information of molecular interactions and biological networks regarding flavonoids and atopic dermatitis from the articles by using a text mining method. We then compared both of these biological networks, and tried to discover key molecules which would be involved in the function. From this work, it became clear that flavonoids directly and indirectly inhibit or regulate IL4 (Interleukin-4), IFNG (Interferon gamma), and histamine which are constituents of atopic dermatitis network. Particularly, the result showed that the inhibitory pathway from flavonoids to IL4 was similar to the inhibitory mechanism of acute-phase reaction of atopic dermatitis by ketconazole which is a kind of antimycotic agents.

Serotonin in forest healing. Lee, S.H. (*Comprehensive Research Institute for Korea Natural Medicine, Republic of Korea; chief@healience.com*).

Serotonin is a brain neurotransmitter that has many important functions. It helps in regulating body balance, including moods, learning, eating patterns, sexual behavior and sleep. It also plays a role in relieving depression and other psychological and emotional conditions. However, environmental changes caused by the growth of industry and urbanization decrease the amount of serotonin in the brain. Low serotonin levels lead to feelings of depression, anxiety, and other problems and hence it is important to maintain the level of serotonin at the optimum level. The aim of this presentation is to explore the effects of forest on serotonin level. Forests make positive contribution to human psychological health and well-being and forest visits can contribute to improved emotional as well as physical health. Walking through a quiet forest path, with fresh air, fragrant flowers and singing birds helps to increase serotonin level. For this reason we have built a health camp, called Sunmaul, in the deep mountains to promote health condition in general and to prevent life style disorders. We will present results of clients' responses and experiences in the past two years.

A day trip to a forest park enhances human immune function. Li, Q., Kawada, T. (*Nippon Medical School, Japan; qing-li@nms.ac.jp; kawada@nms.ac.jp*), Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; kagawa@ffpri.affrc.go.jp*).

We have previously found that 2-night/3-day trips to forest parks enhance human immune function. In the present study, we investigated the effect of a day trip to a forest park on human immune function. Twelve healthy male subjects, aged 35–53 years, were selected after giving informed consent. The subjects visited a forest park for one day. They walked for two hours in the morning and afternoon, respectively, in the forest park. Blood and urine were sampled on days 2 and 7 after the trip. Natural killer (NK) activity, numbers of NK, and anti-cancer protein-expressing lymphocytes, the concentrations of cortisol in blood samples, and the concentration of adrenaline in urine were measured. Similar measurements were made before the trip as the control. The day trip to the forest park significantly increased NK activity and the numbers of NK, anti-cancer protein-expressing lymphocytes and significantly decreased the concentrations of cortisol and adrenaline. The increased NK activity lasted for 7 days after the trip. Phytoncides, such as isoprene and alpha-pinene, were detected in the forest air. These findings indicate that the day trip to the forest park enhanced human immune function, and that this effect lasted for 7 days after the trip.

Prospecting for new personal and health care ingredients from some Malaysian aromatic plants. Mohamad Ali, N.A., Jamil, M., Saidin, S.H., Abdul Ghani, S.H., Jalil, A.M., Pisar, M., Mohd Zaki, Z., Mohtar, M., Jamaluddin, F. (*Forest Research Institute Malaysia, Malaysia; norazah@frim.gov.my; malina@frim.gov.my; saidatul@frim.gov.my; sitihumairah@frim.gov.my; majid@frim.gov.my; mazura@frim.gov.my; zaridah@frim.gov.my; mastura@frim.gov.my; fadzureena@frim.gov.my*).

Herbal health care and aromatherapy products based on plant essential oils and plant extracts are increasingly available in the global market. Realizing the tremendous beneficial potential of the Malaysian biodiversity; there is a need to examine the suitability of new plant essential oils and plant extracts for health and personal care use. Species selected for this study included those from the family Lauraceae, Rutaceae, Zingiberaceae, Thymelaceae and Annonaceae. The investigation began with gathering traditional knowledge, taxonomy identification, extraction, chemical profiling, standardization, biological activity, prototype product development, efficacy and quality control. Extracts and essential oils with therapeutic potential were developed into personal and health care products such as anti-inflammatory cream, insect repellent product, aromatherapy massage oil, soap, shampoo and bath salts. The presence of specific terpenoids, flavonoids and phytosteroids in these aromatic plants may be contributing to the bioactivity, fragrance and moisturizing effects of these products. Our results so far had reemphasized the importance of scientific research findings in providing basis to the use of these aromatic plants in traditional knowledge as well as new applications as personal and health care ingredients for human health.

Recent scientific findings on the health benefits of forests in Europe. Nilsson, K. (*University of Copenhagen, Denmark; kjni@life.ku.dk*), Sangster, M. (*Forestry Commission, UK; marcus.sangster@forestry.gsi.gov.uk*).

The following conclusions are the major results of COST Action E39 "Forests, Trees and Human Health and Wellbeing". The Action, involving 160 researchers from 23 European countries, started in 2004 and terminated in 2008. A comprehensive textbook will be published by Springer in 2010. There is suggestive evidence of substantial economic benefits arising from lower rates of illness and a reduced requirement for medical interventions. Because of the potential scale of the savings a concerted, Europe-wide effort to understand the costs and benefits is called for. The current scale of research is disproportionately small relative to the potential public benefit. Current policy on health and the environment over-emphasizes environmental hazards and neglects the potential for natural environments to make very large positive contributions to health. In addition the emphasis on hazards creates behavioural barriers to public use of, and public benefit from greenspace. A more persuasive evidence base is needed on the links between natural outdoor environments and human health and wellbeing. Studies should investigate the mechanisms at work, and look at effects for different target groups.

Assessment of the physiological effects of forest bathing (taking in the forest atmosphere) in field tests at 35 sites throughout Japan. Park, B.J. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp*), Tsunetsugu, Y., Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; yukot@ffpri.affrc.go.jp; kagawa@ffpri.affrc.go.jp*), Miyazaki, Y. (*Chiba University, Japan; ymiyazaki@faculty.chiba-u.jp*).

The aim of this study was to determine the physiological effects of forest bathing (taking in the forest atmosphere). Groups of twelve subjects walked in and viewed the landscapes of forest and city areas in a total of thirty-five separate locations (total 420 subjects; 21.7 ± 1.5 years of age). The subjects' physiological condition were assessed by measuring salivary cortisol concentration, blood pressure, pulse rate, and heart rate variability (HRV) before and after walking in and viewing the forest and city area. The R-R intervals of subjects were also measured continuously during walking and viewing. Compared to city areas, walking in forest areas and viewing forest landscapes resulted in a lowered concentration of salivary cortisol (walking: 15.8%; viewing: 13.4%), lowered systolic blood pressure (1.9%; 1.7%), lowered diastolic blood pressure (2.1%; 1.6%), lowered pulse rate (3.9%; 6.0%), increased parasympathetic nervous activity (103.5%; 56.1%) and lowered sympathetic nervous activity (14.0%; 18.0%). All results showed a significant difference between the effect of city and forest areas on subject relaxation. We concluded that forest bathing was effective for relaxing the human body.

Human responses to forest environments: physiological assessment and individual differences. Tsunetsugu, Y. (*Forestry and Forest Products Research Institute, Japan; yukot@ffpri.affrc.go.jp*), Park, B.J., Miyazaki, Y. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp; ymiyazaki@faculty.chiba-u.jp*).

Natural environments, such as forests, provide humans with feelings of relaxation or refreshment. To verify this innate wisdom, the authors conducted on-site experiments in actual forests in Japan. In a field experiment, usable physiological measurements are limited; the indices must be easily measurable within a short time, and must be tolerable of environmental factors such as temperature, wind, light, noise, and vibration. In the present study, the authors demonstrate a physiological assessment system developed through the field experiments. By combining physiological indices such as salivary cortisol concentration, heart rate variability, blood pressure, and pulse rate, it was elucidated that forest environments generally had relaxing effects on human physiology. It was also elucidated that there were large individual differences in the physiological responses to forest environments. The authors focused on personality traits and baseline values (physiological values at rest) and found that these two had a certain association with the variations in the physiological responses. The physiological approaches, with individual differences taken into consideration, will contribute to a better knowledge of the beneficial effects of forests on human health.

Posters

Forest environments as complement in health promotion. Annerstedt, M., Norman, J. (*Swedish University of Agricultural Sciences, Sweden; matilda.annerstedt@ltj.slu.se; johan.norman@ess.slu.se*).

Mental diseases are expected to dominate the global burden of disease within a couple of decades. Contemporary health care has insufficient means to meet the demands from mental illnesses. As one possible solution WHO has suggested a much higher focus on promoting health. Since resources are restricted it is necessary to find cost-efficient and sustainable manners to provide opportunities for promotion. Drawing on theories from environmental psychology we have epidemiologically investigated access and use of forests among a Swedish population and made statistical correlations to self rated health, level of stress, visits to health care and proportion of sick leave. The results suggest that there may be an association between access to forest nature and healthier lives. This supports the hypothesis of nature as an efficient way towards promoting health and preventing stress related illness and other mental disorders. By emphasizing this role of forest values a sustainable management of forestland should be motivated, wherein the aspect of human health is incorporated in decisions concerned with planning, establishing and managing of forests.

Psychological, physical and social benefits of nearby forests in contrast to other landscape types. Degenhardt, B., Buchecker, M. (*Swiss Federal Institute for Forest, Snow and Landscape WSL, Switzerland, barbara.degenhardt@wsl.ch; matthias.buchecker@wsl.ch*).

Nearby outdoor recreation areas (NORAs) can provide important opportunities for individuals to recover from their various demands of daily life. To design NORAs that support individual coping with daily demands, it is important to understand what individual benefits people associate with particular landscape characteristics. Therefore, we investigated which landscape elements residents preferred in the NORA when seeking to fulfil their specific restorative needs. A total of 542 inhabitants of a periurban Swiss town returned a postal questionnaire in which they indicated (a) how often they used the NORA with which of 28 cognitive, emotional, physical, social and ego-related goals, and (b) their preference for each of 20 potential landscape elements on their routes within the NORA. Initial factor analysis yielded 7 landscape "types" which we labeled forest, savannah, mountain, open country, water, semi-private outdoors, and light & space. Ordinal correlations between landscape type and restorative goals show general and specific patterns of the landscape types with the use goals, such as that forest visits are associated with social

retreat, and centering-oriented goals, but less with spiritual goals. The results suggest that the type of landscape matters when designing nearby nature to support people's recovery and well-being.

Effects of forest therapy on oxidative stress and antioxidative potential. Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; kagawa@ffpri.affrc.go.jp*), Hattori, M. (*Nippon Medical School, Japan; hattori@erutaner.com*), Miura, Y. (*University of Tsukuba, Japan; s0921307@u.tsukuba.ac.jp*), Kaneko, Y. (*Wismerll Company Limited, Japan; y-kaneko@wismerll.co.jp*).

Recently, there has been remarkable progress in research on the effects of forest therapy, and an increasing number of Japanese municipalities are using forest therapy for revitalizing the local area and maintaining the health of local residents. In Japan, approximately 40 forest therapy areas have already been designated. Our field experiment was implemented at a therapy trail in planted cedar forests located in Okutama-machi, Tokyo, with 13 adult volunteers aged in their 30s to 50s. The subjects were divided into groups, and each group had a one-hour guided tour in the forest. Their blood samples were obtained both before and after the experiment, and were then examined using the Free Radical Analytical System 4 (FRAS4) to assess their oxidative stress levels by measuring the hydroperoxide concentration by a d-ROMs test, as well as assess their antioxidative potential by measuring the reduction potential of Fe^{3+} by a BAP test. The results of blood tests before and after the forest therapy showed no significant difference in the oxidative stress, but revealed a significant increase in the antioxidative potential. Thus, these results suggest that forest therapy in a planted cedar forest improves the antioxidative potential and enhances the reduction potential for active oxygen/free radicals.

Well-being effects of nature-based physical activity. Karjalainen, E. (*Finnish Forest Research Institute, Finland; eeva.karjalainen@metla.fi*), Borodulin, K. (*National Institute for Health and Welfare, Finland; katja.borodulin@thl.fi*), Korpela, K. (*University of Tampere, Finland; kalevi.korpela@uta.fi*), Neuvonen, M. (*Finnish Forest Research Institute, Finland; marjo.neuvonen@metla.fi*), Paronen, O. (*UKK Institute, Finland; olavi.paronen@uta.fi*), Pouta, E. (*MTT Agrifood Research, Finland; eija.pouta@mtt.fi*), Sievänen, T., Tyrväinen, L. (*Finnish Forest Research Institute, Finland; tuija.sievanen@metla.fi; liisa.tyrvainen@metla.fi*).

In Finland, the natural environment is the most popular scene for physical activity. Almost all Finns recreate in nature during the year. Previous research shows that recreation in natural environment induces many health benefits. In addition, green environment creates aesthetic experiences, motivates for exercise, and helps in strengthening and regulating social contacts. This study explores the perceived well-being effects of different forms of nature-based activities in comparison to the benefits of indoor exercise. The study also examines the differences in restorative outcomes between various types of natural environments and the environmental qualities that generate positive and negative effects on human well-being. This study looks at both the restorative benefits gained during single outdoor recreation visit and the long-term influences of nature-based activities on the perceived health and well-being. Two inquiries were conducted; a nationwide survey (3060 respondents), and a follow-on survey for those who volunteered for further inquiry (around 565 respondents). The questionnaires measured e.g. the type and frequency of nature-based activities, self-rated health and mood, the restorative experiences of the last outdoor recreation visit, qualities and types of the outdoor recreation environment, and the quality of a respondent's residential environment. Preliminary results are presented.

Radical scavenging and antioxidant activities of essential oils from three *Eucalyptus* species. Kaur, S. (*Panjab University, India; kaur_shalu@yahoo.com*).

Eucalyptus is a large genus of tall evergreen trees that are extensively planted throughout the world for pulpwood. Additionally, the tree leaves are harvested for the essential oil that is used in food, flavour, and perfumery industry. The present work investigated the antioxidant and free radical scavenging activities of essential oils from leaves of three *Eucalyptus* species (*E. citriodora*, *E. globulus* and *E. tereticornis*) in terms of DPPH radical, hydroxyl radical, and superoxide anion scavenging activity. All the three oils (50–400 µg/ml exhibited strong total antioxidant activity showing 85.4–67.2, 68.5–45.6 and 78.4–23.4% inhibition. Among the three species, *E. citriodora* essential oils showed maximum DPPH radical scavenging activity followed by oils from *E. globulus* and *E. tereticornis*. Further, the three leaf oils possessed hydroxyl radical scavenging activity in the range of 56–69%. The radical scavenging and antioxidant properties of the oils were comparable to those of commercial antioxidant BHT/ascorbic acid. The results indicate that volatile oils from *Eucalyptus* spp. are a good source of naturally occurring antioxidants for use in food preservation and in pharmaceutical industry.

Comparison of psychological effects of forest bathing between coniferous and broad-leaved forests. Kasetani, T., Miyakawa, J. (*Chiba prefecture/Chiba University, Japan; t.kstn@mc.pref.chiba.lg.jp; j.mykw@ma.pref.chiba.lg.jp*), Takayama, N. (*Forestry and Forest Products Research Institute, Japan; hanri@ffpri.affrc.go.jp*), Park, B.J. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp*), Morikawa, T., Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; tmorik@ffpri.affrc.go.jp; kagawa@ffpri.affrc.go.jp*), Iwasaki, Y. (*Chiba University, Japan; iway@faculty.chiba-u.jp*).

The purpose of the present study was to compare the psychological effects of forest bathing in coniferous forest and broad-leaved forest. We examined the psychological effects of coniferous forest (*Cryptomeria japonica*) and broad-leaved forest (*Carpinus tschonoskii*, *Acer palmatum*) for 3 days in August and 3 days in December 2009 at Chiba Kenmin-no-mori in Funabashi city, downtown inner city area serving as a control. The subjects were twelve and eighteen females. They sat in a coniferous forest, broadleaf forest, and city for 15 minutes each. The profile of mood states (POMS) and the semantic differential (SD) were measured before and after viewing the coniferous forest, broad-leaved forest and city landscapes. The results showed that after sitting in a forest the subjects reported improved POMS indexes such as "tension and anxiety" and "vigor". Sitting in the broad-leaved forest decreased "fatigue". The SD responses showed that the subjects experienced coniferous and broad-leaved forests significantly more comfortable, friendly and healthy places compared to city areas. We concluded that (1) forest setting had a relaxing effect on subjects when rated subjectively, and (2) the psychological relaxing effect did differ in coniferous and broad-leaved forests.

Improvement of liver function using extracts of Korean raisin tree (*Hovenia dulcis* var. *koreana* Nakai). Kim, S.H., Na, C. S., Lee, K.Y., Han, J.G. (*Korea Forest Research Institute, Republic of Korea; goldtree@forest.go.kr; spectreena@hanmail.net; leeky99@forest.go.kr; stationair@forest.go.kr*).

Korean raisin tree (*Hovenia dulcis* var. *koreana* Nakai), which is widely distributed in Korea, China and Japan, has shown to improve liver function and to reduce the acute alcohol toxicity. In this study, the improvement effect of the peduncle extracts on liver function was investigated through the chemically induced experimental liver injury models as well as the alcohol-administered animal models. HdfHW-1, HdfM-1 and HdbrM-1 which are the extracts of fruit and young branches with hot water, 70% methanol and 100% methanol, were significantly reduced the CCl_4 or D-galactosamine/LPS-induced damages on the sliced liver. The hot water or methanol extracts from fruit peduncles protected the primary hepatocyte culture against CCl_4-induced toxicity in a dose-dependent manner. Moreover, the released amount of LDH was reduced to the control level at 500μg/Mℓ 5 of hot water extracts. HdfHW-1 also decreased the CCl_4-induced hepatotoxicity in rats. The active components of HdfHW-1 seemed to contain high molecular weight substances because 0.2M NaC1 HdfHW-1 fraction was the most effective among NaCl fractions of through DEAE 650C column chromatography. HdfM and HdfHW also significantly reduced the levels of blood alcohol in both rats and mice, which were previously administered with 40% alcohol.

Forestry biodiversity and well-being: on-site experiences in urban areas in Italy. Lafortezza, R., Sanesi, G., Colangelo, G. (*University of Bari, Italy; r.lafortezza@agr.uniba.it; sanesi@agr.uniba.it; giu.colangelo@gmail.com*), Carrus, G. (*University of Roma 3, Italy; g.carrus@uniroma3.it*), Ferrini, F., Salbitano, F. (*University of Florence, Italy; francesco.ferrini@unifi.it; fabio.salbitano@unifi.it*), Semenzato, P. (*University of Padoa, Italy; paolo.semenzato@unipd.it*).

In this study, we selected five types of urban green spaces in Italy, ranging from a minimum of biodiversity and a maximum of man-made elements to a maximum of biodiversity and a minimum of man-made elements. A convenience sample (N = 125) was contacted in the city of Padua, Florence, Rome, Bari. A questionnaire focusing on people's experiences in the environment (length and frequency of visits, activities performed, perceived restorativeness, affective qualities of the place, perceived well-being during and after the visits) was administered. Results showed that the perceived restorative properties are higher in the peri-urban green areas, and significantly increasing as a function of biodiversity levels in the environment. Moreover, the activities performed in the environment impacted both perceived restorativeness and respondents' well-being. Finally, frequency and duration of visits positively predicted self-reported well-being. As expected, a significant mediating role of both perceived restorativeness and affective qualities upon the relationship between duration and frequency of visits and individual well-being was detected. The theoretical implications in the analysis of the process leading to restoration are discussed, and potential guidelines for a more healthy management of everyday urban and peri-urban natural environments are envisaged.

The influence of forest scenes on psychophysiological responses. Lee, J.H., Shin, W.S., Yeoun, P.S. (*Chungbuk National University, Republic of Korea; qudgh1012@nate.com*).

Viewing or contacting with forest provides restoration from daily stress or fatigue. This study examined the effect of urban scenes and several types of forest biomes on psychophysiological responses of human body. The overall purpose of this study was to examine which specific forest settings evoke the most positive reactions in people. The experiment was performed with 30 subjects who were university students. The subjects were exposed to 27 types of scenery (for 10 seconds each). ANOVA tests and post hoc comparisons using setting scores across the participants' data on the responses to the 27 biome slides regarding scenic beauty, preference, Perceived Restorativeness Scales (PRS) and alpha wave (brain wave) were performed. The results of data analysis showed that the subjects preferred forest sceneries to urban sceneries. The results also indicated that scenery with forest and water was the most favored and evoked the highest level of psychophysiological responses to the subjects. These findings support the biophilia hypothesis and provide some evidence toward the restorative benefits of forest environments. Findings are discussed in relation to psychological research in forest therapy.

Health-related benefits of forest stimulation based on indoor experiments. Lee, J.Y., Park, B.J. (*Chiba University, Japan; juyoung@graduate.chiba-u.jp; bjpark@faculty.chiba-u.jp*), Tsunetsugu, Y. (*Forestry and Forest Products Research Institute, Japan; yukot@ffpri.affrc.go.jp*), Miyazaki, Y. (*Chiba University, Japan; ymiyazaki@faculty.chiba-u.jp*).

With growing interest in the therapeutic effects of forest environments, there have been great needs for scientific evidence of these effects. Therefore, this study aimed to elucidate the physiological benefits of forest-related stimulation through laboratory experiments. Sensory information was input via the five senses (vision, olfaction, etc.), and it was attempted to clarify the physiological reactivity to each stimulation. The tests were carried out in a room with a controlled setting. Subjects were young male students. Cerebral and autonomic nervous activities were measured using near infrared spectroscopy of the prefrontal area and blood pressure, respectively. For the forest-related stimulations, forest scenery was used for vision, the smell of cedar chips for olfactory, the sound of streams for audition, and the taste of cedar barrel-aged whisky for taste sensation. The results showed that viewing the forest scenery, smelling cedar chips and listening to the sound of streams caused significant reductions in prefrontal area activity and blood pressure. Also, tasting cedar barrel-stored whisky suppressed the increase of prefrontal area activity and systolic blood pressure was induced significantly by whisky alone. In conclusion, this study provided scientific data supporting the idea that forest-related stimulation has positive effects in terms of physiological relaxation.

Physiological relaxation produced by horticultural activity. Lee, M.S., Park, K.T., Lee, J., Park, B.J. (*Chiba University, Japan; lmsid26@gmail.com; forever8312@gmail.com; juyoung@graduate.chiba-u.jp; bjpark@faculty.chiba-u.jp*), Ku, J.H., Lee, J.W., Oh, K.O., An, K.W. (*Chonnam National University, Korea; kuja99@cnu.ac.kr; jwlee@cnu.ac.kr; ohkok@cnu.ac.kr; kiwan@jnu.ac.kr*), Miyazaki, Y. (*Chiba University, Japan; ymiyazaki@faculty.chiba-u.jp*).

The aim of this study was to determine physiological effects of horticultural activity. A first experiment compared the physiological effects of transplanting flowers (*Chrysanthemum morifolium*) for 15 minutes and transplanting artificial flowers for 15 minutes. A second experiment compared the effects of transplanting foliage plants (*Peperomia angula*) for 15 minutes and

working with computer for 15 minutes. On the first day of the experiments, thirteen subjects transplanted flowers and foliage plants. The other thirteen subjects (control group) transplanted artificial flowers and worked with computer. On the second day of the experiments, the subjects went to the opposite works. Twenty-six male university students (25.9±2.1 years old) were subjects of the experiments. The physiological condition of subjects was assessed by measuring heart rate variability, heart rate, blood pressure, and a semantic differential rating used as a subjective assessment. Transplanting flowers produced significantly reduced values of LF/(LF+HF) of HRV, an index of sympathetic nervous activity, during the last five minutes. Subjective assessments showed that this activity produced a comfortable and calm feeling. Transplanting foliage plants produced significantly reduced values of LF/(LF+HF) during the last three minutes and decreased diastolic blood pressure. We concluded that horticultural activity had a relaxing effect in the subjects both physiologically and by subjective assessment.

Pre-evaluation of twig bark extract from *Cryptomeria japonica* on antioxidant effect. Li, W.H., Cheng, S.S., Lee, C.J., Wang, Y.N., Chang, H.T. (*National Taiwan University, China-Taipei; wenhsinli@ntu.edu.tw; sensung@exfo.ntu.edu.tw; 1327@exfo.ntu.edu.tw; m627@ntu.edu.tw; clairechang@ntu.edu.tw*).

Sugi (*Cryptomeria japonica*), extensively planted in Japan and China, is well known to contains a high amount of health promoting antioxidants. We studied ethanolic extract of sugi bark and found that its total phenolic content is about 134 mg/g of GAE (Gallic acid equivalent) and that it showed good antioxidant activities. Using liquid-liquid partition, we separated the extract into *n*-hexane fraction (HEF), ethyl acetate fraction (EAF), and water fraction (WAF). Of these three fractions, EAF contained highest content of total phenolics (389 mg/g), proanthocyanidins (135 mg/g), and total flavonoids (9.34 mg/g). The main phenolic constituents of twig bark extract were proanthocyanidin type. Results of various antioxidant assays showed that different polar solvents affected the antioxidant activities significantly. EAF had the ability to scavenge the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and was with the lowest IC_{50} of 16.7 μg/mL better than other fractions. Outcomes of reducing power assay revealed EAF got higher optical density (OD) value at the wavelength of 700 nm. Also, EAF demonstrated better trolox equivalent antioxidant capacity (TEAC) of 0.442 mM. The order of three fraction by their antioxidant activities was EAF > WAF > HEF. This order is related to total phenolic contents, and might be used as an index for pre-evaluating research.

Physiological effects of a rooftop forest-like area on elderly women requiring care. Matsunaga, K. (*Matsunaga Hospital, Japan; keiko1@matsunaga-hp.jp*), Park, B.J. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp*), Aoyama, Y. (*Earthconscious Corporation, Japan; aoyama@earth-con.co.jp*), Seki, T. (*Corporation Aquaforest, Japan; info@aqua-forest.jp*), Miyazaki, Y. (*Chiba University, Japan; ymiyazaki@faculty.chiba-u.jp*).

The purpose of this study was to determine the physiological effects of a rooftop forest-like area on elderly women requiring care by measuring their heart rate variability (HRV). Thirty female subjects without dementia (81.7 ± 5.6 years old) were exposed to a rooftop forest-like area on the fourth floor of a health service facility (area 122 m^2), an outdoor car park area serving as a control. Fifteen subjects were assessed in the rooftop forest-like area and fifteen in the control area on the first day, and the groups changed areas for the second day. HRV was measured in subjects for seven minutes, with analyses being conducted once a minute, while subjects sat in a wheel chair viewing the environment. Subjects were also interviewed for subjective feelings three times each day. As a result, the power of the High Frequency (HF) band of HRV, which reflects parasympathetic activity, increased from 3 minutes to 5 minutes after beginning to view the rooftop forest-like area, indicating a relaxed physiological state. According to the interviews, "comfortable," "lively," and "relaxed," feelings were found to be strengthened. In conclusion, a period spent in a rooftop forest-like area physiologically relaxed elderly women requiring care.

Medicinal plants in an urban environment: the medicinal flora of Rômna Uddan of Dhaka, Bangladesh. Mollik, A.H., Faruque, R., Akter, K., Hossain, A. (*Peoples Integrated Alliance, Bangladesh; mollik_bge@live.com; pia.bd.org@gmail.com; pia.bd.org@gmail.com; peoplesintegratedalliance@gmail.com*), Chowdhury, D.I., Rahman, M. (*Biogene Life Care, Bangladesh; biogenelifecare@yahoo.com; biogenelifecare@yahoo.com*).

Dhaka is one of the oldest continuously inhabited cities of the world, and one of the most important Muslim pilgrimage sites. Despite this importance, very little information exits on the city's flora in general, and medicinal plants found within its limit in particular. Traditional medicine plays a large role in Bangladeshi society. The presented study attempted to investigate if traditional plant use and availability of important common medicinal plants are maintained in urban environments. The paper presents information on the traditional uses of eighty-eight medicinal plants collected from the Rômna Uddan in Dhaka, Bangladesh, and highlights the uses of these medicinal plants by the local inhabitants. The field survey covered different seasons. The survey was started in rainy seasons (July 2008) and collections were repeated every month for one and a half year. Seasonal variations and frequency of medicinal plants occurrence were noted. All medicinal plants were photographed, collected, identified, and vouchers were stored at the Bangladesh National Herbarium under the first author's collector series. The study provides a veritable source of information for traditional medicinal practitioners and medicinal plant researchers. These medicinal plants may be incorporated into the healthcare delivery system of the country.

Ethnomedicinal survey of plants used in Chapai-Nawabganj district of Bangladesh. Mollik, A.H., Faruque, R., Akter, K. (*Peoples Integrated Alliance, Bangladesh; mollik_bge@live.com; pia.bd.org@gmail.com; pia.bd.org@gmail.com*), Shadique, S. (*Government Azizul Haque College, Bangladesh; mollik_bge@yahoo.com*), Hassan, A.I. (*Biogene Life Care, Bangladesh; biogenelifecare@yahoo.com*), Thapa, K.K. (*Dinhata College, India; peoplesintegratedalliance@gmail.com*).

Chapai-Nawabganj, a district in Rajshahi division of Bangladesh, has a predominantly rural population that relies on traditional healers for the treatment of diseases. We conducted an ethnomedicinal survey amongst the traditional healers to obtain information on the plants used to cure various ailments. Detailed interviews were conducted and both plant samples and information on formulations and dosages were gathered. Plant samples were identified at the Bangladesh National Herbarium. A total of fifty-three plant species distributed into nineteen families were collected. The major families included *Leguminaceae* and *Compositae* (eight species each), *Euphorbiaceae* (six species), *Solanaceae* (four species) as well as *Combretaceae, Zingiberaceae, Amaranthaceae, Labiatae, Rutaceae*, and *Acanthaceae* (three species each). The remaining nine species were distributed in nine families.

These plants were used to treat respiratory tract, gastrointestinal, cardiovascular, ophthalmic, and hepatic disorders, as well as skin diseases. A number of plants were used as remedies for insect-bites, cancer, diabetes, arsenic poisoning, epilepsy, brain hemorrhage as well as bacterial and viral diseases. Plants were also used to as analgesics, and to treat sexual transmitted diseases and anti-spasmodic effects. The large number of complicated diseases treated with these plants warrant scientific studies for possible discovery of novel compounds with pharmacological activity.

Local knowledge on medicinal plants and its relation to coffee farmers' livelihood strategies in the Cordillera Volcánica Central-Talamanca Biological Corridor, Costa Rica. Noh, J.K. (*CATIE, Costa Rica; njk1201@hotmail.com*).

This study analyzed coffee farmers' knowledge on coffee-associated medicinal plants and its relation to coffee farmers' livelihood strategies. 32 farmers were interviewed in the Central Volcanic Ridge-Talamanca Biological Corridor, CVRTBC, Costa Rica. A total of 63 species of coffee-associated medicinal plants was identified. The most frequently observed families were *Asteraceae, Myrtaceae, Rutaceae* and *Fabaceae*. In order to evaluate the producers' knowledge on medicinal plants they were inquired the following aspects: common name, uses of medicinal plant, used parts, preparation, dose, handling, growth within the coffee plantation and provision of other ecosystem services besides the curative one. The coffee farmers with less than 5 ha farm areas and whose home was next to their coffee plantation showed a statistically significant knowledge on medicinal plants. A positive correlation between the knowledge on medicinal plants and the presence of medicinal plants in the coffee plantations was observed due to the producers' vision that other plants in the coffee plantation can affect coffee productivity. It was observed that some aspects of this knowledge has a direct influence on the human, cultural, social, financial and political capitals fortifying coffee farmers' livelihood strategies.

Evalution of antioxydant activity of *Mycoleptodonoides aitchisonii*, *Sparassis crispa*, *Lentinus lepideus* and *Lentinula edodes*. Oh, D.S. (*Jeonnam Forest Resources Research Institute, Republic of Korea; ohye@korea.kr*), Kim, S.K. (*Chungnam National University, Republic of Korea; sangkim@cnu.ac.kr*), Shin, H.J. (*Chosun University, Republic of Korea; shinhj@chosun.ac.kr*), Wi, A.J., Park, W.S. (*Jeonnam Forest Resources Research Institute, Republic of Korea; ajwiko@korea.kr; pws0815@korea.kr*), Park, J.M. (*Jeonbuk Forest Environment Research Institute, Republic of Korea; joonmoh@korea.kr*).

Edible mushrooms including *Mycoleptodonoides aitchisonii, Sparassis crispa* (cauliflower mushroom), *Lentinus lepideus and Lentinula edodes* (oak mushroom) are employed as folk remedies for diabetes and inflammatory diseases. Evaluation of antioxidant activities using the extracts from these mushrooms is interesting because oxidative stress plays a critical role in pathophysiology of these diseases.The total oxyradical scavenging capacity (TOSC) assay based on the inhibition of oxyradical-induced production of ethylene gas from alpha-keto-gamma-methiolbutyric acid can evaluate antioxidant capacity against physiological oxidants including peroxynitrite, peroxyl radicals and hydroxyl radical. In our study, specific TOSC values calculated from the slope of the linear regression for extracts from mycelials and fruit-body of *M. aitchisonii*, fruit-body of *S. crispa*, fruit-body of *Lentinus lepideus*, and fruit-body of *Lentinula edodes* against peroxynitrite, peroxynitrite, and hydroxyl radicals. The results of these evaluations suggest potent oxy-radical scavenging capacities of extracts from mushrooms used in this study, which warrants further studies for evaluation of pharmacological activities of these mushrooms.

Relationship between psychological response and physical environments. Park, B.J., Furuya, K. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp; k.furuya@faculty.chiba-u.jp*), Kasetani, T. (*Chiba prefecture and Chiba University, Japan; t.kstn@mc.pref.chiba.lg.jp*), Takayama, N., Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; hanri@ffpri.affrc.go.jp; kagawa@ffpri.affrc.go.jp*), Miyazaki, Y. (*Chiba University, Japan; ymiyazaki@faculty.chiba-u.jp*).

The aim of this study was to determine the psychological effects of forest recreation and clarify the relationship between psychological response and the physical environment. Field experiments were conducted in fourteen forest and city environments across Japan with 168 subjects. A semantic differential (SD) method was used for responses after walking in forest and city environment, profile of mood states (POMS) was measured before and after walking, as well as before and after viewing the two settings. Temperature, relative humidity, radiant heat, wind speed, predicted mean vote (PMV), and predicted percentage dissatisfied (PPD) were surveyed as indexes of physical environments. A significant relationship was found between psychological responses (SD and POMS) and physical environments (temperature, relative humidity, radiant heat, wind speed, PMV, and PPD) for all sites. The SD results showed that subjects found forest areas to be significantly more enjoyable and friendly places than cities, and the results of POMS showed that forest settings significantly suppressed negative feelings ('tension and anxiety,' 'anger and hostility,' 'confusion,' 'fatigue'), while they increased feelings of 'vigor.' We conclude that (1) there is a significant relationship between psychological responses and physical environments, and (2) forest settings significantly enhance positive emotions and decrease negative emotions compared to city settings.

Forest experience and self-esteem: a case study with alcoholics in Korea. Shin, W.S. (*Chungbuk National University, Republic of Korea; shinwon@cbnu.ac.kr*).

A potential benefit of forest is its capacity to help people improve their self-esteem, especially people with mental/psychological problems such as alcoholics. Alcoholism is a major psychological problem in South Korea. Recent changes in the socioeconomic status of South Korea have caused big differences in alcohol-related social and health problems. This study investigated whether forest experience had a positive impact upon alcoholics' self-esteem levels. Self-esteem is used to reflect a person's overall evaluation or appraisal of his or her own worth. Psychologists argue that self-esteem encompasses one's beliefs and emotions. Therefore one's behavior may reflect self-esteem. Data was collected from 47 alcoholics who participated in nine-day forest healing program during the summer of 2007. Self-esteem levels were measured at the beginning and end of the camp experience. There was a significant improvement in alcoholics' self-esteem after the forest camp experience. The data was also analyzed by some of alcoholics' personal variables such as age and education levels. Those participants in their forties who had severely high self-esteem levels at the beginning of the program improved most significantly during the program experience.

The effect of forest experience on elementary school students' depression, school adaptation, and coping to learning stress. Song, J.H., Shin, W.S. (*Chung Buk National University, Republic of Korea; batuhara@yahoo.co.kr; shinwon@chungbuk.ac.kr*), Choi, M.D. (*Forest Interpreter's Association of Korea, Republic of Korea; mdchoi44@yahoo.co.kr*), Ko, D.H., Park, Y.M., Yeoun, P.S. (*Chung Buk National University, Republic of Korea; goda2000@hanmail.net; mindmapcoach@hanmail.net; imoscow@hanmail.net*), Kim, H.J. (*Top Dong Elementary School, Republic of Korea; smallrat63@hanmail.net*).

The overall purpose of this study was to investigate the relationship between the elementary school students' forest experience and their depression, school adaptation, and coping to learning stress. To collect data, 31 students from Topdong Elementary School in Kyungi-do, South Korea were selected and randomly assigned into experimental and control groups. During the spring and summer seasons of 2009, the students in the experimental group participated sessions of forest programs. The programs were composed of 12 sessions, and conducted forests near the school they attending. The data were analyzed with several statistical techniques such as frequency test, t-test and test of independence. The result of the data analyses indicated that the students who participated forest program had significant decreases in the levels of depression and school adaptation stress. On the other hand, their coping ability level to learning stress was positively increased. However, the students in control group had no significant changes in their depressions, school adaption stress, and learning stress. The result of this study suggested that forest program is the optimal tool for enhancing students' psychological well-beings from their daily school lives.

Can the boreal forest be used for rehabilitation and recovery from stress-related exhaustion? A pilot study. Sonntag-Öström, E. (*Umeå University, Sweden; elisabet.ostrom@envmed.umu.se*), Dolling, A., Lundell, Y. (*Swedish University of Agricultural Sciences, Sweden; ann.dolling@svek.slu.se; ylva.lundell@sek.slu.se*), Nordin, M., Slunga-Birgander, L. (*Umeå University, Sweden; maria.nordin@envmed.umu.se lisbeth.birgander@vll.se*).

It has been suggested that people recover better from mental exhaustion in environments that do not demand directed attention. Hence, we hypothesized that forests have restorative effects and tested it in a pilot study. Six persons suffering from mental exhaustion (chronic burnout) were offered visits twice a week, for eleven weeks, in six different forest settings, denoted; lake, rock outcrops, pine forest, mixed forest, spruce forest and small stream. The participants chose one of the forest settings prior to each visit. The mental state of each person was evaluated before and after each visit. Interviews focusing on the experience of the forest were conducted after the 22 visits. Solitude and forest settings with light were identified as positive factors for recovery. The darker settings were less frequently visited. Although only a limited amount of data was collected, it was clear that the visits had a positive effect on the subjects' mental state. The interviews also indicated that the concept seems suitable for a larger randomised study. It is important to provide a variety of forest settings to meet the preferences among the participants and to offer the possibility of solitude.

The influence of user's personality on the therapeutic effects of on-site forest environments. Takayama, N. (*Forestry and Forest Products Research Institute, Japan; hanri@ffpri.affrc.go.jp*), Park, B.J. (*Chiba University, Japan; bjpark@faculty.chiba-u.jp*), Kasetani, T. (*Chiba Prefecture, Japan; t.kstn@mc.pref.chiba.lg.jp*), Morikawa, T., Kagawa, T. (*Forestry and Forest Products Research Institute, Japan; tmorik@ffpri.affrc.go.jp; kagawa@ffpri.affrc.go.jp*), Nakano, H., Tsutsui, S. (*University of Human Arts and Sciences, Japan; nakano@human.ac.jp; tsutsui@human.ac.jp*).

This research sought to clarify how personality affects the therapeutic effects of on-site forest environments. The subjects were 33 students. First, we examined their personalities by a profile questionnaire, NEO Five-Factor Inventory, General Self-Efficacy Scale, and Thompson and Barton Scale -test. We then conducted a forest bathing experiment for each subject in several forest environments, and carried out the POMS (Profile of Mood States) test before and after each experiment. The results showed that all subjects reported improvements in POMS indexes such as "Vigor" and "Fatigue". Therapeutic effects of forest bathing varied according to the individual situation, experience, knowledge, personality characteristics, self-efficacy, sense of values, concern, and so on. Forest bathing was particularly effective for persons who had characteristics such as neuroticism, introversion, and low self-confidence. Among such subjects, the effects of forest bathing differed by activity, for example, strolling decreased "Anger-Hostility" and watching increased "Vigor" and decreased "Fatigue" more significantly than in the other groups.

I-03 Urban Forestry Combating Poverty — Building a Collaborative Stakeholders Dialogue

Organizers: Giovanni Sanesi, *University of Bari, Italy, sanesi@agr.uniba.it*; Michelle Gauthier, *FAO-Forestry, Italy, michelle.gauthier@fao.org.*

The functions and benefits expected from the urban forest of Istanbul metropolis, and a planning procedure application in the Validebag urban forest: a case study. Asan, Ü., Özkan, U.Y., Zengin, H., Sağlam, S. (*University of İstanbul, Turkey; asanunal@istanbul.edu.tr; uozkan@istanbul.edu.tr; hzengin@istanbul.edu.tr; nuhres@istanbul.edu.tr*).

Istanbul is the largest city of Turkey, and although its natural vegetation cover was destroyed during the historical eras, it still has some amount of urban forests in a form of city groves and parks. These woody lands in the city play very important roles on the social, cultural and spiritual human needs such as recreational usage, visual effect, nature conscience and creative inspiration, carbon sequestration for climate change, oxygen release, dust filtration and erosion control. Also these urban forests have importance for the poor communities that live near the periurban areas, providing food and income by marketing fruits gathered from these areas. The functions and benefits expected from these groves, and the basic principles foreseen during planning process like sustainability, multiple use, participation, etc. are explained in this paper. Technical procedures of the planning system known as the "Ecosystem Based Functional Planning" approach for determination of spatial functions by means of 3D digital terrain models is discussed in detail in the paper. Environmental capacity of the planning units, and the functions appearing spatially in some parts of the 14 city groves that are useful for determining management goals are outlined.

Trees and forests for cities: building alliances and good governance for poverty alleviation and food security. Gauthier, M., Custot, J., Egal, F., Gianfelici, F. (*FAO, Italy; michelle.gauthier@fao.org; julien.custot@fao.org; florence.egal@fao.org; francesca.gianfelich@fao.org*).

In cities and countries where urban forestry has not been promoted and where land use change associated to urbanization have resulted in critical degradation of land and tree cover, the impacts on poverty and food insecurity are alarming. The world financial crisis and the extreme weather events induced by climate change exacerbate this situation. Contrary to other domain were expertise, knowledge, policies and forum of dialogue are in place, the land and forestry issues related to urbanization are overlooked. This presentation focuses on worldwide experiences witnessing the role of integrated management of natural resources and specifically, on the role of urban and peri-urban forestry. The role of the Food and Agriculture Organization of the United Nations (FAO) will be emphasized. It will suggest opportunities to address the challenges and the vicious circle of environmental degradation, poverty increase and economic instability. It aims at building stakeholders networking, including United Nations agencies, local and national authorities, research and development agencies, private sector and civil society. Finally, it intends to stimulate the development process of decision making tools in a participatory and inclusive manner in view of "Forests and Trees for Healthy Cities – Improving Livelihood and Environment for All".

Urban forestry as a vehicle for healthy and sustainable development. Nilsson, K. (*University of Copenhagen, Denmark; kjni@life.ku.dk*).

Urban forestry has been defined as the art, science and technology of managing trees and forest resources in and around urban communities for the environmental, social, economy and aesthetic benefits trees provide. The importance of urban forestry has received limited attention in many poor countries as it is often perceived as being associated with beautification projects, which are considered a luxury benefiting only the wealthier part of the population. However, urban forestry may have a number of environmental, economic and socio-cultural values, which will also benefit poorer segments of city populations. The Forest & Landscape Denmark has been leading actor in the development of Urban Forestry in Europe during the last decade. CARe-FOR-US (Nordic-Baltic Centre for Advanced Research on Forestry Servicing Urbanised Societies), EUFORIC (European Urban Forestry Research and Information Centre), COST Action E12 "Urban Forests and Trees" and E39 "Forests, Trees and Human Health and Wellbeing", and the EU Project PLUREL on Peri-urban land use relationships", are all examples of activities initiated and coordinated by the Danish centre. It has also developed urban forestry and urban greening as a concept for environment and development aid projects in Eastern Europe and newly industrialised countries, e.g. China, Malaysia and South Africa.

A research/action approach in developing a strategy and an action plan to promote urban and periurban forestry: the case study of Bangui, Central Africa Republic. Salbitano, F. (*University of Florence, Italy; fabio.salbitano@unifi.it*), Gauthier, M. (*FAO, Italy, michelle.gauthier@fao.org*).

The dramatic urbanization of poverty of sub-Saharan Africa concerns 72% of urban citizens. The policy and administrative boards of the cities slowly approach the problem of accommodating the rapidly growing populations, providing them with adequate resources while ensuring environmental sustainability and combating poverty. Urban/periurban forestry (UPF) represents a opportunity by which cities and institutions can take responsibility for the needs and operate to improve a better livelihood for urban dwellers. This assumption was tested along a research/action approach oriented to build a Strategy and an Action Plan to promote UPF in Bangui, the capital city of Central Africa Republic, thanks to a TCP/FAO project. An open and incremental methodology was applied through different qualitative and quantitative tools along a communicative and participatory process. Three levels of action were discussed and developed by using thinking days, formal/informal interviews, *in situ* observations: political/institutional; structural/tactic; operational/action oriented. A range of pilot actions were implemented. The results served to design, together with a group of experts and key actors, three thematic strategies: reduction of deforestation and land degradation; contribution to combat urban/periurban poverty; ameliorate the wood energy chain. Two strategic platforms (WISDOM and JURIDIC) were prepared to facilitate implementation of the action plan.

The green system in Milan: an important tool for promoting a better quality of life. Sanesi, G. (*University of Bari, Italy; sanesi@agr.uniba.it*).

Poverty is the condition of individuals and human communities as a whole, found to have, for economic reasons, poor access to essential goods and primary goods and social services of vital importance. Poverty alone can constitute one of the major causes of social exclusion or marginalization, but at the same time represents a condition whose perception is closely tied to the social, economic and cultural context which helps to define standards of quality of life. Green spaces, considered in terms of quantity and quality, facilitate quality of life in contemporary cities, particularly in major metropolitan areas. Therefore, the urban and suburban green system, through the production of goods and services, may be an important resource for alleviating poverty in developed countries. This paper briefly analyzes the process of creation of the green system in the metropolitan area of Milan and discusses the main function of metropolitan green areas in terms of goods and socio-economic and environmental services. It also illustrates the actions that EXPO 2015 will take in the coming years to consolidate this important role, in particular to promote and consolidate the sense of well-being and health of urban populations.

The fuelwood market chain of Kinshasa: socio-economic and sustainability outcomes of the number one household energy in the Democratic Republic of Congo. Schure, J., Ingram, V., Awono, A. (*Center for International Forestry Research, Cameroon; j.schure@cgiar.org; v.ingram@cgiar.org; a.abdon@cgiar.org*).

Fuelwood is the premier domestic energy source for households in Kinshasa, the capital of the Democratic Republic of Congo (DRC). Urbanization, combined with low access to alternative energies, has led to massive exploitation of trees around the urban area (over 200 km distance), raising questions about sustainability of this resource. At the same time, the exploitation of firewood and the production of charcoal provides an important source of cash income for many farmers and unemployed citizens. This study aims to improve understanding of the market chain of fuelwood around Kinshasa, to assist developing policies to reconcile environment and development needs. The study's approach combines a value chain analysis and livelihood perspective to distil

key indicators. Interviews with stakeholders, mapping exercises and surveys with fuelwood producers, traders, and consumers provided data about the social, economic and environmental impacts of the sector. Preliminary findings suggest that the institutional framework in the DRC does not mirror the main drivers and actively provides disincentives to sustainably manage the sector. Learning from past experiences, recommendations include improving the uptake and awareness of fuel efficient stoves, charcoal ovens, agroforestry and plantation schemes.

I-04 Knowledge systems, societal participation, and sustainable forestry for human well-being

Organizers: P.S. Ramakrishnan, *Jawaharlal Nehru University, India, psr@mail.jnu.ac.in*; John Parrotta, *U.S. Forest Service, USA, jparrotta@fs.fed.us.*

Community involvement in the construction of cultural ecosystem services within a framework for forest stewardship. Asah, S.T. (*University of Washington, USA; stasah@uw.edu*), Blahna, D.J. (*U.S. Forest Service, USA; dblahna@fs.fed.us*).

Although science can contribute to effective decisions by clearly classifying ecosystem services (ESs), it is obvious that final decisions are unavoidably socio-political, and embedded within specific cultural value systems. Thus, local ways of "seeing and knowing" ESs are inevitable for effective decision making and sustainable management. The Pacific Northwest Research Station of U.S. Forest Service is working with the Deschutes National Forest (DNF) to explore and demonstrate how an ESs Framework can be developed and used for forest stewardship and decision making. As part of that effort, this study explores the intangible values provided to the people of the DNF. We examine how local residents of the DNF "see" and "understand" benefits from the forest. We used focus group and key informant interviews to enable the collective identification and classification of cultural ESs. Interview participants were local citizens within the DNF area and Forest Service staff. Interviews were tape recorded, transcribed, coded and thematic analysis conducted. In this paper we compare the results with the classification suggested by Millennium Ecosystem Assessment. A two-staged cultural ecosystem classification system emerged. Implications of our findings regarding the essence of place-specificity and cultural context in effective decision making and sustainable management will be discussed.

Combining indigenous and scientific knowledge to understand habitat use of bushbuck (*Tragelaphus scriptus*) and red-flaked-duiker (*Cephalophus rufilatus*) in Pendjari Biosphere Reserve (Northern Benin). Djagoun, C.A.M.S., Sinsin, B. (*Université d'Abomey-Calavi, Benin; sylvestrechabi@gmail.com; bsinsin@bj.refer.org*), Schrenk, F. (*Department of Paleoanthropology and Quaternary Paleontology, Germany; chadamasfr@yahoo.fr*).

Local knowledge of particular species is required for their conservation and management in tropical forests, where their range has either disappeared or their numbers are shrinking due to anthropogenic factors. We combined indigenous knowledge obtained by interviewing people living near the reserve and the long term data collection on wildlife observation recorded by the ecological office of Pendjari Biosphere Reserve to understand the habitat use of bushbuck (*Tragelaphus scriptus*) and red-flaked-duiker (*Cephalophus rufilatus*) in Pendjari Biosphere Reserve. According to the local population bushbuck was found to be more of a generalist in the rainy season than in dry season and mostly destroyed crop (rice, corn) in the farm. But it was recorded to be mostly in closed habitat during the dry season whereas the red-flanked-duiker preferred closed habitat during both seasons. Moran's index calculated using available data to assess the distribution pattern of bushbuck shows that this species is much more evenly distributed over the landscape whereas red-flanked duiker are more clustered in the landscape (Moran's Index, $I = 0.10 > 0$). Consequently, conservation of ungulate species such as bushbuck and red-flanked duiker in the Pendjari Biosphere Reserve requires protection of areas of all major habitat types.

Sustainable spatial planning: the Mexican case of "Territorial Ecological Order" and the UNESCO Biosphere Reserves for the future. Gaudry, K.H. (*University of Freiburg, Germany; khgaudry@gmail.com*), Konold, W. (*University of Freiburg, Germany; werner.konold@landespflege.uni-freiburg.de*).

"Think global, act local" has been a slogan mostly used for branding the concept of sustainability. While successful in promoting complex and system thinking, markets and governments have failed in integrating the human-nature concerns into one spatial planning mechanism. The Mexican notion of sustainable spatial planning until recently was divided into two sectoral branches, the "Ecological Order" and the "Territorial Order". Either as a political instrument for forest conservation or for democratic participation in development, these approaches were only recently integrated. The state of Campeche and its municipality Calakmul, recently formulated its sustainable spatial plan into the Territorial Ecological Order (*Ordenamiento Ecológico Territorial*). This paper introduces Mexican sustainable spatial planning approaches and discusses governance decision making processes at the municipal and state levels. It presents a comparative analysis of the first Mexican cases of this nature – the case of Campeche's and Calakmul's Territorial Ecological Order and the UNESCO Biosphere Reserve zonation's contribution – for social wellbeing and environmental security. Both, the Biosphere Reserve designation and the Territorial Ecological Order, shed light on a new interplay between domestic multi-scale geopolitics, conservation land as part of urban land-use, and the creation of global spaces in changing environments.

The role of knowledge systems in development of community reward mechanisms for maintenance of ecosystem services in the Hindu Kush-Himalayas. Kotru, R., Sharma, E. (*International Centre for Integrated Mountain Development, Nepal; rkotru@icimod.org; esharma@icimod.org*).

The Hindu Kush-Himalayan ranges are highly heterogeneous in their geographical features, ecological systems and cultural dimensions. Vegetation ranges from subtropical semi-desert and thorn steppe formations in the northwest to tropical evergreen rainforests in the southeast. As a result, these mountains are rich in biodiversity, often with sharp transitions (ecotones) in vegetation types and equally rapid changes from vegetation and soils to snow and ice. This mountainous region collectively

provides water and other ecosystem services for about 1.3 billion people in the river basins. It has been realised that sustenance of ecosystem services can only be achieved by developing good knowledge systems for management of resources while applying participatory approaches. Mechanisms to reward communities are equally fundamental in developing sustainable ecosystem services for human wellbeing. There are various possibilities of rewarding maintenance of ecosystem services, including payments for watershed services in hydro-power or water supply projects, ecotourism development for biodiversity services in the protected areas, carbon financing for different land use systems especially forestry sector etc. This paper discusses both the roles of scientific and traditional knowledge systems in developing community reward systems for ecosystem services with specific examples from the Hindu Kush-Himalayan region.

Tree domestication and local knowledge within the forest-agriculture interface in southern Cameroon. Mala, W.A. (*University of Yaounde, Cameroon; williammala@yahoo.fr*), Geldenhyus, C.J. (*University of Stellenbosch, South Africa; cgelden@mweb.co.za*), Prabhu, R. (*UNEP, Kenya; Ravi.Prabhu@unep.org*).

This paper analyses relationships between domestication of tree species and traditional forest knowledge within agricultural landscape mosaics. Historical ecology and socio-economic of land uses are characterized as well as biophysical parameters of tree species and their socio-economic uses based on ten uses. A logistic regression analysis was used to analyze the decision to domesticate tree species during the clearing of the forest. Knowledge of land use history, whether agricultural or non-agricultural, and uses values of species (mainly food, fuel wood, timber) affect these decisions, and only tree species with multiple uses are domesticated by farmers. Tree species and stem densities of trees retained on the land decreases significantly from small to large trees in balance with their potential for regeneration (seedlings, sprouts, saplings and poles) and typical tree species abundance. This creates optimal conditions for plant species to regenerate the forest vegetation. Maintenance of a pool of plant species is based on local knowledge of complementary, competitive and supplementary interactions between tree and crop species. The farmers' practices and their bio-ecological knowledge are the drivers of agricultural and forest productivity, ecological processes, and species richness patterns by combining both crop and non-agricultural plant species within the cropping-fallow-forest conversion cycle.

The conflict between traditional and scientific knowledge in Finnish and Swedish forest management in the twentieth century. Siiskonen, H. (*University of Eastern Finland, Finland; harri.siiskonen@uef.fi*).

Characteristic of forest ownership in Finland and Sweden has been the crucial role of non-industrial private forest owners, who own more than half of the productive forest land. Due to the important role of private forests in these countries their management has not been an insignificant question for economic reasons and also, during the last decades, for environmental reasons. The paper focuses on exploring the gap between traditional knowledge and scientific knowledge that prevailed in the Finnish and Swedish forest management throughout the study period. In the early twentieth century, peasants' conception of good forest management was firmly based on knowledge adopted from their relatives and neighbours. At that time scientific knowledge was introduced to the forest owners through counselling and implementation of forest legislation by the forest authorities. However, the improved availability of scientific knowledge did not lead to displacement of traditional knowledge in forest management but, on the contrary, its significance has been increasing during recent decades. In these contries the conflict between traditional and scientific knowledge in forest management has culminated throughout the study period in the struggle between the uneven-aged and the even-aged system of forest management.

Systematic approaches to combining local and scientific knowledge about ecosystem services of trees. Sinclair, F.L. (*World Agroforestry Centre, Kenya; f.sinclair@cgiar.org*), Lamond, G. (*Bangor University, UK; g.lamond@bangor.ac.uk*), Pagella, T. (*Bangor University, UK; t.pagella@bangor.ac.uk*), Cerdan, C. (*CATIE, Costa Rica; ccerdan@catie.ac.cr*), Mohan, D. (*University of Agricultural Sciences, India*).

Coffee is a crop often found at forest margins and trees in coffee fields can provide vital connectivity to sustain the ecological integrity of protected forest areas. While there is scientific information on a limited number of tree species that combine well with coffee, often used outside their native ranges, local farmers who manage shade coffee systems have knowledge of hundreds of trees. We present a global synthesis of farmers' local knowledge about tree attributes that affect coffee productivity and other ecosystem services made possible by application of systematic knowledge acquisition methods in seven countries spanning Central America, East Africa and India. We show how acquisition of local ranking for different attributes and knowledge of tree phenology can complement science and underpin development of decision support tools that promote retention of tree diversity rather than focus on one or two best bet species. The methods used have universal application to acquiring local knowledge about trees and their ecosystem service functions, able to put local knowledge on a par with systematically recorded science and to customise application of scientific knowledge locally. Opportunities and dangers associated with employing systematic knowledge acquisition are discussed.

Localized silviculture: empowering upland communities towards forest rehabilitation and biodiversity conservation. Tolentino, E.L., Pulhin, J.M. (*University of the Philippines Los Baños, Philippines; eltolentinojr@uplb.edu.ph; jmpulhin@uplb.edu.ph*).

The paper elucidates how Upland Peoples' Organization (UPOs) in the Philippines successfully rehabilitated and restored biodiversity in denuded grasslands using indigenous trees and vines. UPOs were engaged in a domestication research involving species selection, planting stock production, and tree/vine management in two sites. Researchers and UPOs partnered in developing "localized silviculture", a fusion of formal silviculture and indigenous/local knowledge systems. Developed for a period of five years it involved regular meetings, writeshops, actual plantation establishment and farm/institution/industry visits. The features of a Localized Silviculture include species ranking and selection based on species-site matching, product suitability, market niche and conditions, livelihood contribution, familiarity with species, product processing skills and technologies and tree harvesting and transport policies; planting stock production employing crop/exotic tree production practices, complemented by experimentation on seed and seedling production technologies; tree management covers regular weeding by members, use of

bio-fertilizers, UPO-led growth monitoring scheme, and community-based fire protection system. Four tree and five vine species were planted. Sustainability mechanisms requires benefit-cost sharing among members, assistance from institutions for funding and/or proposal development, and other income generating projects, e.g. agroforestry projects, furniture and handicraft sales. The system could be easily replicated and tailored to specific UPO and site.

Culture as capital: problems with stretching economic concepts. Trosper, R.L. (*University of British Columbia, Canada; Ronald.Trosper@ubc.ca*), Hebert, M. (*University of Laval, Canada; martin.hebert@ant.ulaval.ca*), Natcher, D. (*University of Saskatchewan, Canada; dan130@mail.usask.ca*), Bouthillier, L. (*University of Laval, Canada; luc.bouthillier@sbf.ulaval.ca*).

The idea that culture is a form of capital has recently gained in usage. It is variously described as human capital, institutional capital, and cultural capital. The paper considers the extent to which this analogy holds. Is it reasonable to regard culture as a stock suitable for investment: can a rate of return be defined? Can the units of cultural capital be traded or converted? Can there be an investment bubble in cultural capital? Does it wear out with use? Positive answers to these questions could suggest that the analogy between cultural and manufactured or financial capital is valuable. Since case studies examined here rather point to negative answers to these questions, this paper suggests that cultural capital be defined in a new way which respects the value of culture without suggesting it is capital. Culture is entangled with people and organizations. Qualities of culture affect the strength and endurance of organizations. Cultural capital becomes a kind of public good, another metaphor from economics. Cooperative support of mutually useful rules and ideas depends upon and reinforces the value of those concepts, while limiting the value of competing ideas. Logical conflicts among cultural capitals need attention, especially when change is needed.

Traditional ecological knowledge and natural resource management: A case study of Paiwan people in Taitung County, Taiwan. Wu, C.S., Wu, M.S., Lee, C.C. (*Taiwan Forestry Research Institute, China-Taipei; johnwu@tfri.gov.tw; wumengshan@tfri.gov.tw; ybia@tfri.gov.tw*).

Recently, new paradigms that introduce concepts like local community participation and collaborative processes have led scientists in Taiwan to accept new approaches such as adaptive and ecosystem management. These concepts also facilitate the use of traditional ecological knowledge (TEK) in natural resource conservation. Since the Aboriginal Basic Law was passed in 2005, aborigines have rights to use natural resource and management lands. To the public, aboriginal peoples' legitimacy for co-management of the land partly lies in the traditions that have existed from far back in history. TEK is not documented but transmitted by oral history, fables and ceremonies. The purpose of the study is to find out how the native people recognize TEK. The study used in-person surveys of the Paiwan people who live in Jialan village, Jinfeng Township, Taitung County. The results summarize the perceptions of TEK, utilization of forest resources, and environmental attitudes held by aboriginals, and how TEK influences their attitudes towards forest management. Although TEK does not have economic value in practice, most people still agree TEK could be a good reference for natural resource management of the authorities.

Posters

Dependence of rural communities on indigenous medicinal plants in Madhya Pradesh, India. Bhatnagar, P., Shukla, P.K., Singh, N., Vishwa, S. (*Madhya Pradesh State Forest Research Institute, India; cesd_1@yahoo.com*).

Medicinal plants form the basis of indigenous health care in many rural parts of India. Traditional healers collect medicinal plants from forests and treat people for various ailments. Recently, with the availability of modern (allopathic) medicine, the dependence on medicinal plants has been observed to have reduced. A study was undertaken to find the medicinal plants used by rural population for curing various ailments and extent of dependence on traditional healers. The methodology used was a primary survey of rural households in 20 villages in different zones of the state. In each zone 5 villages were surveyed to find extent of dependence on medicinal plants and traditional healers. The study revealed that for minor ailments like cold, fever, flu and bone fractures people preferred to consult traditional healers. For major illness they go to hospitals and consult doctors. The study reported them as using 25 different medicinal plants for healing. The estimated rural demand for medicinal plants used in Madhya Pradesh is 8,604 (metric) tonnes. Traditional healers further dispense 59 medicinal species with annual requirement of 4317 tonnes. Thus the annual rural demand for medicinal plants is 12,921 tonnes. Despite the introduction of allopathic medicine, people still prefer treatment by traditional practitioners.

Traditional forest conservation knowledge and technologies in the Cordillera, Northern Philippines. Camacho, L.D. (*University of the Philippines Los Baños, the Philippines; camachold@yahoo.com.ph*), Youn, Y.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*), Combalicer, M.S., Combalicer, E.A. (*Nueva Vizcaya State University, the Philippines; marilyn_sabalvaro@yahoo.com; eacombalicer@yahoo.com*), Carandang, A.P., Camacho, S.C., De Luna, C.C., Rebugio, L.L. (*University of the Philippines Los Baños, the Philippines; tony115858@yahoo.com; sonny_camacho@yahoo.com; delunacc@yahoo.com; lucrebugio@gmail.com*).

In the Philippines, indigenous knowledge has been recognized to contribute to sustainability of production systems, having been validated for technical and scientific soundness by many investigators. Cordillera in the Northern Philippines is home to many indigenous cultures like *Isneg*, *Kalinga*, *Bontok*, *Kankanaey*, *Tingguian*, *Gaddang*, *Ayangan* and *Tuwali*, *Kalanguya* or *Ikalahan*, *Ibaloy* and *Karao* whose traditional knowledge systems have been the subject of many studies and investigations. We describe the various traditional knowledge systems for natural resources management in the Cordillera as practiced by the people with different beliefs, culture and traditions. The paper showcases different resource conserving experiences in these cultures such as *muyong* and *ala-a* systems of the *Ifugaos*; *lapat* among the *Isneg* and *Tingguians*; *inum-an, gen-gen, day-og, balkah, kinebbah, tuping* and *pamettey* of the *Ikalahans*. These knowledge systems have been practiced by the indigenous peoples in the Cordillera and have been transmitted from generation to generation, harmonizing their way of life with their physical and social surroundings. While culture is environment specific, adoption/transfer of some indigenous technologies that may be adapted and used other cultures and communities with a little modification to suit their needs.

Compatibility of indigenous practices in sustainability community forest management systems: a case study in Nagano prefecture, Japan. De Zoysa, M. (*University of Ruhuna, Sri Lanka; mangalaxyz@yahoo.com*), Inoue, M., Yamashita, U. (*The University of Tokyo, Japan; mkinoue@fr.a.u-tokyo.ac.jp; utaco@chikumagawa.jp*), Okuda, H. (*Forest Research Institute, Japan; hironori@ffpri.affrc.go.jp*).

Community forest management systems in Japan from the viewpoint of "common pool resources" management seem to be resilient institutions for sustainable production and environmental conservation. The study examined the sustainability of the "property ward" forest management system, which is similar to, and originated in, the indigenous "Iriai" forest management system. The study, conducted in Osawa Property Ward of Nagano prefecture, involved group discussions, field observations and an in-depth field survey. The paper discusses the transformation of the "property ward" forest management system in terms of awareness and interest in forest management, forest management activities, role of forest, and collection of forest products. Current threats for "property ward" forest management have been identified as deterioration of forest environment, and conflict with local government authorities and outsiders. Community-centered forest management rules, livelihood contribution, protection of environment, and local initiatives for protection and economic activities are the prevailing opportunities for "property ward" forest management. The main requirements for revitalization of property ward forest management are local conduciveness, impose of community based forest rules, encouragement of local innovations, and building partnerships with stakeholders. The system addresses limitations of conventional forestry models and keys for restoring sustainable use of forest and environmental resources.

Harmonizing traditional forest knowledge and scientific forestry for sustainable forest management in India. Gupta, H. (*Ministry of Environment and Forest, India; hemantgup@gmail.com*), Gupta, A. (*Loreto Convent, India; anuguptaevs@gmail.com*).

Sustainable forest management incorporates economic, environmental and socio-cultural aspects to varying degrees. Institutionalized scientific forestry dating back to 1864 in India aims to optimize a single dominant value from a given landscape. The forestlands are managed to maximize timber production while protected areas are managed to maximize conservation values. Scientific forestry has its basis in state property, monocultural management, commercial timber species, and economic botany that treats most forest products as minor and neglects the role of social systems. The evolution of forestry practices has moved through periods of *colonialism, commercialism*, and *conservation*, and now *collaboration*. Traditional knowledge is an intangible component of the resource itself and is reflected through diverse forest dependence, product utilization and management practices. Contemporary traditional forest knowledge (TFK) is dynamic, evolving and institutionally based on common property, community-based, relies on ethno-botanical knowledge, and treats non-timber products as major produce with livelihoods its main concern. We compare examples found in TFK and their equivalent scientific forestry prescriptions such as conservation, maintaining biodiversity, land tenure, indigenous and community managed systems. Best practices of TFK and scientific forestry for harmonizing for sustainable forest management by including contemporary prescriptions for sustaining forest resources are proposed.

Current status of traditional knowledge of three tribal groups of Madhya Pradesh, India. Shukla, P.K. (*Madhya Pradesh State Forest Research Institute, India; sdfri@rediffmail.com*).

Madhya Pradesh, in central India, possesses vast ethnobotanical wealth. Many tribal groups, such as the Sahariyas, Baigas and Bharias, inhabit the forests. These tribal groups, who depend on forests for their sustenance and livelihood, have traditional knowledge which has been developed and passed down through many generations. A project was undertaken to collect and document indigenous knowledge from the available literature on tribal groups in the region. Published references were collected, reviewed, scanned, classified and recorded. The results of this study indicate that: the Sahariyas use 109 species for medicine, 30 species for food and about 40 species for ropes, mats, basketery, insecticides and other purposes; the Baigas usee 7 species as antidotes, 149 species for medicine, 15 species for food, 8 species for building, 6 species for tannin, 8 species for mats, grooms, baskets and 10 species for agricultural implements, and the Bhariyas use 6 species for food, 7 species for house construction, 4 species for agricultural implements, 8 species for baskets, brooms, 5 species for gums, 7 species for tannins and dyes and 179 species for medicinal purposes. Further documentation of the traditional knowledge of the Sahariyas, Bharias and Baigas should be given high priority.

Local knowledge and rebuilding the social capital required to sustain marula populations. Sinclair, F.L. (*World Agroforestry Centre, Kenya; f.sinclair@cgiar.org*), Lamond, G. (*Bangor University, UK; g.lamond@bangor.ac.uk*), Njoni, D. (*South Africa*).

The marula tree (*Sclerocarya birrea*) produces oil that is internationally traded as a basis for modern cosmetics. Despite this, collection of fruit is largely done by women from wild trees in Namibia and South Africa. It is unclear whether tree populations are sustainable. Most marula trees in contemporary African landscapes are sparsely distributed, mature and have arisen from past natural regeneration. The species is dioecious and since male trees cast a lot of shade but don't produce fruit they are often cut. If too many male trees are removed from an area then females stop fruiting because they are not pollinated. There were traditional societal rules surrounding cutting and exploitation of the tree that are no longer applied. We present here a study of contemporary knowledge about marula at village level in South Africa, using knowledge based systems methods. This reveals that rebuilding social capital is required for people to co-operate amongst villages to maintain appropriate ratios of male to female trees in the landscape, linking social and natural capital. But, neither local nor scientific knowledge now exists on how many male trees are required at what distances from females to effect pollination and sustain the resource.

Community-based carbon monitoring: a pilot project in Ghana. Stanturf, J.A. (*U.S. Forest Service, USA; jstanturf@fs.fed.us*), Blay, D. (*Forest Research Institute, Ghana; drdominicblay@yahoo.com*), Schelhas, J., Johnson, C., O'Brien, J.J. (*U.S. Forest Service, USA; jschelhas@fs.fed.us; cjohnson09@fs.fed.us; jjobrien@fs.fed.us*).

The Upper Guinea Ecosystem of West Africa is a high priority globally for biodiversity conservation. Reducing carbon emissions from deforestation and degradation is a key element in efforts to combat climate change. Forest landscape restoration is one strategy for addressing both the loss of biodiversity and reducing carbon emissions and may also contribute to food security for

forest fringe communities. One mechanism for promoting forest restoration is the provision of payments to local communities for ecosystem services such as carbon sequestration. A key scientific challenge to international schemes such as REDD is to estimate carbon loss from forest clearing and carbon storage in restored or intact forest. In Ghana, as in many developing countries, there are few reliable data for estimating current carbon stocks and historic reduction rates from deforestation. Approaches that involve local people directly in data collection and interpretation have been shown to overcome these resource limitations with the added benefits of linking monitoring to the decisions of local people and building cooperation between local people and authorities. We describe a pilot project in Ghana to develop a robust method for community-based carbon monitoring that can be used throughout West Africa.

I-05 Non-timber forest resources and human welfare

Organizers: Carsten Smith-Hall, *University of Copenhagen, Denmark, cso@life.ku.dk*; Jim Chamberlain, Susan Alexander, *U.S. Forest Service, USA, jchamberlain@fs.fed.us, salexander@fs.fed.us.*

Potential of *Buchanania lanzan*, an edible forest product for enhancing livelihood of rural communities in Madhya Pradesh, India. Bhatnagar, P. (*Madhya Pradesh State Forest Research Institute, Jabalpur, India; cesd_1@yahoo.com*).

Buchanania lanzan, commonly known as chironji, is an important tree species found in mixed dry deciduous forests of Madhya Pradesh. Its fruits are edible and collected by rural population. Seasonal income is also generated by sale of nuts in the lean agricultural period during the month of May. A study was undertaken to find the method of harvesting and post harvest processing, income generation at household level and marketing of these nuts. A sample survey of 125 households in 25 randomly selected villages in four districts was done. To study the market channel a sample of markets ranging from village level, regional to National level was undertaken to find price variation, quantum of trade and to study processing and grading practices. A number of processing units were also visited. The study revealed that it is an important source of seasonal income and there is scope for value addition if small scale processing units are established for decortication at village level. These small scale units operated at household and village level will reduce drudgery of women who have to do processing by hand grinding to decorticate nuts and enhance income considerably.

Managing forests for edible plants: understanding demand and production of forest onions to conserve a globally important species and way of life. Chamberlain, J.L. (*U.S. Forest Service, USA; jchamberlain@fs.fed.us*).

Allium triccocum (ramps) are native to hardwood forests of eastern United States and are one of the first edible plants to emerge in the spring. Early European settlers to this region brought with them traditional knowledge about a similar forest species (*Allium ursinum*) that they had been collecting from native lands. The tradition of harvesting ramps continues for personal consumption and as a source of income. This study documents the volumes of ramps harvested for festivals in western North Carolina and southwest Virginia. By going out with local harvester groups I weighed and measured the amounts used by each group. Doing this several years provided consistent estimations of the amount needed for the festivals. I documented changes in biomass and estimated optimal harvest time for maximum biomass through weekly forays to ramp patches during which plant dimensions were measured. Tree canopy transparency was measured using digital photographs. Plant development relative to tree canopy transparency was correlated to improve our understanding of the potential for co-management for timber. The impact of canopy closure was estimated on plant development. These findings have implications that could improve how forests throughout the world are managed for edible forest products

Contribution of non wood forest products to poverty reduction and food security in central Africa. Masuch, J., Ndoye, O., Tieguhong, J.C. (*FAO, Cameroon; juliane.masuch@fao.org; ousseynou.ndoye@fao.org; chupezi@yahoo.co.uk*), Vantomme, P., Grouwels, S. (*FAO, Italy; paul.vantomme@fao.org; sophie.grouwels@fao.org*), Asseng Ze, A., Fokou Sakam, I. (*FAO, Cameroon; assengze@yahoo.fr; fosidel2003@yahoo.fr*).

Non wood forest products (NWFP) are valuable natural resources that support the livelihood of forest dependent people and minorities (women, children, elderly) involved in their gathering, processing, and commercialization. They provide valuable sources of incomes and employment as well as food, medicine and construction materials. Using examples from various household and market surveys carried out in Central Africa, this paper argues that NWFP are safety nets for rural people in terms of food security and satisfying basic needs such as getting kitchen accessories, curing common ailments, paying children school fees, procuring important household assets such as cellular phones and televisions, and connecting homes to important utilities such as electricity and portable water. In addition, for many actors involved in the value chains, NWFP provide monthly incomes that are comparable to those of civil servants working in public administrations in the region. The paper recommends the need to develop the value chains of the major NWFP, to improve the management and the regulatory and institutional framework of these resources so that they can continue to enhance the livelihood of the present and future generations that will depend on them.

Motives, benefits and challenges of collective action to promote sustainable production and marketing of products from Africa's dry forests and woodlands. Paumgarten, F. (*Center for International Forestry Research, Zambia, f.paumgarten@cgiar.org*), Kassa, H. (*Center for International Forestry Research, Ethiopia, h.kassa@cgiar.org*), Zida, M. (*Center for International Forestry Research, Burkina Faso, m.zida@cgiar.org*).

While non-timber forest products (NTFPs) contribute to rural households in Africa's dry forests, producers face barriers to raising incomes. This study contributes towards the growing discourse over rural producer organisations and collective production and marketing of NTFPs through an analysis of producer organisations in Burkina Faso, Ethiopia and Zambia: what motivates producers to act collectively, and what are the benefits and associated challenges. In each country two organisations and one NTFP were selected (criteria: products are traded in local, regional and international markets; contribute to local livelihoods and

the national economy; are associated with examples of collective action). Qualitative data were collected over a two year period through focus group discussions and key informant interviews. Rural producers were found to act collectively in response to opportunities and challenges, including restrictions on individual access to the resource base and access to markets. The role of external parties in facilitating the formation of groups was notable. Each case faces challenges to long term sustainability including dependence on external funds, limited income generating activities, government regulations, scepticism of collective action, lack of transparency and obstacles to achieving participation. Collective action alone is not sufficient: there is the need to identify challenges along the value chain and provide targeted support.

The role of traditional medicine in the health care provision of households in central Burkina Faso. Pouliot, M. (*University of Copenhagen, Denmark; mapo@life.ku.dk*).

Medicinal plants indisputably play an important role where the provision of Western medicine is inadequate. Quantifying their use at the household level is therefore essential to the development of sustainable health care policy in the developing world. This case study paper aims to quantify household-level use and value of medicinal plants in central Burkina Faso, which is commonly characterized as having limited economic resources, low access to public health care, and low ratio of doctors to patients. Moreover, the livelihood strategies employed to cope with the cost of illness have been investigated. Structured interviews at the household level (n = 323, random selection), focussing on collecting data on household assets and income, as well as their strategies used to prevent and cure diseases and the related expenditures, were conducted in nine villages over a full year from November 2007 to November 2008. Comprehensive analysis of expenditure on health care was done through multivariate analysis. Preliminary results indicate that the use of the medicinal plants will depend on the nature of the encountered disease rather than on the socio-economic disposition of households. Gifts and trade in livestock were found to be common coping strategies employed by households facing illnesses.

Forest-human health linkages: empirical evidence from the Himalayas. Smith-Hall, C., Larsen, H., Nielsen, Ø. (*University of Copenhagen, Denmark; cso@life.ku.dk; hol@life.ku.dk; ojn@life.ku.dk*).

The World Health Organization has estimated that 80% of the world's population relies solely or largely on traditional remedies for health care and the World Bank speculates that more than two billion people may be heavily reliant on medicinal plants. Although considerable uncertainty surrounds these often cited figures, there is no doubt that traditional remedies, many of which include medicinal products harvested in forests, play an important role in the livelihoods and welfare of a vast number of people in both developed and developing countries. The health supporting functions of forests are particular important at the individual and household-levels in developing countries with limited public health care delivery. There are only few studies that provide empirically based quantitative data on the importance of traditional medicine at the household-level. This paper quantifies the economic importance of medicinal plant dependency at the household level in the Central Himalayas; it is based on a one-year survey of 533 households distributed across the three main physiographic zones in Nepal. The survey included detailed data collection on household characteristics including demographics, income and assets. Medicinal plant dependency is analysed across these characteristics to promote our understanding of differentiations in dependency across households and locations.

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Enhancing livelihood options through sustainable harvesting and primary processing of *Boswellia serrata* gum oleo-resen in central India. Bhatnagar, P., Shukla, P.K., Mishra, A. (*Madhya Pradesh State Forest Research Institute, India; cesd_1@yahoo.com*).

Boswellia serrata Roxb. is an important gum oleo-resin yielding species which occurs profusely in the northern part of the state. It is locally known as Salai and is an important source of livelihood support to many tribal communities. The gum, known has Indian frankincense, has industrial and medicinal uses. The gum oleo-resin is collected in small quantities by tribals adopting traditional techniques and sold in raw form without grading or value addition. Improper processing leads to impurities and high microbial content. Objectives of the study were post-harvest management for loss prevention and value addition. Primary processing techniques were standardized and sustainable harvesting methods developed. A primary survey of households engaged in tapping, collection and marketing of gums was conducted. The traditional tapping techniques used were documented and improved. Training workshops were conducted in selected model villages in Shivpuri district where forest communities were given training in sustainable harvesting and processing methods. This has enhanced livelihood options and proper processing has added value, and enhanced the conservation of this important tree species promoting sustainable harvesting.

Nipa (*Nypa fruticans*) plantation management for sustainable production of thatching materials in Bohol, Philippines. Carandang, M.G., Camacho, L.D., Carandang, A.P, Camacho, S.C., Gevaña, D.T., Rebugio, L.L. (*University of the Philippines Los Baños, the Philippines; mgc405@yahoo.co;m camachold@yahoo.com.ph; tony115858@yahoo.com; sonny_camacho@yahoo.com; wuweidix@yahoo.com; lucrebugio@gmail.com*), Youn, Y.C. (*Seoul National University, Republic of Korea; youn@snu.ac.kr*).

Nipa (*Nypa fruticans*) is a true mangrove palm and a valued plant in many coastal areas in the Philippines. It has numerous economic uses, one of which is for thatching materials for roofing in rural areas. This study examined the production practices, yield, and livelihood generation of nipa plantations in the province of Bohol, in the Philippines. A mature nipa plantation can have an average of 17,233 mature plants per hectare, capable of producing an average of 51,148 shingles per year. Potential production can range from 80,233 shingles on good sites, to 52,964 on medium sites, with a low of 32,243 shingles on poor sites. The study found that long harvest cycles of nipa increase the percentage of waste due to fronds over-maturing. Shorter harvest cycles yield more mature fronds and facilitate the growth of juvenile fronds due to reduced competition among nipa leaves. At least two to three juvenile fronds are left per plant during harvests. A three-month harvest cycle is best for nipa stands, releasing maturing leaves from competition and preventing crowding of fronds. A 2-hectare nipa plantation can provide full time employment for one person all year round.

Promoting wicker (*Salix*) products to reach Millennium Development Goals in traditional communities in southern Brazil. Hermoso Barroso, L., Ziantoni, V., Angelo, A.C. (*Federal University of Parana, Brazil; letiziahermoso@gmail.com; vziantoni@gmail.com; alessandro.angelo@ufpr.br*).

This study highlights ecological, social and economical aspects of wicker (*Salicaceae*) that are directly related to Millennium Development Goals. Wicker use was assessed in twenty- five small communities in Lages and Rio Rufino, in the state of Santa Catarina. Ninety percent of Brazilian wicker products are made in Santa Catarina. Wicker is a natural and renewable raw material produced in a non-mechanized way. It has tremendous economic value and a wide range of applications, mainly in the production of handicrafts for the national market. Pressure from agriculture for arable land is one of the main challenges for small communities in the area. Wicker presents a productive alternative for families in these traditional communities. Wicker is directly linked with three of the Millennium Development Goals and indirectly with three more. The social and ecological benefits need to be considered more strongly. Government credit schemes should be established as a production incentive. Environmental and social pressures affecting small rural communities can be reduced by agroforestry crops and the use of non-wood forest products. Wicker can reduce poverty and enhance the farming economy in Brazil.

Promoting beekeeping as a means for forest conservation and preservation in the Lebialem highlands, Cameroon. Ndeola, C. (*Centre for Development and Community Welfare, UK; ndeloa@yahoo.com*).

Rapid deforestation and exploitation of forest resources is a major problem in the Lebialem highlands, one of the richest tropical forest ecosystems in Cameroon that provides important global services, including climate regulation and biodiversity protection. The people living there very poor with limited alternative economic resources and myriad pressing social needs. Frequent wild fire, indiscriminate logging, cutting of trees for fire wood and timber, fire, and shifting cultivation jeopardize government forest conservation and sustainable management policies. My research found that beekeeping, which generates income without destroying forest habitat, is the most popular option among local people and was found to have similar characteristics to farming and other activities in terms of earnings potential, market demand, land requirements and time investment. People will be trained, supported and equipped with beekeeping skills and instruments in order to produce and market honey. This initiative is sustainable because it touches the bases of human survival and well-being (health, agriculture, jobs/livelihoods, and the environment). Therefore, encouraging and facilitating trade in ecologically sensitive products, such as honey and beeswax which have strong market potential both nationally and internationally, will have poverty alleviation as well as conservation benefits.

Harvest and economic impacts of non-wood forest products in the United States: an overview. Oswalt, S.N., Alexander, S., Emery, M., Chamberlain, J.L., Smith, B. (*U.S. Forest Service, USA; soswalt@fs.fed.us; salexander@fs.fed.us; memery@fs.fed.us; jchamberlain@fs.fed.us; bsmith12@fs.fed.us*).

Non-wood Forest products include medicinal plants, food and forage, floral and horticultural products, resins and oils, arts and crafts, and game animals. As demand for these products grows, it is important to monitor the removal of products from forests, and the effects of removals on the viability of current and future forest ecosystems. Over-harvesting may result in negative impacts to species diversity, ecosystem dynamics, and cultural practices. Products of economic and cultural importance vary by region. Examples include maple syrup in the northeast, mushrooms in the Pacific Northwest, and medicinal plants in the southern Appalachian Mountains. Permitted harvests of arts and crafts products on public lands in the United States totaled over 622 thousand tons (fresh) in 2007. Wild blueberry exports from the United States were valued at over $48 million, maple syrup exports were valued at $8 million, and wild mushroom exports constituted a $14 million industry in 2007. Wild animal hunting and trapping remains a billion-dollar industry in the United States. The statistics presented on this poster summarize key findings from the 2010 United States Report on Sustainable Forests.

Cultivation of medicinal plants in the understory of forest stands. Sinha, P. (*Bangladesh Council of Scientific and Industrial Research, Bangladesh; pinakiju@yahoo.com*), Roy, S.K. (*Jahangirnahar University, Bangladesh; shkmroy@yahoo.com*).

The promotion of non-wood forest products (NWFPs) can and should contribute to rural development and appropriate forest management as they are sources of alternative employment and income generation. The management of NWFPs should not be seen separately from general forest management, and sustainable collection of these products must be ensured through proper management and restoration of forests. In the present investigation two important medicinal plants, *Andrographis paniculata* and *Rauvolfia serpentina*, were cultivated in the understory of mixed forests of dipterocarps and *Acacia* as well as in open fields. After harvesting, plants were dried in the sun and weight of the dried plants were taken. The results show that both species of medicinal plants could be cultivated in the forest understory as the total dry weight of plants produced in the two habitats (forest *vs* open conditions) were very similar. The study shows that commercial cultivation of medicinal plants inside forests is quite feasible and that through this system of cultivation, the endangered medicinal herbs could be saved from extinction while generating income to support rural livelihoods.

Factors affecting community based forest enterprises to address poverty reduction. Thapa Magar, S.K. (*ForestAction, Nepal; eco_sushila@yahoo.com*), Vacik, H. (*University of Natural Resources and Applied Life Sciences, Austria; harald.vacik@boku.ac.at*).

Establishment of community based forest enterprises (CBFEs) is one strategy to shift existing subsistence-oriented community forestry towards commercialization of non-timber forest products for poverty reduction by increasing incomes and improving livelihoods of poor people. To access whether and under what conditions a CBFE can contribute to poverty reduction, a study was carried out in three enterprises of Dolkha, mid hill district of Nepal. For the purpose of this study, well performing, medium performing and poorly performing enterprises were selected based on a formal evaluation by stakeholders. The study has used traditional as well as participatory methods for information collection. In-depth quantitative and qualitative analysis identified eight internal as well as one external factor to be mainly important in affecting enterprise for poverty reduction. Internal factors includes share allocation among shareholders, cash flow, scale of enterprises, enterprise internal governance, pro-poor focus of enterprise policies, awareness ad participation of shareholders, benefit distribution mechanism. External factors include support form service providers. A discussion about the relevance of the individual factors influencing the performance of CBFEs allowed drawing conclusions ad recommendations for future actions in community forestry.

I-06 Healthy forests, healthy people—gender perspectives on climate change

Organizers: Gun Lidestav, *Swedish University of Agricultural Sciences, Sweden, gun.lidestav@srh.slu.se*; Carol Colfer, *CIFOR, USA, c.colfer@cgiar.org*; Maureen Reed, *University of Saskatchewan, Canada, m.reed@usask.ca*; Siegfried Lewark, *University of Freiburg, Germany, siegfried.lewark@fobawi.uni-freiburg.de*; Ann Merete Furuberg, Gjedtjernet *Furuberget, Norway, meretefuruberg@gmail.com.*

Gender, climate change and women. Arora-Jonsson, S. (*Swedish University of Agricultural Sciences, Sweden; Seema.Arora.Jonsson@sol.slu.se*).

How can gender and climate change be considered in diverse countries in the South and in the North? Two themes recur throughout the existing though limited literature on the subject of climate change and gender: women in the South will be affected much more adversely by climate change than men in those countries and that men in the North pollute much more than their female counterparts. Common to both places is that women are not part of decision making bodies as are the men in their societies and that affects policy making to the detriment of women. In other words, women in the South are extremely vulnerable to climate change while women in the North are much more conscientious when it comes to dealing with climate change, possessing virtues of environmentalism which men with their propensity for long distance travels and meat eating habits do not. The paper examines these claims and what it might mean for dealing with the problems vagaries of climate change.

Adapting to climate and economic change in Swedish multi-use boreal forests. Keskitalo, E.C.H. (*Umeå University, Sweden; Carina.Keskitalo@geography.umu.se*).

Governance and conflict resolution in multi-use forests requires the integration of stakeholders and decision-makers in multiple sectors. These include among others forestry, reindeer husbandry, conservation, tourism, and local use such as hunting and berry-picking. The sectors are to a large extent characterized by interest groups with divergent interests, size and power discrepancy. The sectors are also to a large extent influenced by current and future economic and environmental changes, which will in the future include climate change. The paper departs from a framework on vulnerability and adaptive capacity with a focus on social or community vulnerability, described in among others the CAVIAR project and Keskitalo (2008). Drawing upon semi-structured interviews in Gällivare municipality, northernmost Sweden, the study describes the interaction between sectors of forestry, reindeer husbandry and mainly small-scale winter tourism in the municipality of Gällivare, situated in northernmost Sweden. The study concludes that institutional conflicts between the sectors have a large impact on possibilities for both present and future adaptation to change, and that climate and economic change have to be viewed together as impacts on future land use and forest management.

Gender and adaptive capacity in Canadian model forest regions. Reed, M.G. (*University of Saskatchewan, Canada; maureen.reed@usask.ca*), Klenk, N. (*McGill University, Canada; nicole.klenk@mail.mcgill.ca*), Hemingway, D., McLennan, C. (*University of Northern British Columbia, Canada; hemingwa@unbc.ca; wnn@unbc.ca*).

Adaptive capacity of people in forestry communities to address climate change can be analyzed by considering assets and endowments as well as formal and informal governance institutions. Assets involve capital formation and mobilization while institutions include formal and informal rules, procedures, and relations. In this paper, we argue that the adaptive capacity should be interpreted by using a gender lens to an assessment of assets and institutions, even in forestry communities of industrialized nations. In this paper, we establish a framework that considers assets, endowments, and governing institutions, as key components of adaptive capacity. We then examine socio-economic data from Canadian model forests to demonstrate gender-based differences in access to assets and endowments that facilitate adaptation. This analysis demonstrates the *gender of adaptive capacity* by pointing to differences in the access of women and men the range of capitals deemed necessary for dealing with climate change. We then consider how environmental management policies work to produce and reinforce particular expectations of gender and adaptation. We frame this analysis as *adaptive capacity of gender*. We conclude that gender and adaptive capacity shape one another and inform our understanding of adaptation in forestry communities.

Women's status as owners and workers in Japanese forestry. Sato, N., Kawasaki, A. (*Kyushu University, Japan; sato@agr.kyushu-u.ac.jp; kerria-a@kyudai.jp*).

The role of women has been emphasized to realize the multi-functionality of forest, including contribution to climate change mitigation. However studies on the status of women in forestry field are relatively rare in Japan. Based on 2005 census data, this paper aims to: 1) evaluate the facts regarding women's position as forest owners and forestry labor force members; 2) consider two case studies, and; 3) discuss conditions under which women can sufficiently contribute to the health of forests and people in these capacities. Our findings indicate that Japanese women still have a very low status in rural area. The proportion of women who are private forest owners is only 6.5%, and the average age (69.5 years old) of the female owners is higher than their male counterparts. On the other hand, 22.8% of forestry households' members who had worked in their family forests are women. In the case study, it was remarkable that a female forest owner has tried to integrate other owners' forests and to establish sustainable forest management. It is necessary to review forest policies from the point of view of gender.

Posters

Concepts for creating gender competence through international e-learning courses. Lewark, S. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de*).

The need for gender competence in professionals in forestry and related fields has been described many times, among others by the Team of Specialists on Gender and Forestry of FAO. Gender competence can be developed through courses of higher

education, open for students as well as for professionals working in forestry and related fields. In order to give interested individual students, small groups, and professionals access to this option for development of gender competence, more international e-learning courses should be developed. Some ideas about organisation, didactical aspects as well as contents will be presented, along with experiences from an e-learning course on gender in natural resources management already held over five years. Contents could include: gender analysis, methods of gender studies, history of women and men in small scale and industrialized forestry, roles of women and men in adapting to climate change worldwide. Stimulation and organisational frame for such courses, bundled in a gender course package could come from WELAN (World-Wide E-Learning Academy for Natural Resources, Forestry & Wood Science), which has been developed by higher education specialists from IUFRO, IPFE and forestry faculties of six universities presented elsewhere during the IUFRO World Congress.

Gender-based climate change adaptation strategies: a case study of Anyinamso in the Offin River Basin, Ghana. Lewark, S., Amuzu, C. (*University of Freiburg, Germany; siegfried.lewark@fobawi.uni-freiburg.de; christieamuzu@yahoo.com*).

Gender-based climate change adaptation strategies are studied by using a case study approach and a purposive sampling technique to select individuals for interview and also participant observation. The research questions were used to identify emerging themes, patterns and sequences in transcribed texts. The results showed low levels of knowledge about the concept of climate change with women having less knowledge than men. While some experiences of climate change were similar for both men and women, the outcomes were not the same due to the socially ascribed roles of men and women. The people have adopted various strategies to cope with climate variability even though they did not have enough knowledge. The adaptation strategies were gendered as more women saw diversification into non-farm activities as a livelihood option, men considered a shift from food crops to cash crop cultivation. Lack of finances and agricultural credit were identified as barriers. Lack of sector diversity and unemployment have translated into low adaptive capacities. Climate change education and awareness creation and the provision of capital to facilitate diversification of livelihoods are needed. The study suggests that traditional adaptation strategies of communities should be studied and incorporated in scientific and national adaptation strategies and policies.

"Green care"—challenging gendered structures in family forest farming. Lidestav, G., Umaerus, P. (*Swedish University of Agricultural Sciences, Sweden; gun.lidestav@srh.slu.se; patrik.umaerus@srh.slu.se*).

In Sweden, there are about 250,000 family forest farms and the potential for both conventional business and diversification into new ventures are extensive. However, traditional perceptions and on farming and forestry as well as gender structures, seems to hamper the development of new business in e. g. rehabilitation and like "green care". Just like the labor market in general is gender segregated, with a many women in care-taking professions and men mostly in resource dependent industries; women have not yet fully made their way into forestry. Through an analysis the Federation of Swedish Farmers member database, and data from a nationwide mail survey to 4000 forest owners, we will explore the impact of gender on traditional and new business based on family forestry farming. In particular the hypothesis that the less traditional from a forestry perspective and the less commodity oriented production, the higher the proportion of practicing women will be. Results will be discussed in relation to the theories of gender in family farming/forestry and the impact of social and commercial capital and networks.

General Posters: Forests, Human Health and Environmental Security

The impact of social forestry concepts through agroforestry to support socio-cultural and household food security. Afifah, D., Nurbaity, L. (*Bogor Agricultural University, Indonesia; dzulafifaharifin@yahoo.com; l.nurbaity@yahoo.com*).

Poverty is increasing in Indonesia and throughout the world for many reasons, including the encroachment on forest areas by surrounding communities. Despite political commitments to reduce world hunger, the number of people lacking access to the minimum dietary energy requirements (2,000 kilocalories per day) has risen from 824 million in the baseline year (1990) to 963 million in 2008. A further 750 million are estimated to be at risk according to the OneWorld.net website. Enhancing the contribution and value of forests to world food security may be part of the solution. Tree and forest products play an extremely important role in ensuring adequate nutrition. Although availability of calories is accepted as the most important issue for the world's hungry, certain micro-elements are essential for health. Beyond the direct contribution of food, trees and forests play a critical role in ensuring sustained agricultural production, including animal husbandry and, in some instances, fisheries. In the future agroforestry could become become a major alternative for forestry development in Indonesia, considering the increasing large of area of degraded forests in the country.

Loss of forests and its effects on diseases in the humid tropics of West Africa. Ardayfio-Schandorf, E. (*University of Ghana, Ghana; ardayfel@ug.edu.gh*).

Forest loss and biodiversity degradation have influenced human diseases for so long and continue to impact on health problems of humans and animals. Throughout Africa, deforestation and forest degradation have affected the epidemiology of tropical diseases that plague the human population. The process of change is quite complex both ecological and anthropogenic. The drivers and underlying causes for forest loss such as poverty, economic and socio-cultural developments and climate change among others, underlie the destruction of most tropical African forests at unprecedented rates. In West Africa, deforestation is associated with an increase in certain killer diseases which are preventable. These include diseases which previously were thought to be controlled and some neglected tropical diseases. The paper seeks to raise awareness of these issues by examining the changing ecological landscape through the lens of forest cover change and the contribution of forests in the etiology and management of diseases among the population of West Africa. The causal links between deforestation and incidence of certain diseases will be demonstrated as well as explore possible policy considerations in the face of increasing deforestation and emerging serious infectious diseases.

Deforestation, land use change and re-emergence of malaria in the southeastern Amazonia region of Madre de Dios, Perú. Correa, G.H., Vela, L.M. (*Universidad Nacional Amazónica de Madre de Dios, Perú; biologo.geo@yahoo.com; cibdamdd@yahoo.com*).

In the region of Madre de Dios, the biodiversity capital of Peru bordering Brazil and Bolivia, the main economic activity is alluvial gold mining, which constitutes an increasing threat to Amazonian biodiversity and the tropical rainforest as it causes drastic changes in the landscape due to the deforestation that precedes the extraction of gold particles from the subsoil. In the past decade, the impact of this mining activity has contributed to the creation of environmental problems in the form of great depressions in the land which, due to the rain, have become habitats for species of the class *Anopheles* (Diptera: Culicidae), vectors of malaria in the region. In a direct field inspection (search for larvae) it was observed that the vector colonization differed depending on the presence of artificial ponds or the formation of pastures (for extensive cattle farming) after deforestation of the natural forest. The two species *Anopheles benarrochi* and *Anopheles darlingi* (main vectors of malaria), are the most successful ones that settle in these man-made habitats, which increases the risk of contracting malaria for the local population in these deforested areas.

The global and regional situation of Iran in the trade of non-wood forest products. Ghanbari, S. (*University of Tehran, Iran; ghanbarisajad@gmail.com*).

Non-wood forest products (NWFPs) play an important role in the national economy. This study compares the situation of Iran in the trade of NWFPs with Asia and the world. Results showed that income Iran from NWFPs was approximately US$551,000 in 2005. Among NWFPs, exudates had the highest value (US$84780), followed by raw materials for medicine and aromatic products (US$6,560) and food (US$710). The reported value of NWFP removal in Asia and the world was about US$4.7 billion and US$1.7 billion in 2005 respectively. The share of Iran to Asia and world in 2005 was about 0.032% and 0.012% respectively. The employment created in the forestry sector was about 107 thousand person years in Iran in 2000. The amount of forestry employment in Asia and the world was 8,140 and 9,939 thousand person years respectively. The employment share in Iran into Asia and world in 2000 was 1.31% and 1.08%, respectively. However, low income from and employment in the forestry sector is logical because of low forest cover in Iran, activities such as identification of NWFPs, correct exploitation, appropriate processing and marketing can increase employment and income.

Difficulties in managing solid waste generated in certified forest communities and the health risks to traditional populations in the Brazilian Amazon. Imperador, A.M. (*Universidade Federal de Rondônia, Brazil; adrianaimperador@yahoo.com.br*), Wadt, L.H.O. (*Empresa Brasileira de Pesquisa Agropecuária-EMBRAPA, Brazil; lucia@cpafac.embrapa.br*), Brucha, G. (*Universidade Federal de Rondônia, Brazil; gbrucha@unir.br*), Crestana, S. (*Empresa Brasileira de Pesquisa Agropecuária-EMBRAPA, Brazil; crestana@cnpdia.embrapa.br*).

The certification granted by the Forest Stewardship Council (FSC) is a management tool for the sustainable use of forest resources, considering social, economic and environmental aspects. Efforts to promote community certification intended for the development of rural populations and forest conservation present many challenges, such as the lack of scientific studies addressing the managers' perception in implementing the actions for certification standards. Given the experience of the Porto Dias and Remanso de Capixaba Association, in the Brazilian Amazon concerning Forest Certification, this research evaluates the difficulty of the managers in complying with the actions concerning the management of solid waste generated in the communities and its relationship with the local population's health. The data were collected through structured interviews and focused observation. Both associations face great difficulty in disposing and allocating household waste, including that classified as hazardous waste, such as batteries, oils and fuels, which contaminate the soil and water, putting at risk the local population's health. The contribution by research institutions in training the handlers and indicating alternatives can help towards compliance with the requirements for certification and thus contribute to the proper management of solid waste in the communities.

A study on the physiological and psychological effects of volatile fragrance components from *Dendropanax morbifera*. Jung, B.M., Wi, A.J., Park, W.S. (*Jeonnam Forest Resources Research Institute, Republic of Korea; jbm8001@korea.kr; ajwiko@korea.kr; pws0815@korea.kr*), Heo, B.G. (*Naju Foundation of Natural Dyeing Culture, Republic of Korea; bukgu@naver.com*).

This study was conducted to evaluate the effects of the fragrance ingredients of leaves in *Dendropanax morbifera* (which grows wild in Wando districts of Korea) on changes in brain activity and feeling sensation. Volatile fragrance components in the leaves were extracted in the condition of SPME 30 and analyzed by GC/MS. Changes in brain waves were measured in 60 people before and after inhalation of yellow dye extract solution of *D. morbifera*. Mental stability and changes before and after inhalation were also examined by POMS. A total of twelve hydrocarbons were detected in the leaves of *D. morbifera*, the main volatile components being α-neoclovene (32.8%), germacrene-D (20.49%) and trans-caryophyllene (18.66%). Brain waves of relative alpha wavelength increased by 0.4337 to 0.5041 before and after inhalation. However, relative beta wavelength decreased significantly by 0.5041 to 0.2200. We conclude that the fragrance of yellow dye solution has a physiologically stable activity. Changes in psychologically stable activity before and after inhalation were not significant in cases of 'tension-anxiety', 'vitality' and 'confusion', but decreased in cases of 'depression', 'anger + hostility' and 'fatigue'. We conclude that the fragrance of yellow dye solution can be helpful for physiological or psychological stability.

Visual preference patterns for therapeutic forest landscaping. Lee, Y.H., Kim, C.Y., Kim, K.W. (*Kookmin University, Republic of Korea; shineryh@kookmin.ac.kr; made@lycos.co.kr; kwkim@kookmin.ac.kr*), Yoo, R.H., Park, C.W. (*Korea Forest Research Institute, Republic of Korea; cham0505@forest.go.kr; PCWPCW@forest.go.kr*).

The appreciation of forest landscapes is a typical forest recreational activity, as the beautiful scenery increases visual quality and satisfies one's aesthetic desires. This study presents visual preference patterns for various forest landscapes and trails analyzed from the data acquired by questionnaires to provide basic information and useful clues for managing and planning the forest landscape. The results of our study indicated that the following forest types were preferred in comparison with other forest structures: conifer forest, especially fir and pine forests; birch and oak forests among hardwood forests; managed forest; harmonious stand structure; forest with a lawn; and forest with unexposed stems and with waterside spaces and dirt trails. From the aesthetic point of view, pruning shape applied with the reverse golden section was preferred. In case of trails, curved trails were preferred over straight trails and luxuriant, snug and narrow trails were preferred over luxuriant, bright and wide trails, and

people preferred unpaved trails and trails with natural rather than cleaned edges or planted flowers. Overall, the trails with snug, restful, natural and luxuriant atmosphere were preferred.

Reactions of local population around the Dja reserve about the process of community forestry in Cameroon. Meyanga Tonga, Y. (*Ministry of Scientific Research and Innovation, Cameroon; meyanga_yves@yahoo.fr*).

The objective of this research endeavour, as the FAO (1995) put it is: "How to make good use of trees and natural forest resources for the betterment of the environment and the well-being of the populations, while preserving these resources for future generations?" Field data were collected from 70 household heads, 50 from the Ze village and 20 from the Esseng village, using a questionnaire. The analysis of data led to the following results. Among respondents young, adult and old people were able to participate. Sixty percent of respondents believed the level of communication on community forestry is high. 52% of respondents believed they are sufficiently involved in decision making in community forestry. Fifty-seven of respondents are ready for a collective mobilisation as community forestry in concern, 85% relate their participation to a benefit and 90% believe the cost for appropriation of this innovation is high. For our respondents, the main criteria of well-being are: ability to feed one's family, ability to meet their health-related needs, being useful to society and ability to get an accommodation.

Effect of thinning on male flower production in hinoki cypress (*Chamaecyparis obtusa*) stands in southwestern Japan. Miyamoto, K., Okuda, S., Noguchi, M., Itou T. (*Forestry and Forest Products Research Institute, Japan; mkazuki@affrc.go.jp; okuchan@affrc.go.jp, mahoko@affrc.go.jp; takeharu@affrc.go.jp*).

Pollen allergies are a serious health problem in Japan. In addition to Japanese cedar (*Cryptomeria japonica*) plantations, hinoki cypress (*Chamaecyparis obtusa*) plantations are a major source of pollen. In this study we evaluated the effect of thinning intensity on male flower production, as a means of controlling the pollen source, in hinoki cypress stands with different thinning treatments (30–50% thinned and un-thinned stands) and different times after thinning (1 and 6 years). In the stands 1 year after thinning, male flower production significantly increased with thinning intensity (compared with un-thinned stands). Six years after thinning, male flower production in the thinned stands was lower than or similar to that in the un-thinned stands in most cases, and the relationship between male flower production and thinning intensity was obscure. In all the stands, male flower production seemed to be affected more by interannual variation than by thinning. The results suggest that thinning is not an effective means of controlling the pollen source in hinoki cypress plantations. Nevertheless, thinning should be promoted in conifer plantations in Japan for effective forest management and to develop multiple functions of forests such as carbon sequestration, biodiversity conservation, and soil and water conservation.

Deforestation and the controlling factors: a cross-country analysis. Miyamoto, M. (*Forestry and Forest Products Research Institute, Japan; motoe@affrc.go.jp*).

Agricultural expansion into forest lands is the main factor contributing to deforestation. Road construction is one of the most important determinants of the conversion of forest to agriculture. By contrast with such immediate causes of deforestation, the underlying causes are still ambiguous, but they are the keys to success in reducing deforestation. This paper examines the effects of population pressure, poverty and the other economic factors on the deforestation occurred from 1990 to 2005, by conducting a cross-country comparison. Data used in this study were the FAO Global Forest Resources Assessment 2005 and other United Nations statistics. The main objective of this study was to indentify the factors reducing or controlling deforestation. This study showed that several economic factors including lack of off-farm employment opportunities have significant effects on deforestation. It also showed that population pressure may be significantly related to historical deforestation, but does not have a significant effect on recent deforestation for many countries. The study results suggest that increasing the availability of off-farm employment would be necessary to reduce deforestation over the long term.

Research and policy trends for improving human health and therapeutic functions of forest in South Korea. Yoo, R. (*Korea Forest Research Institute, Republic of Korea; cham0505@forest.go.kr*).

Rapid urbanization and increased leisure time due to higher income and a 5-day work week have attracted public attention to eco-friendly lifestyles. Under such circumstances, the public is now taking interest not just in how to lead their lives but in how to improve their quality of life. As a solution to improve health and prevent disease, the forest is taking center stage in the public's mind among others. In Korea, 65 percent of land area is covered with forests. In 1988, a 'recreation forest' system was introduced in order to use forests as places for recreation and relaxation. In addition to this, 'forest bathing' (taking a stroll or spending time in the forest) has become a popular activity to enhance the quality of life and human health. Research on recreation forests and forest bathing has been conducted to examine interactions between forests and human health, focusing on the effects of forests on human health mainly based on empirical and/or psychological indicators. But more recently, research has shifted to a more objective and scientifically reliable focus using physiological indicators associated with incretion and central/autonomic nervous systems.

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