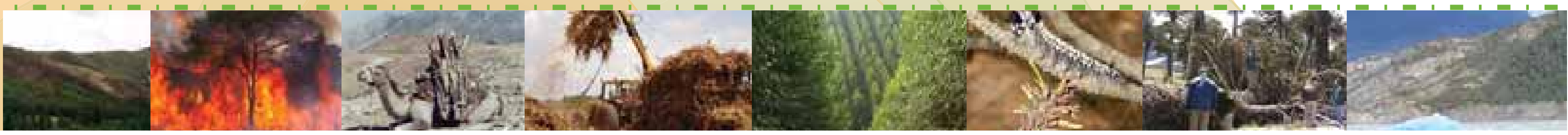
INTERNATIONAL CONFERENCE ON ADAPTATION OF FORESTS AND FOREST MANAGEMENT TO CHANGING CLIMATE WITH EMPHASIS ON FOREST HEALTH: A REVIEW OF SCIENCE, POLICIES AND PRACTICES

Book of Abstracts and Preliminary Programme

Umeå, Sweden
25-28 August, 2008



Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health: A Review of Science, Policies and Practices

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Organized by
Swedish University of Agricultural Sciences (SLU)
Food and Agriculture Organization of the United Nations (FAO)
International Union of Forest Research Organizations (IUFRO)

Supporting organizations and sponsors
Canadian Forest Service
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International Union of Forest Research Organizations
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Seoul National University

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Distinguished guests, colleagues, ladies and gentlemen,

It is a great pleasure for me, as Vice-chancellor of SLU, to welcome you to Umeå, the city of birches. SLU is Sweden's main centre for research and higher education in forestry and natural resource management. SLU has four main campuses in the country and whilst the Faculty of Forest Sciences is located here, forest research also takes place in our Uppsala and Alnarp campuses as well.

This Conference on "Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health" is a joint venture between SLU, FAO and IUFRO - three organizations which are deeply involved in research and development of forests all around the world. The Conference is conveniently taking place in a country of forests. Swedish forests belong to the boreal forest zone of the northern hemisphere. In an evolutionary perspective our forests are young, following in the foot steps of the melting ice some ten thousand years ago. They have been utilized by man since pre-historic times. Initially, agriculture and mining industries and later lumber and pulp industries have shaped almost all of the present Swedish landscape. Today, forests cover about 50% of Sweden's land area and account for more than 10% of the national export.

Forest systems are impacted by multiple uses and influenced by global drivers. The multiple–use character of forests means that many different and sometimes conflicting goals exist regarding their management. Wide-ranging effects on the condition of forest ecosystems and their services are to be expected based on factors such as global market changes, increasing per capita income, demographic change, changes in consumption patterns, urbanization, globalization of the economy and new technology.

Climate change will influence forest ecosystems around the world and the chain of causality is currently difficult to understand. Projected changes in the climatic system will affect natural and social systems globally, increasing their vulnerability and affecting their ability to supply goods and services to meet an ever increasing demand. For forestry and other natural resources management, the major challenges are in developing best practises for adaptive measures to maintain ecosystem resilience, and to reduce vulnerability under various climate change scenarios.

The main purpose of this Conference is to unite our forces in order to meet the challenges that forests are facing. Today it is more evident than ever before how important forests are. Not only do they have the ability to sequester carbon dioxide, forests are also the planet's largest and most important terrestrial ecosystem. They have a profound influence on the structure and function of the human habitat, both locally and globally. Forests are also the largest reservoir of plants and animals on land. They sustain much of the world's diversity of life with its body of genetic information developed over evolutionary time.

Forests and trees will continue to play a major role in the future and I am proud that SLU, together with FAO and IUFRO, has decided to launch this Conference in order to encourage all of you, researchers and practitioners, to address relevant issues within the theme of this Conference. For as was stated by the Brundtland Commission in 1987 - "Since the answers to fundamental and serious concerns are not at hand, there is no alternative but to keep on trying to find them".

Lisa Sennerby Forsse
Vice-chancellor, SLU

Dear Conference Participants,

On behalf of FAO, it is my pleasure to welcome you to the Conference on “Adaptation of Forests and Forest Management to Changing Climate with Emphasis on Forest Health”. Forests are large, dynamic and diverse ecosystems upon which we rely for provision of a wide range of forest products and social and environmental services. We are most familiar with the function of forests in providing wood, fibre, fuel, food, fodder, medicines and other goods that support livelihoods, whether for subsistence use or commercial trade. However, there are indirect, less tangible, but critically important social and ecosystem services that are increasingly being valued. These include the roles of forests in maintaining and rehabilitating soils and nutrient cycles, watershed protection and water balances, conservation of biodiversity, sequestering and storing of carbon, recreation and landscape aesthetics and diversity.

Forests are also resilient in that they have, over millions of years, advanced and retreated with glaciers, changed in extent and composition, but have always been there as an integral part of the global balance. Currently, however, the resilience of forest ecosystems around the world is being challenged like never before, as we are modifying our living environments at local and global scales, and doing so at unprecedented rates.

We recognize that global change, of which climate change is one important component, is inexorably changing forest ecosystems which impact peoples’ lives and livelihoods around the world. We need to be aware of the nature of these changes, the rates at which they are taking place and their impacts on forests and forest management. Forest health was the initial FAO emphasis for this event, and remains the cornerstone of adaptation to climate change. We need to understand the impacts of a changing climate on forests and forest management, including health, productivity, biodiversity and sustainability in maintaining flows of goods and services in ecosystems and to society in the future. We need to be able to forecast these changes in order to adapt scientific research programmes, review forest policies and embrace more adaptive forest management practices.

FAO is delighted to co-host this Conference with IUFRO and SLU and to acknowledge the generous support from the Canadian Forest Service, USDA Forest Service, United States Geological Survey, Royal Swedish Academy of Agriculture and Forestry, and the Seoul National University.

As scientists, policy makers, planners, managers and academics representing a wide range of socio-economic, ecological and institutional contexts from around the world, you have the expertise and experience to view the challenges from your different perspectives and to channel this diversity into making this conference a success. It is proposed that the Conference outputs will feed into the work of the Collaborative Partnership on Forests, including into the Joint Initiative Report on Adaptation of Forests to Climate Change.

An interesting programme is in place for you to exchange, contribute and learn. Good luck for a productive event.

Jan Heino
Assistant Director-General
Forestry Department
Food and Agriculture Organization of the United Nations

Distinguished guests and participants,

It is a great honor to welcome you all to the International Conference on the “Adaptation of Forest and Forest Management to Changing Climate with Emphasis on Forest Health”, in Umeå, Sweden, from 25 to 28 August 2008. The relationship between forests and climate is, needless to say, a complex one. We know that climate has a profound impact on the way forests grow, function, regenerate, and interact with the natural world around them.

Since the release of the IPCC’s Fourth Assessment Report, there has been increased certainty that climate change is an inevitable consequence of past and present human activities on this planet. We must evaluate the ongoing effects and implications of climate change on forests and tailor our research, policies and practices accordingly in order to plan for and manage healthy and productive forests. It is critical that the importance of forests, as a sink and absorber of carbon, as well as a mechanism for greenhouse gas reduction, be recognized and acknowledged on the global level. Forests absorb carbon twenty four hours a day, three hundred and sixty five days a year. Overlooking their importance, and not acting upon it, would be a fatal error on our part.

This Conference will focus on the current state of knowledge and understanding surrounding climatic patterns and changes in various regions around the world. We will discuss the need for changes to research, policies and practices to enable us to plan and manage healthy and productive forests worldwide.

I, as the IUFRO President, sincerely hope that this Conference will serve as a successful venue for the active exchange of scientific and technical information among countries and regions and will help seek for better partnerships and collaborations. Many thanks are given to our sponsors and organizers for making this possible. I am very certain that this event will provide a meaningful chance for all the participants to identify new approaches and strategies for sustainable forest management and to address the relationship between climate change and forest management.

Don K. Lee
IUFRO President

Week at a Glance - The Schedule

This schedule offers a schematic view of time allocation for the full conference week. If you want to see when your preferred session is taking place, see “Week at a Glance: Programming the Sessions”. If you want to see the preliminary day-by-day programme, see “Preliminary Detailed Programme”. If you want to see the session contents, see “Preliminary Session Contents”.

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<tr><td rowspan="2">10</td><td>0 10 20</td><td rowspan="2">Opening welcome and addresses</td></tr>
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Week at a Glance - Programming the Sessions

This schedule offers a schematic view of session placement for the full conference week during the periods (P) allocated for the technical sessions. If you want to see a schematic view of the week's schedule, including when these periods are, see "Week at a Glance – the Schedule". If you want to see the preliminary day-by-day programme, see "Preliminary Detailed Programme". If you want to see the session contents, see "Preliminary Session Contents".

#	Session title	Monday		Tuesday			Wednesday		Thursday	
		PM		AM	PM		AM	PM	AM	PM
		P1	P2	P3	P4	P5	P6	P7	P8	P9
1	Physiological responses of trees to climate change	S1								
2	Climate induced changes in forest ecosystems						S2			
3	Impacts of altered regime of extreme abiotic events	S3								
4	Impacts of climate change on forest growth			S4						
5	Forest health: effects of air pollution, forest pests and pathogens			S5						
6	Silviculture and production of wood and non-wood forest goods						S6			
7	Biodiversity, conservation and protective functions of the forest								S7	
8	Socio-economic functions and livelihoods			S8						
9	Innovative management and policy approaches								S9	
10	Climate Change and Forest Sector Adaptive Capacity	S10								
11	Tropical Forest Management and Climate Change Adaptation						S11			
12	Genetic and physiological adaptation to changing climate								S12	
13	Forest dieback and mass mortality: Assessments and Early Warning	S13								
14	Forest dieback and mass mortality: monitoring and mitigation of consequences						S14			
15	Scenarios and modelling for forest management planning			S15						
16	The "Swedish Model" as a Tool for Global Carbon Mitigation						S16			
17	Opportunities for combining adaptation and mitigation objectives								S17	
18	Wood as a green building material							S18		

Preliminary Detailed Programme

Sunday 24 August

16.00 – 18.00 hours: Registration and poster installation

Monday 25 August

08.00 – 10.00 hours: Registration, poster installation and coffee

10.00 – 11.00 hours: Opening welcome and addresses

- Ms. Lisa Sennerby Forsse - Rector, SLU
- Mr. Jan Heino - Assistant Director-General, Forestry Department, FAO
- Mr. Don K. Lee - President, IUFRO

11.00 – 12.00 hours: Keynote addresses

- Ms. Abigail R. Kimbell - *Managing forests in an era of climate change: Perspectives from the U.S. Forest Service*
- Michael Wood - *Sweden and the United States: Partners in Solving the Problem of Global Climate Change*
- Risto Seppälä - *Increasing Knowledge about Adaptation of Forests to Climate Change: An Expert Panel Approach*

12.00- 13.00 hours: Lunch

13.00 – 15.00 hours: Parallel technical sessions (Part 1)

- Physiological Responses of Trees to Climate Change
- Impacts of Altered Regimes of Extreme Abiotic Events
- Climate Change and Forest Sector Adaptive Capacity
- Forest Dieback and Mass Mortality: Assessments and Early Warning

15.00 – 16.00 hours: Coffee break and **poster session**

16.00 – 17.00: Parallel technical sessions (Part 2)

- Physiological Responses of Trees to Climate Change
- Impacts of Altered Regimes of Extreme Abiotic Events
- Climate Change and Forest Sector Adaptive Capacity
- Forest Dieback and Mass Mortality: Assessments and Early Warning

17.00 – 18.00 hours: Informal poster session

18.00 hours: Social and walking dinner party

Tuesday 26 August

08.00 – 09.30 hours: Keynote addresses

- Jacques Régnière - *Predicting insect continental distributions from the physiology of individuals.*
- Brent Larson - *Phytosanitary issues related to climate change, invasive alien species and trade: How to use the framework of the International Plant Protection Convention for the management of forest health.*
- Dieter Schoene - *Forest health and adaptation of forest management: Perspectives from the IPCC's Fourth Assessment Report (AR4)*

09.30 – 10.30 hours: Coffee break and **poster session**

10.30 – 12.00 hours: Parallel technical sessions (Part 1)

- Impacts of Climate Change on Forest Growth
- Forest Health: Effects of Air Pollution, Forest Pests and Pathogens
- Socio-Economic Functions and Livelihoods
- Scenarios and Modelling for Forest Management Planning

12.00- 13.00 hours: Lunch

13.00 – 14.30 hours: Parallel technical sessions (Part 2)

- Impacts of Climate Change on Forest Growth
- Forest Health: Effects of Air Pollution, Forest Pests and Pathogens
- Socio-Economic Functions and Livelihoods
- Scenarios and Modelling for Forest Management Planning

14.30 – 15.00 hours: Coffee break

15.00 – 17.00 hours: Parallel technical sessions (Part 3)

- Impacts of Climate Change on Forest Growth
- Forest Health: Effects of Air Pollution, Forest Pests and Pathogens
- Socio-Economic Functions and Livelihoods
- Scenarios and Modelling for Forest Management Planning

Wednesday 27 August

08.00 – 09.30 hours: Keynote addresses

- Doug Konkin - *Learning to deal with climate change and catastrophic forest disturbances*
- Balgis Osman Elasha – *Assessment of Impacts and Adaptation to Climate Change and the Links to Sustainable Development in Africa*
- Nur Masripatin - *Mainstreaming Climate Change Adaptation Issues into Forest Policies and Management Practices: A Way to Bring Concepts into Actions*

09.30 – 10.30 hours: Coffee break and **poster session**

10.30 – 12.00 hours: Parallel technical sessions (Part 1)

- Climate-Induced Changes in Forest Ecosystems

- Silviculture and production of wood and non-wood forest goods
- Tropical Forest Management and Climate Change Adaptation
- Forest Dieback: and Mass Mortality: Monitoring and Mitigation of Consequences
- The "Swedish Model" as a Tool for Global Carbon Mitigation

12.00- 13.00 hours: Lunch

13.00 – 15.00 hours: Parallel technical sessions (Part 2)
- Climate-Induced Changes in Forest Ecosystems
- Silviculture and production of wood and non-wood forest goods
- Tropical Forest Management and Climate Change Adaptation
- Forest Dieback: and Mass Mortality: Monitoring and Mitigation of Consequences
- Wood as a Green Building Material

15.30 hours: Bus departure for *Reception at SLU*

18.00 hours: Banquet

Thursday 28 August

08.00 – 09.30 hours: Keynote addresses
- Malik Amin Aslam - *Development of the Carbon Market in Pakistan – Issues and Opportunities for Sustainable Forestry*
- Catherine Potvin - *Reducing Emissions from Deforestation and Forest Degradation: Negotiations and Methodological Issues*
- Hans R. Heinimann - *Precision Forestry - A Key Concept to Make Adaptive Management Operational?*

09.30 – 10.30 hours: Coffee break and **poster session**

10.30 – 12.00 hours: Parallel technical sessions (Part 1)
- Biodiversity, Conservation and Protective Functions of the Forest
- Innovative Management and Policy Approaches to Climate Change Adaptation
- Genetic and Physiological Adaptation to a Changing Climate
- Opportunities for Combining Adaptation and Mitigation Objectives

12.00- 13.00 hours: Lunch

13.00 – 14.30 hours: Parallel technical sessions (Part 2)
- Biodiversity, Conservation and Protective Functions of the Forest
- Innovative Management and Policy Approaches to Climate Change Adaptation
- Genetic and Physiological Adaptation to a Changing Climate
- Opportunities for Combining Adaptation and Mitigation Objectives

14.30 – 15.00 hours: Coffee Break

15.00 – 17.00 hours: Conclusion of the Conference: Poster Awards, Summaries and Closure

KEYNOTE SPEAKERS

Preliminary Session Contents

Session 1 – Physiological Responses of Trees to Climate Change

Oral Presentations:

- **Reaction of Growth and Litterfall of *Fagus sylvatica* to Climatic Variability -** Eichhorn Johannes, Dammann Inge and Paar Uwe
- **Stand Level Variation in Leaf Area to Sapwood Area Ratio along an Aridity Gradient in the Jarrah Forest of South-Western Australia -** Pekin Burak, Boer Matthias, Macfarlane Craig and Grierson Pauline
- **Experimental Frost and Drought Affect Fine Root Dynamics and Carbon Input to the Soil in a Spruce Forest** - Gaul Dirk, Hertel Dietrich, Leuschner Christoph
- **Unraveling the Influence of Temperature, Latitude and Local Environment on the Reproduction of Six Forest Herbs along a Latitudinal Gradient -** De Frenne P., Kolb A., Verheyen, K., Hermy, M. and Graae B. *et al*.
- **Effects of Climate Change on Wood Properties: Overview of Current Knowledge** - Kostiainen Katri, Kaakinen Seija, Saranpää Pekka and Vapaavuori Elina
- **Simulated Regional Effects of Climate Change on Net Primary Production for Forests in Sweden –** Bergh J., Nilsson U. and Karlsson M.
- **Analysis of the Shifting of Phenophases of Common British Wild Plants in Response to Climate Change –** Faisal Arif M., Davy Anthony J. and Sparks Tim
- **Mediterranean Forest Under Climate Change Scenarios: the Response to Increase of Drought** - Ripullone F., Borghetti M., Raddi S. and Magnani F.
- **Drought Responses of Different Tree Species in Bavaria: Evidence from Tree Ring Growth and Wood** - Zang Christian, Rothe Andreas and Pretzsch Hans

Associated Posters:

- **Mathematical Analysis of Change in Forest Carbon Use Efficiency With Stand Development: A Case Study on *Abies veitchii*** - Kazuharu Ogawa
- **Plant Water Relation and Growth Response of *Cordia africana* Lam. Seedlings of Three Seed Sources Exposed to Different Water Regimes -** Seyoum Yigremachew and Fetene Masresha
- **Monitoring the Masting Behaviour of Beech (*Fagus sylvatica*) in Flanders (Belgium)** - Sioen G., Roskams P., Verschelde P, Van der Aa B. and Verstraeten A.
- **Responses to Flooding of Poplar Clones Planted in the Paraná River Delta, Argentina** - Luquez V.M.C., Achinelli F.G., Cortizo S. and Guiamét J.J.
- **Simulation of Photosynthetic Production of Beech (*Fagus crenata*) Trees Affected by Temperature Oscillation Amplitude** - Chiba Y., Migita C. and Han Q.
- **Photosynthesis Rate and Antioxdant Enzyme Activities in Polluted and Non-Polluted Areas in The Philippines** - Woo S.Y., Lee D.K., Lee Y.K., Ryang S.Z., Lee S.H., Je S.M., Cheng C.H., Baek S.G. and Lee E.D.
- **Fruit Dormancy in *Ceriops decandra*: An Adaptation to Overcome Climate Adversary?** - Nagarajan B., Krishnamoorthy M. and Pandiarajan C.
- **A Phenology Model to Predict Spring Canopy Onset of Vegetation in Korea Using MODIS –** Kim Sohee, Kang Sinkyu and Lim Jong-Hwan
- **Phenological Response to Changing Environmental Conditions of Western Ghats, Southern India** - Krishnamurthy Yelugere L., Nanda, A. and Prakasha Hiregouja M.
- **Flowering Calendar of a Protected Forest: a Case Study of Arabuko Sokoke Forest, Kenya** - Sande Susan, Nicolson Sue and Gordon Ian
- **Effect of Soil Temperature Fluctuations on Root Respiration Under Global Warming -** Je S.M., Woo S.Y., Ryang S.Z., Park J.H. and Sung J.H.

Session 2 – Climate-induced Changes in Forest Ecosystems

Oral Presentations:

- **An Indicator of Tree Migration in Forests of the Eastern United States -** Woodall C.W., Oswalt C.M., Westfall J.A., Perry C.H. and Nelson M.D.
- **Present Vulnerability and Future Trends of Changes for *Pinus cembra* L. in the Alps -** Casalegno S. and Reithmaier L.M.
- **Disturbance-Driven Land Cover Changes in Western Canada Under Observed and Projected Climate Change -** Wang Xianli and Hamann Andreas
- **A Conceptual Model for Studying the Effects of Landscape Connectivity on Ecosystem Adaptation to Climate Change in Central America -** Locatelli Bruno and Imbach Pablo
- **Forest Trees Composition, Fisheries and Wildlife Status of Omo Biosphere Forest Reserve, Ogun State, Nigeria -** Akegbejo-Samsons Y., Alegbeleye W.O. and Ojo L.O.
- **Major Conifers Distribution in Russia in a Warming Climate -** Tchebakova N.M. and Parfenova E.I.
- **Impact of Future Droughts on Forested Mountain Catchments: Carbon Storage and Hydrology -** Wolf A. and Bugmann H.
- **Persistence of the Fog-Dependent Fray Jorge Forest in Semi-Arid Chile during the Past Two Centuries -** Gutiérrez Alvaro G., Barbosa Olga, Christie Duncan A., del-Val Ek., Ewing Holly A., Jones Clive G., Marquet Pablo A., Weathers Kathleen C. and Armesto Juan J.
- **Effect of Global Climate Change on Rare Trees and Shrubs in the Southern United States -** Devall, M.S.
- **Impact of Climate Change on Indian Forests: A Short- and Medium-Term Assessment -** Chaturvedi Rajiv Kumar and Tiwari Rakesh
- **Disturbance in Sudanian Savanna Woodlands and Ecological Responses under Climate Change: The Contribution of Long-term Ecological Research on Fire, Grazing and Selective Tree Cutting -** Zida Didier, Savadogo Patrice, Tiveau Daniel, Dayamba Djibril, Sawadogo Louis, Tigabu Mulualem and Odén Per Christer
- **Studies on Population Structure and Regeneration of Woody Species in Dry Afromontane Forest, South Eastern Ethiopia** - Girma A. and Mosandl R.

Associated Posters:

- **Examination of Tree Mortality in Semi-Arid Central Anatolian Region of Turkey during the Last Six-Year Period (2002-2007) -** Semerci A., Sanlı B.N., Sahin O., Çelik O., Balkız B., Ceylan S. and Argun N.
- **Climate Change Impact on Spruce (*Picea Abies* L.) and Beech (*Fagus sylvatica* L.) Growth Potential in Slovakia -** Baláž Peter and Hlásny Tomáš
- **National Inventory of Landscapes in Sweden (NILS) as a Platform for Monitoring Impacts of Climate Change in the Swedish Mountain Areas -** Heiskanen J., Olsson H., Sundquist S., Nilsson B., Allard A., Moen J., Holm S. and Mäki A.-H.

Session 3 – Impacts of Altered Regimes of Extreme Abiotic Events

Oral Presentations:

- **Sensitivity of Tropical Dry Forests to Climate Variability: Results of an 18-Year Study from Mudumalai, Southern India -** Suresh H.S., Dattaraja H.S. and Sukumar R.
- **The Future of Forest Fires in Central America Under Climate Change and Socio-Economic Scenarios -** Locatelli Bruno, Imbach Pablo, Guillermo Molina Luis, Palacios Elena
- **The Effect of Environmental Changes on Forest Disturbances in South Korea -** Park P.S., Lee K.H., Jung M.H., Shin H., Jang W., Bae K. and Lee J.
- **The Risk of Abiotic Forest Damages will Alter Under the Climate Change in the Boreal Conditions -** Kellomäki S., Kilpeläinen A. and Peltola A.
- **Burning Regimes and Dynamics of The Sudanian Savanna Ecosystems: The Case Study of Katiali, Côte d'Ivoire -** Koné M., Bassett T. J. and Nkem J.N.
- **Tree-Ring Analysis Used for Climate Reconstruction and Fire Frequency in Mongolia -** Baatarbileg Nachin
- **Impacts of Frost on Beech (*Fagus sylvatica* L.) Susceptibility to Scolytine Ambrosia Beetles -** La Spina S., De Cannière C., Sawadogo A.-K., Mayer F., Molenberg J.-M. and Grégoire J.-C.
- **Changes in Liana and Tree Community Structures as Consequence of Increased Hurricane Frequency in Tropical Forests in Cozumel, Mexico -** Pérez-Salicrup, D. R. and Patiño-Conde, P.
- **Climate Change and the Probability of Wind Damage in Two Swedish Forests -** Blennow Kristina, Andersson Mikael, Sallnäs Ola and Olofsson Erika

Associated Posters:

- **Influence of Surface Fires on Vegetation Diversity in Hemiboreal *Pinus sylvestris* Forests Under Climate Change Conditions -** Marozas Vitas, Racinskas Jonas and Bartkevicius Edmundas
- **Modelling forest fire ignition and propagation for two fire-prone regions in Switzerland -** Weibel P., Reineking B., Conedera M. and Bugmann H.
- **Estimate of Forest Damage Using the "Potential Level of Forest Destruction by Fire" Methodology -** Sant'Anna C.M. and Pedroso D.O.
- **Fire Impact on Components of Forest Ecosystems of Central Siberia, Russia -** Ivanova G., Bogorodskaja A., Krasnoshekova E, Kovaleva N., Perevosnikova V., Conard S. and McRae D.

Abstracts accepted but not presented:

- **Evaluating Future Wildfire Risk Using the Keetch-Byram Drought Index** - Liu Yongqiang, Stanturf John and Goodrick Scott

Session 4 – Impacts of Climate Change on Forest Growth

Oral Presentations:

- **Elasticity of Tree Radial Growth to Environmental Stress -** Kahle Hans-Peter
- **Quantifying the Height Growth-Temperature Relationship of Plantation Taiwan Spruce -** Guan Biing T., Chung Chih-Hsin and Lin Shu-Tzong
- **Climate-Sensitive Modeling of Site-Productivity Relationship -** Albert M. and Schmidt M.
- **Simulating Tree Growth Under Climate Change Using Altitudinal Shift as Proxy -** Huber M. and Sterba H.
- **Utility of Biological Expansion Factors for Estimating Above Ground Component Biomass of *Picea abies* L. Karst. –** Albaugh Timothy J., Linder Sune, Nilsson Urban, Lundmark Tomas, Bergh Johan, Allen H. Lee, Flower-Ellis Jeremy
- **Climate Change Impact on Soil Salinity and Tree Growth of Tidal Freshwater Forested Wetlands of the Southeastern United States -** Krauss Ken W., Doyle Thomas W., Conner William H., Day Richard H. and Duberstein Jamie A.
- **Long-Term Trends and Fluctuations of Common Beech and Sessile Oak Growth in France during the 20th Century and their Compared Climatic Interpretations -** Bontemps Jean-Daniel, Hervé Jean-Christophe, Dhôte Jean-François
- **Predicting the Impacts of Pest Attack on Forest Productivity Under Changing Climate -** Pinkard Libby and Battaglia Michael
- **Potential Forest Productivity Impacts of Climate Change on Forests of the United States Pacific Northwest -** Latta Gregory, Temesgen Hailemariam, Adams Darius and Barrett Tara
- **New Zealand's Potential Forest Responses and Threats Under Climate Change - An Overview of Related Research -** Paul T.S.H., Watt M.S. and Kirschbaum M.U.F.
- **Climate Change Effects on Site Index Estimation in Mediterranean Maritime Pine Forests -** Bravo-Oviedo A., Gallardo-Andrés C., del Río M. and Montero G.
- **Dealing With Error: Will Climate Change Have a Significant Effect on Predictions from Empirical Growth and Yield Models? -** Coulombe S., Bernier P.Y. and Raulier F.

Session 5 – Forest Health: Effects of Air Pollution, Forest Pests and Pathogens

Oral Presentations:

- **Forest Health in North America: Current Conditions, Historic Trends, and Future Risks -** Tkacz Borys, Moody Ben, Villa Castillo Jaime and Fenn Mark E.
- **Effects of Climate, Air Pollution, Pests and Pathogens on Forest Health – An Integrative Perspective of IUFRO -** Bytnerowicz A., Wingfield M., Paoletti E., Laflamme G. and Liebhold A.
- **Climate Change, Pollutant Deposition and the Ozone Situation Worldwide: Implications for, and the Role of, Forests** - Kuylenstierna Johan
- **Forest Monitoring and Critical Loads Assessments as a Scientific Basis for Air Pollution Control in Europe -** Lorenz M., Nagel H.D., Granke O. and Kraft P.
- **How to Protect Forests Against Aggressive Biotic Factors Under Changing Climate Scenarios? -** Skorupski M. and Magowski W.
- **Climate Change Impacts on Forest Health: Insect Pests, Diseases and Invasive Alien Species -** Moore Beverly A. and Allard Gillian B.
- **Mountain Pine Beetle Attack in Immature Lodgepole Pine Stands in Central British Columbia, Canada -** Hawkins Chris and Runzer Kyle
- **Does Climate Change Promote Insect Outbreak Situations and Altered Forest Ecosystem Functions? -** Le Mellec Anne, Vogt-Altena Holger, Reinhardt Annett, Gerold Gerhard and Michalzik Beate
- **Foliage Browsing Insect Outbreaks in Ukraine: Incidence, Duration and Severity -** Meshkova Valentyna
- **Climate Change Impacts on Population Dynamics of *Ips typographus* (L.) Using Fine Scale Climate Change Scenario -** Hlásny Tomáš, Turčáni Marek, Bucha Tomáš and Sitková Zuzana
- **Potential Effects of Climate Change on Herbivores and Pathogens – A Review and an Example -** Netherer S., Lindner M., Garcia-Gonzalo J. and Schopf A.
- **Perspectives on Boreal and Tropical Tree Pathology with a Changing Climate -** Barklund Pia, Njuguna Jane, Gure Abdella, Nyeko Philip and Stenlid Jan
- **Resistance of Introduced *Pinus contorta* and Native *P. sylvestris* to *Gremmeniella abietina* (Ltt, European Race) in Sweden -** Bernhold A., Hansson P., Rioux D., Simard M. and Laflamme G.
- **Was the Latest Outbreak of *Gremmeniella abietina* in Sweden Caused by Certain Climatic Sequences? -** Hansson P. and Ottosson-Löfvenius M.
- **Can Long Distance Gene Flow Contribute to Adaptation of Fungal Pathogen Populations to Changing Climate? -** Müller Michael M. and Hantula Jarkko

Associated Posters:

- **Local Community's Perception about *Lantana camara* Wide Spread in Uganda Woodland Forests -** Ssetenda Peter
- **On the Rise - Plant Invasions into Mountain Forests -** Parks C.G. and MIREN
- **Possibilities and Limitation in Changing of Species Composition – Tree Disease Phenomena in Poland -** Zachara Tadeusz and Gil Wojciech
- **Occurrence and Effects of Two Micromycetes in a Relict European Beech Forest in Southern Italy –** Sicoli G., Bruno G., Boncaldo E. and Luisi N.
- **Tree Mortality, Increment Loss and Foliage Recovery in Middle-Aged *Pinus sylvestris* following Defoliation by *Gremmeniella abietina* and Subsequent Attack by *Tomicus piniperda* -** Bernhold A. and Witzell J.
- **Climatic Factors Affecting the Needlecast Epidemics Caused by *Lophodermium seditiosum* -** Vuorinen Martti
- **Forests and Climate Change - Lessons From Insects -** Nomi Frederick Nubed

Abstracts accepted but not presented:

- **Will Adoption of Carbon-Lean Management Practices Lead to Increased Pest Incidence? –** Bertin Sophie, Perks Mike, Straw Nigel, Mason Bill, Grace John and Mencuccini Maurizio

Session 6 – Silviculture and Production of Wood and Non-Wood Forest Goods

Oral Presentations:

- **Effects of Forestry on the Winter Grazing Resources of Semi-Domesticated Reindeer (*Rangifer tarandus*) in Sweden -** Moen Jon, Kivinen Sonja and Berg Anna
- **Positive Effect of Thinning on Throughfall as Possible Way for Adaptation of Young Scots Pine Monocultures to Changing Climate -** Novák Jiří, Slodičák Marian and Dušek David
- **Forest Regeneration and Changing Climate -** Jõgiste Kalev and Metslaid Marek
- **Trees for Energy: A Better Bet for Biofuels -** Eav B., Barbour J. and White R.
- **Climate Change and Non-Timber Forest Products in Ghana: Impacts, Vulnerability and Adaptations -** Blay D., Idinoba M., Nkem J. and Kalame F.
- **Can Intensive Thinning Regimes Mitigate Drought Effects on Norway Spruce? -** Kohler M., Nägele G. and Bauhus J.
- **A Cognitive Mapping Approach to Estimate Current and Future Functionality of Non-Timber Forest Products and Services -** Wolfslehner Bernhard and Vacik Harald
- **Modelling the Dynamics of Vegetation Diversity Under Different Forest Management Regimes and Climate Change Scenarios -** Khanina L., Bobrovsky M., Komarov A., Mikhailov A., Shanin V. and Bykhovets S.
- **Impacts of Harvesting and Thinning on Carbon Dynamics in a Balsam Fir Ecosystem in New Brunswick, Canada -** Lavigne M.B., Foster R.J. and Goodine G.K.
- **Modelling Soil Organic Matter Dynamics and Forest Nutrition Under Climate Change -** Komarov A., Mikhailov A., Shanin V., Bykhovets S.
- **Evaluating Macroscopic Effects of Impregnation with Hydrophobic Oil on Norway Spruce (*Picea abies* L. Karst) Mature Sapwood Structure -** Ulvcrona Thomas

Associated Posters:

- **Ecological Sustainability of Community Forest Management – A Case Study from the Midhills of Nepal -** Baral S.K. and Katzensteiner K.
- **Modeling Diameter Growth in Open Oak Woodlands Using Gamma Regression** - Gea-Izquierdo G. and Cañellas I.
- **Spanish Experimental Long-Term Network for Sustainable Forest Management -** Cañellas I, del Río M, Calama R, Pardos M, Sixto H, Roig S, Mutke S, Bravo-Oviedo A., Chambel R, Alía R, Montero G.
- **Biomass Equations for *Eucalyptus globulus* in Portugal: An Assessment of Carbon Involved in Forest Harvesting -** Fontes L., Tomé M. and Coelho M. Baptista

Abstracts accepted but not presented:

- **Expanded Silvicultural Approaches to Sustainable Bioenergy Plantations to Mitigate Climate Change -** Stanturf J.A., Stokes B.J.. Buford M.A. and Perdue J.H.

Session 7 – Biodiversity, Conservation and Protective Functions of the Forest

Oral Presentations:

- **Mapping Biologically Important Forests - Towards the Restoration of a Trans-European Forest Mega-corridor -** Kostovska Diyana
- **Biodiversity Conservation, Forest Management and Climate Change Adaptation in Bolivia Under the Current Political Context: Implications for Policies and Conservation** - Peredo-Videa Bernardo
- **Impacts of Climate Change on Forests in Europe – A Review of the State of Knowledge in Different European Regions -**Lindner Marcus, Garcia-Gonzalo Jordi, Kolström Marja, Netherer Sigrid and Schopf Axel
- **Nurturing Water and Protecting Soil Through Forest Cover – A Case Study from India -** Sharma S. K.
- **Impacts of Climate Change on Hydrological Ecosystem Functions in Mesoamerica** - Imbach Pablo, Locatelli Bruno and Guillermo Molina Luis
- **Climate Change Impacts on Goods and Services of European Mountain Forests – A Review** - Maroschek M., Seidl R., Lindner M., Garcia-Gonzalo J. and Lexer M.J.
- **Protection Forest and their Vulnerability in Europe: A First Approach for Harmonized Large Area Mapping in Alpine Area** - Reithmaier L.M., Casalegno S. and Fernándes-Rosa V.L.
- **Impacts of Climate Change on Landslides and Using Vegetation as an Adaptation Option to Reduce the Landslide Risk** - Santoso Heru, Hairiah Kurniatun, Tohari Adrin, Soedradjat Gatot M., Herawati Hety

Associated posters:

- **Valorisation of the Fauna Communities in the Algerian Forests: Case of the National Park of Belezma (Algeria, North Africa) –** Chenchouni Haroun, Righi Yassine, Si Bachir Abdelkrim and Hamchi AbdelHafidh
- **Forest Conservation in the Climate Change: The Case Study of Puglia Region – Italy** - Carella Rocco
- **Genetic Consequence of Human Impact on Diversity and Response to Climate Change in Two Tropical Tree Species with Contrasting Successional Status** - Akinnagbe A., Gailing O. and Finkeldey R.
- **Analyses of Adaptation Strategies of Forest-Forming Tree Species and Forest Stands Based on Reconstruction of Their Post-Fire Successions** - Nazimova D.I., Drobushevskaya O.V., Kofman G.B. and Konovalova M.E.
- **Managing True Mangroves: Are Bird Pollinated Taxa the Most Vulnerable to Climate Changes?** - Nagarajan B., Pandiarajan and Krishnamoorthy M.
- **Climate Change and *Araucaria angustifolia* Bert O. Ktze Conservation Strategy -** Silveira Wrege Marcos, Victoria Higa Rosana Clara, Miranda Britez Ricardo, Aparecida de Sousa Valderês, Caramori Paulo Henrique, Braga Hugo José and Radin Bernadete
- **Studying the relationship of forest cover and run off volume from precipitation Geographic Information System (GIS) -** Maskani Jifroudi Hamid Reza, Meraji Ali, Haghyghy Khomami Maryam, Dazeh Leila, Hossein Firoozan Amir

Abstracts accepted but not presented:

Restoration for the Future: The Challenge from Global Change - Stanturf J.A., Madsen Palle, Löf Magnus and Liu Yongqiang

Session 8 – Socio-Economic Functions and Livelihoods

Oral Presentations:

- **Factors Affecting the Role of Urban and Peri-Urban Forests in Adaptation to Changing Climatic Conditions in Khartoum State, Sudan** - Rahamtalla Hamad Ibrahim
- **Climate Change, Non-Timber Forest Products and Rural Livelihood: A Study in the Drought-Prone District of West Bengal** - Basu Jyotish Prakash
- **Integrated Forest Management for Restoration of Ecosystem Services and Rural Livelihood Security in Himalaya, in View of Impacts of Climate Change** - Tiwari Prakash C.
- **Balancing Livelihoods Needs for Adaptation and Reducing Carbon Emissions from Forests: Case Study of Community Forestry in the Cameroon Forest Policy Reform** - Bele M.Y., Jum C. and Nkem J.
- **Mitigation and Adaptation Potential of Agroforestry: Adaptation Implications and Policy Options for Meeting Challenges of Sustainable Livelihoods and Environmental Sustainability -** Saxena Vivek
- **Impacts of Climate Change on Forest Recreation and Tourism and the Livelihoods of Communities that Depend on this Industry -** Dimond Alison T., Brown Perry and Freimund Wayne
- **Adaptation of Forest Management among Small-Scale Private Forest Owners** - Blennow Kristina
- **Effects of Land-Use and Climate Changes on the Mount Marsabit's Forest Ecosystem, Kenya** - Adano Wario R.
- **Role of Community-Based Forest Management to Address Climate Change Problem: A Case of Nepalese Community Forestry -** Dhakal M. and Masuda M.
- **Land-Use/Land-Cover Change, Deforestation and Food Insecurity in Ethiopia** - Garedew E., Sandewall M. and Söderberg U.
- **Climate Variability and Change in North-Western Bangladesh: Role of Smallholder Agroforestry in Adaptation to Desertification -** Alam M.
- **Contribution of Farmer-Managed Tree Natural Regeneration to Environmental and Climatic Risks Minimization in the Sahelian Part of Niger (West Africa)** - Larwanou M., Illiassou M. and Moustapha M.A.
- **Towards Developing Options and Indicators on Community-Based Sustainable Management of Forest Resources in the Era of Climate Change - Case Study From Orissa, India** - Ojha Nabaghan

Associated Posters:

- **Community-Based Forest Management: A Case Study of Wuda-Taye Forest Reserve, Nigeria** - Aneni T.I. and Okali D.U.
- **Finding the Deforestation, Energy and Food Security Nexus: Is a PCD Approach to Adaptation the Link?** - Muller J. and Sparks D.
- **The Socio-Economic Impact of Industrial Plantation Programmes on Rural Livelihood: A Case Study of Communities in Forest Reserves in Nigeria** - Afolabi O.R. and Onyekwelu, J.C.
- **Community-Based Activities in Disaster-Prone Upland Areas as a Means of Adapting to a Changing Climate in The Philippine Countryside** - Sanchez P.A.J. Lasco R.D. and Espaldon M.V.O.
- **Climate Change, Resettled Communities, Forest Resources Conservation and Livelihood Options around Kafta-Sheraro Forest Reserve, Tigray Region, Ethiopia** - Eniang Edem A., Mengistu Genet F. and Yidego Teshale
- **A Battlefield for Forests: An Actor-Oriented Analysis for Studying Local Institutions and the Deployment of Ecosystem Services in Central Argentina -** Rodríguez-Bilella P.
- **Impact Assessment of Climate Change on Fuelwood Production and Utilization in Ghana: An Essential Tool for Adaptation** - Tekpetey S.L., Frimpong-Mensah Nana K. and Idinoba M.

Session 9 – Innovative Management and Policy Approaches to Climate Change Adaptation

Oral Presentations:

- **Adapting Forest Ecosystems to Climate Change: Implications for Participatory Learning and Action Research Platforms in Bridging Forest Science-Policy-Practice Interfaces -** Idinoba P.A., Defoer T., Idinoba M.E. and Nkem J.
- **Adaptation to Climate Change in Certified Forests – The International Trade in Timber and Adaptive Forest Management** - Nsoh Walters
- **Mainstreaming Climate Change Adaptation in Forest and Natural Resources Management in The Philippines: The Role of Local Governments -** Lasco R., Jaranilla-Sánchez P., Delifino R. and Rangasa M.
- **"Forest Development Types"- Developing Adaptive Forest Management in a Science-Stakeholder Dialogue** - Larsen J. Bo
- **Alternatives for Deforestation Reduction in the Legal Amazonian** - Shiota Montandon Erika and Simões Andre Felipe
- **Possibility of Adopting REDD Principle in the Context of Nepal –** Oli Bishwa Nath
- **Adapting to Climate Change on National Forests in the United States** - Blate Geoffrey M.
- **Forest Policies: Vulnerability and Adaptation in the Forest Sector in India -** Murthy I. K. and Ravindranath N. H.
- **Role of Protected Forest Areas in Adaptation to Climate Change: WWF's Perspective** - Mansourian Stephanie and Belokurov Alexander

Associated Posters:

- **Sustainable Forest Management Systems within Rural Communities of the North-West Province of Cameroon, Strong Strategic Approaches for Climate Change in Sub-Saharan Africa** - Achu Awa Walters
- **Guideline for Climate Change Vulnerability Assessment of Forest Ecosystem Services in Adaptation of Water Resources in West Africa** - Coulibaly Yacouba Noël, Idinoba Monica, Verbeeten Elke and Nkem Johnson
- **Counteracting Desertification and Bushfires Through Reforestation: The Case of Zion Hill, Saint-Vincent and The Grenadines -** Poyer Joel and Ramessar Candice R., MSc.
- **Adaptation to Climate Change in Forest Ecosystems Affected by the Poor –** Robledo Carmenza, Blaser Jürgen and Clot Nicole
- **Italian Forestry Measures Introduced through the New Challenges of the European Silviculture** - Romano Raoul and Cilli Stefano

Session 10 – Climate Change and Forest Sector Adaptive Capacity

Oral Presentations:

- **Adapting to Change: Forest Tenure in Canada's Boreal Plains Ecozone -** Hesseln Hayley, Johnston Mark, Weseen Simon and Williamson Tim
- **Adaptation Measures to Changing Climate in Different EU Countries** - Kolström Marja, Lindner Marcus, Garcia-Gonzalo Jordi, Delzon Sylvain and Kremer Antoine
- **Canada's Forest Sector Capacity to Adapt: The Need for Increased Levels of Innovation** - Van Damme Laird, R.P.F.
- **Adaptive Capacity in Publicly Owned Forest Landscapes: Forestry Institutions in Canada** - Johnston Mark, Williamson Tim and Hesseln Hayley
- **Adaptive Capacity in Forest-Based Communities** - Williamson Tim B.
- **Sustainable Development through Building Adaptive Capacity: The Model Forest Circumboreal Initiative** - Svensson Johan and Majewski Przemyslaw

Abstracts accepted but not presented:

- **New Institutional Analysis and the Adaptive Management of Climate Change: Implications for the Forestry Industry and Forestry-Based Communities** – Matthews Ralph
- **Resilience and Adaptation in Communities in Alaska -** Kruger Linda E.

Session 11 – Tropical Forest Management and Climate Change Adaptation

Oral Presentations:

- **The TroFCCA Policy Research Framework on Actors, Decision-Making and Policy Networks** - Brockhaus M., Vignola R., Santoso H., Sanchez P., Siagian Y. and Lasco R.
- **Impacts of and Adaptation to Climate Change of Forest Biodiversity in The Philippines** - Pulhin Florencia B. and Lasco Rodel D.
- **Using Forest Ecosystem Goods and Services for Climate Change Adaptation in Burkina Faso and Ghana: Policy Gaps and Constraints** - Kalame Fobissie B., Brockhaus Maria, Nkem Johnson, Idinoba Monica and Kanninen Markku
- **Tropical Forest Values and Vulnerability to Climate Change** - Nkem J.N. and Locatelli B.
- **Estimating Deforestation and Forest Degradation in Sri Lanka – A Pilot Project of a Potential REDD Mechanism** - Mattsson Eskil, Ostwald Madelene, Nissanka S.P. and Achard Frédéric
- **Impact of Climate Change on Distribution and Performance of Tropical Pine Species in Central America and Southeast Asia** - van Zonneveld M. J., Jarvis A., Dvorak W., Koskela J., Vinceti B. and Snook L.
- **Climate Change Considerations in Management of Mangrove Forests: Review and Recommendation for Sundarbans Reserve Forest, Bangladesh -** Khan M.S.I.
- **The River Between: Innovative Fringing Forest Management in Response to Climate Change by Two Communities Lying Across the White Volta River** - Atibila J. M.
- **A Framework for Vulnerability Assessment of Non-Timber Forest Goods for Planning Adaptation to Climate Change and Variability in West Africa** - Idinoba M.E., Nkem J., Kalame F. and Coulibaly Y.
- **The Use of Indigenous Knowledge in Monitoring and Prediction of Climate Change and Seasonal Cycles among the Local Communities in Kenya** - Mhando Nyangila Jacob
- **Exploring Forest Management Solutions in Traditional Knowledge System to Address Climate Change Issues** - Rijal Arun
- **Coping with Climate Change: How Local Communities Use Traditional Knowledge in Rural Ghana** - Gyampoh, B. A., Amisah, S. and Idinoba, M.

Associated Posters:

- **Forest Assessment for Improved Mangrove Forest Management in Kenya** - Lang'at J.K.S., Kirui B., Kairo J.G. and Bosire J.O.
- **Traditional Knowledge on Adaptation to Climate Change with Reference to Woody Species Composition and Socio-Economic Roles of Traditional Agroforestry Practices in South Eastern Langano, Oromiya, Ethiopia** - Asfaw Biruk, Lemenih Mulugeta and Achalu Negussie
- **Climate Change and Indigenous Coping Responses in West Africa** – Cobbinah J.R.
- **Assessing Indigenous Knowledge for Evaluation, Propagation and Conservation of Indigenous Multipurpose Fodder-Trees Towards Enhancing Climate Change Adaptation in Northern, Ethiopia** - Eniang Edem A. and Balehegn Mulubrhan

Session 12 – Genetic and Physiological Adaptation to a Changing Climate

Oral Presentations:

- **Genetic Structure of *Albizia gummifera*: Implications for Restoration in East Africa and Madagascar** - Nantongo J.S., Okullo J.B.L., Eilu G. and Cavers S.
- **Tree Breeding In A Changing Environment: Genetic Gain and Environmental Canalization** - Waldmann Patrik
- **Use of Genetic Variation in Forest Trees to Adapt to Changing Climate** - Wang Tongli, Hamann Andreas, Aitken Sally, O'Neill Greg, Yanchuk Alvin and Spittlehouse Dave
- **The Impacts of Tree Improvement Programmes on Forest Health: The Past Models, and Future Approaches Needed in Changing Climates** - Yanchuk Alvin and Allard Gillian
- **Chilling Requirements of Ash (*Fraxinus excelsior* L.) and Climate Change** - Clark J.R., Cahalan C., Boshier D., Gosling P. and McCarten D.
- **Temporal and Spatial Variation of Flowering Among *Pinus nigra* Arn.Clones Under Changing Climatic Conditions** - Alizoti P.G., Kilimis K. and Gallios P.
- **Effect of Warm Winter Temperatures and Genotype on Budburst of Douglas-Fir** - Harrington C.A., St. Clair J.B. and Gould P.J.
- **Increasing the Resiliency and Carbon Sequestration Potential of Gulf Coast Forests in the United States** - Johnsen K.H., Butnor J.R., Kush J.S., Nelson C.D. and Schmidtling R.C.
- **Genotype X Silviculture Interactions on Productivity and Carbon Allocation in Young Loblolly Pine Plantations** - Maier C.A., Johnsen K.H., Pritchard S., Tyree M., Seiler J. and Dougherty P.
- **Approaches to Determining Appropriate Provenances for Future Climates** - St. Clair J. Bradley, Howe Glenn T. and Wang Tongli

Associated Posters:

- **Immediate Genetic Changes in Tree Deployment and Breeding Because of Global Warming** - Lindgren D.
- **Winter Temperature Rising in Cold Mediterranean Areas: a New Chance for the Evergreen Oak Species?** - Corcuera L., Peguero-Pina J.J. and Gil-Pelegrín E.
- **Chloroplast DNA (cpDNA) Variation of *Shorea leprosula* in Indonesia Assessed by PCR-RFLP** - Siregar I.Z., Resmisari R.S. and Siregar U.J.
- **Early Response to Drought of *Pinus pinaster* Aiton Clones -** Velasco-Conde T., Feito I., Aranda I., Alía R. and Majada J.

Session 13 – Forest Dieback and Mass Mortality: Assessments and Early Warning

Oral Presentations:

- **The Challenges of Assessing Climate Change Vulnerability Using an Ecosystem Approach -** Murdiyarso Daniel, Santoso Heru and Idinoba Monica
- **Early-Warning Detection and Assessment of Drought-Induced Dieback and Mortality of Aspen (*Populus tremuloides*) Forests in Western Canada -** Hogg E.H. (Ted), Michaelian M., Hall R.J. and Arsenault E.J.
- **Monitoring Vegetation Phenology and Biophysical Variables Using MODIS Products -** Kang Synkyu, Jang Keunchang, Kim Sohee and Lee Bora
- **Wildland Threat Assessment and Monitoring Systems on National Forests in the USA -** Beatty J.S. and Ager A.A.
- **Monitoring Insect Defoliation of Forests by Means of Laser Scanning and Hyperspectral Imagery -** Lyytikäinen-Saarenmaa P. and Holopainen M.
- **Climate Change in the Congolese Dense Forest -** Tsalefac M. and Manetsa R.V.
- **The Deterioration of the Atlas Cedar (*Cedrus atlantica*) in Algeria -** Chenchouni Haroun, Si Bachir Abdelkrim and Briki Athmane
- **Increased Decline of Korean Fir Forest Caused by Climate Change in Mountain Halla, Korea -** Lim J.-H., Chun J.H., Woo S.Y. and Kim Y.K.

Associated Posters:

- **Relationships Between Forest Fine and Coarse Woody Debris Carbon Stocks Across Latitudinal Gradients in the United States as an Indicator of Climate Change Effects -** Woodall C.W. and Liknes G.C.
- **Carbon Pools and Fluxes for United States Forest Ecosystems and Products: Results of the USDA Forest Service National Sustainability Report -** Woodall C.W., Skog K.E., Heath L.S., Smith J., Perry C.H. and Piva R.
- **Locating Forest Field Experiments According to Present and Future Climate -** Karlsson, K.
- **Bioclimatic Classification for Climate Change Impact Assessment: Implication for Forest Conservation -** Kim T.K., Yoo B.H., Kim M., Lee J.H., Lee S.M and Lee S.J.
- **Estimation of Evapotranspiration Using MODIS Products at Flux Measurement Sites in Northeast Asia -** Jang Keunchang, Kang Sinkyu and Kim Joon
- **Climate Change and Forest in Morocco: Case of the Decay of the Cedar in the Atlas Mountains -** Adil Said
- **Extensive Mortality of Spruce Forests in Arkhangelsk Region: Satellite Image Analysis -** Kauhanen H., Wallenius T., Kuuluvainen T., Aakala T. and Mikkola K.

Session 14 – Forest Dieback and Mass Mortality: Monitoring and Mitigation of Consequences

Oral Presentations:

- **Climate-Induced Forest Dieback: A Global Overview of Emerging Risks** - Allen Craig D.
- **Means of Combating Forest Dieback – EU Support for Maintaining Forest Health and Vitality** - Requardt Aljoscha, Köhl Michael and Schuck Andreas
- **Monitoring Large-Scale Tree Mortality in the United States of America** - Tkacz Borys
- **Canadian Experiences in Large-Scale Monitoring of Climate-Related Disturbances Causing Forest Dieback and Mortality** - Hogg E.H. (Ted) and Kurz Werner A.
- **Assessment and Management of High Conservation Value Forests in the Context of Mass Forest Mortality** - Shchegolev A.A.
- **National Programmes on Monitoring and Minimization of Consequences of Forest Mortality** - Kobelkov Mikhail

Session 15 – Scenarios and Modelling for Forest Management Planning

Oral Presentations:

- **Identifying Forests Susceptible to Climate Change by GIS-Based Forest Site Classification** - Asche Norbert and Schulz Rainer
- **Sustainable Forest Management under Climate Change: Adaptation Strategies Based on a Comprehensive Vulnerability Assessment** - Seidl R., Rammer W. and Lexer M.J..
- **A Decision Support System to Deal with the Effects of Climate Change on Forests in Southwest Germany** - Hanewinkel Marc and v. Teuffel Konstantin
- **Climate Change Adaptation for Forestry in Western Canada: A Sensitivity Analysis of Model Predictions** - Mbogga Michael and Hamann Andreas
- **Projected Forested Landscapes Uncertainties and Their Sources of Uncertainty** - Gertner George and Xu Chonggang
- **European Scale Forest Resource Modelling at High Resolution Based on Inventory Data** - Nabuurs V., van den Wyngaert V., Hengeveld G. and Schelhaas M.J.
- **Modelling Impacts and Assessing the Willingness to Adapt to the Impacts of Climate Change in Western Canada** - Innes J.L., Nitschke C.R. and Ogden A.E.
- **Climate Change Scenarios for Argentinian Forest and Protected Areas** - Fernández L.C. and Alcobé F.
- **Regional/Country Scale Forest Resource Simulation in a Changing Environment** - Tomé Margarida, Barreiro Susana, Tomé José, Marto Marco, Soares Paula, Faias Sónia
- **Combining Species Suitability Models and Expert Knowledge to Underpin Policy Development for Scottish Forests in a Changing Climate** - Ray D. and C. P. Quine C.P.
- **How to Integrate Natural Risks into a Simple Decision Model for Forest Production** - Staupendahl Kai and Möhring Bernhard
- **Designing Adaptive Strategies for Forests Under Climate Change Using Risk Management** - Hanewinkel M. and Hummel S.
- **Adaptation of Forest Management in Brandenburg: Challenges in a Climate Change 'Hotspot' of Germany** - Spathelf P. and Bolte A.
- **The Role of Pest Insect Damages in the Development of Regional Forest Resources Under Changing Climate** - Matala J., Niemelä P. and Nuutinen T.

Associated Posters:

- **Sketching Future Semi-Evergreen Forest of Bangladesh Considering Climate Change Scenarios and Adaptation** - Al-Amin M. and Khanam C. Sultana
- **Adjustment of an Empirical Growth and Yield Model to Account for Effects of Climate Change on Forest Production** - Freeman M., Wikström P. and Elfving B.O.
- **Using Resilience Theory to Understand and Manage Pine Ecosystem Dynamics in an Era of Rapid Climate Change** - Campbell E.M., Haeussler S. and Nitschke C.R.
- **Impact of Land-Use and Climatic Changes on Pulpwood Production and Carbon Sequestration Sustainability at the Landscape Level** - Soares P., Tomé M., Borges P., Marques S. and Borges J.G.
- **Forecasting Mangrove Forest Response of the Florida Everglades to Sea-Level Rise Under Climate Change -** Doyle Thomas W. and Krauss Ken W.
- **Using GFIS and Other New Technologies for Effective Communication and Sharing of Forestry Information Across Disparate Networks in the Global Community** - McCracken R.D., Stanturf J.A. and Mikkola E.
- **Continuous Tree Cover Forests and Continuous Cover Forestry in Sweden** - Axelsson Robert

Session 16 – The “Swedish Model” as a Tool for Global Carbon Mitigation

Oral Presentations:

- **Can Experiences of Carbon Sequestration in Swedish Forests over the Past Century Be Replicated?** - Holmgren Peter
- **Swedish Forests – Historical Development and Plausible Scenarios for the Next Century** - Ståhl Göran
- **The Potential for Global Carbon Uptake by Using Swedish Forestry Practice** - Örlander Göran
- **Uptake of Carbon in Swedish Forest Ecosystems** - Olsson Matts

Session 17 – Opportunities for Combining Adaptation and Mitigation Objectives

Oral Presentations:

- **Integration of Climate Adaptation and Mitigation Measures is Co-Beneficial for Forest Development** - Gevorgyan Artur
- **Tropical Forests, Water and Carbon Sequestration: Exploring the Opportunities to Link Mitigation and Adaptation to Climate Change** - Murdiyarso Daniel, Malmer Anders and Ilstedt Ulrik
- **Prospects of Afforestation and Reforestation (A/R) Projects in India for Mitigating Climate Change** - Haque M.S. and Karmakar K.G.
- **Optimizing Timber Supply and Carbon Sequestration Planning for Future Spruce Budworm Outbreaks in New Brunswick, Canada** - Hennigar Chris R. and MacLean David A.
- **Biomass Energy and Carbon Sequestration Potential of Wastelands in India** - Ostwald M., Ravindranath N.H., Palm M. and Berndes G.
- **Can Forest Mitigation Strategies also Address Adaptation Objectives?** - Kurz Werner A.
- **Guyana's Proposal for Global Climate Change Adaptation and Mitigation: The Jagdeo Climate Change Initiative** - Caesar John C.
- **Impact of Carbon Trading on Forest Management in New Zealand** - Manley Bruce and Maclaren Piers

Associated Posters:

- **The Forestry Sector of Bangladesh in Global Warming Mitigation: The Future Approach to Forestry Practice** - Miah Md. Danesh and Shin Man Yong
- **Reduced Emissions from Deforestation and Degradation (REDD): A Revenue Source for Natural Forest Management by Communities in Vietnam** - Neupane P.R.
- **Carbon Sequestration in Broad-Leaved and Korean Pine Mixed Forests by Different Harvesting Practices in Changbai Mountain, Northeast China** - Dai L.M., Zhong L., Zhou L. and Yu D.P.
- **Yield and Carbon Sequestration Potential of Wheat-Poplar Based Agri-Silvicultural System** - Chauhan S.K., Sharma S.C., Beri V., Ritu, Yadav S. and Gupta N.
- **Chances and Challenges for a Resource-Depending Society to Mitigate Negative Impact of Forest Loss Through Climate Change (REDD) Support Mechanisms** - Weyerhaeuser Horst, Phengvichith Vanthong and Badenoch Nathan
- **Developing Community Forestry Management For Mitigating Climate Change Impact In Indian Himalayan Region** - Tewari Ashish, Singh Vishal, Tewari Pankaj and Phartyal Pushkin
- **Improving Soil Carbon Accumulation through Integrated Soil Fertility Management** - Yeboah E. and Sohi S.P.
- **Promoting the Plantation of Trees with Low-Density Wood as a Strategy to Reduce Forest Degradation in Indonesia** - Karlinasari L. and Nugroho N.
- **Modelling Carbon Assimilation for An Ontario Boreal Spruce Plantation – Canadian Carbon Program (CCP)** - Reynolds Phillip E. and Brand Gordon
- **Modelling Carbon Assimilation for Boreal Jack Pine Plantations – Ontario Long-Term Soil Productivity (LTSP) Study** - Reynolds Phillip E. and Brand Gordon
- **A Strategic Approach to Ensure Sustainable Management of Forest Resources of Cameroon to Climate Change** - Ngono Grégoire
- **Climate Change Mitigation: Influence of Genetic Stock and Spacing on Carbon Sequestration** - Amanulla B.K.M., Vidyasagar G. and Ramakrishna Hegde

Session 18 – Wood as a Green Building Material

Oral Presentations:

- **The Convenient Truth -** Labbé Sylvain
- **LCA Analysis of Timber House Construction in Japan Focusing on Calculating $LCCO_2$ in Basic Materials -** Kawanabe A., Akita N., Seike T., Iijima Y. and Tarata K.
- **Why Wood Is Key to Green Building –** Beauregard Robert, Morency Pierre-Olivier and Bouthillier Luc
- **A New Zealand Supply Chain Research Strategy for Green Buildings and the Potential Impact on Climate Change –** Nebel Barbara and Love Simon
- **Project MIKADO – Documenting the Environmental Properties of Wood Products (in Norway) –** Svanæs J., Folvik K. and Wærp S.
- **Low-Energy Wood-Framed Buildings Heated with Bio-Based CHP Plants** - Gustavsson Leif and Sathre Roger

Abstracts of Oral and Poster Presentations

Arranged in Alphabetical Order of First Author's Family Name

SUSTAINABLE FOREST MANAGEMENT SYSTEMS WITHIN RURAL COMMUNITIES OF THE NORTH-WEST PROVINCE OF CAMEROON, STRONG STRATEGIC APPROACHES FOR CLIMATE CHANGE IN SUB-SAHARAN AFRICA

Walters Achu Awa[1]

Human actions on forests, such as uncontrollable harvesting of medicinal plants, felling of trees, farming, bush fires and local bee farming practices like generating smoke to drive away bees from a hive by burning fresh leaves of plants, provide negative effects on climate. This paper presents an analysis of the scientific evidence, indicating that negative influence on forests is affecting the climate in Cameroon. Sea levels are rising; rainfall has decreased by 11%, early rains, increased temperatures and flooding. The paper identifies strategic approaches that are practised in tackling forest management and climate change in Cameroon. Examples are: tree planting, renewable energy, solar powers, water powers, etc. It describes also, generated land use systems, forests conservation methods and farming techniques, which influence climate change and the health of the forest positively.

The concept of indigenous ecosystem and forest management systems used in this paper refers to the series of practices based on agreed rules, carried out by the local people, aiming at the sustained availability of products and services from trees, crops and forests through sustainable development for climate change. Local populations surrounding these forests understand the education of community forestry, taking an active leading role in preserving and protecting the forests, in order to ensure long-term benefits and stop the ill effects of climate change in the society.

The paper concludes that this project is building these capacities in collaboration with various stakeholders in the localities for the healthy conservation of forests and monitoring of changes in the climatic conditions of the areas. Forests management and monitoring plans are carried out using participatory methods and are designed to meet the needs of the communities and their families, while at the same time maintaining sustainable biodiversity and climate change functions.

Key words: biodiversity, climate, management and sustainability.

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ID-011

EFFECTS OF LAND-USE AND CLIMATE CHANGES ON THE MOUNT MARSABIT'S FOREST ECOSYSTEM, KENYA

Wario R. Adano[1]

Indigenous forests in Kenya have faced a serious threat of destruction in recent years. Policies to conserve critical forest ecosystems exist, and ecosystems' support of local livelihoods is well understood. Yet evidence linking forest ecosystem functions and their vital hydrological services are lacking. This paper assesses the impacts of rainfall trends and agriculture on the watershed protection function of a sub-humid montane forest on Mount Marsabit in Northern Kenya. Household surveys and historical data are used to assess functions of the forest ecosystem. Analysis of rainfall data reveals reduced precipitation and increased drought years since the 1970s. Farmers' recent growing of horticultural crops using a drip irrigation system harnessed from within the forest area is an innovative adaptive response. The removal of vegetation-cover on the mountain causes modification and fragmentation of the forest habitat, simultaneously endangering ecosystem health and dependent livelihoods. A model relating farmland expansion and climate change to the forest-based urban water production predicts a decreased hydrological service and constrained water-yields for urban uses. The diminishing forest services harm the pastoralists living in the surrounding arid rangeland who fall back on the mountain resources during dry seasons. The model captures jointly delivered public benefits of conservation efforts. Any alterations in the forest composition as land-use changes may signal a warning for conservation agencies and policy-makers alike. Contrary to the current policies and practices, the conservation of montane forests in ecologically sensitive areas requires priority within conservation efforts.

The paper provides empirical evidence of ecosystem functions that challenges the ongoing forests destruction in favour of an integrated conservation and management of wider-ecosystems in the future. There are potential gains in reconciling conservation efforts and local community needs to achieve an equitable and wise use of forest resources.

Key words: climate, land-use, montane forest, water-yields model, Kenya.

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ID-142

CLIMATE CHANGE AND FOREST IN MOROCCO: CASE OF THE DECAY OF THE CEDAR IN THE ATLAS MOUNTAINS

Said Adil[1]

Morocco has a significant forest extending more than 9 million hectares. Meteorological observations during the last three decades have shown irregular and weak precipitation patterns and high temperatures. Violent thunderstorms are concentrated in time, leading to a pattern of droughts and floods (Ourika valley, 1995, Tetouna, 2000, Mohamedia, 2002), accompanied by the degradation and desertification of lands. An increase of the temperature and a decrease of the precipitation can cause forest dieback. Dieback, although caused by drought, is accompanied by parasitic epidemics, an increase of the risk of forest fire, a decrease in the success of natural regeneration and low rate of success of plantations. Dieback results in an erosion of plant and animal biodiversity and an increase of the risk of water and wind erosion.

The stands of the Atlas cedar (*Cedrus atlantica)* are multifunctional and multi-use resources for the local populations. However, observations over the past few years have shown a strong incidence of cedar dieback across its range in Morocco. In response to this situation, a multidisciplinary project was launched to understand the causes of the dieback and the dynamic relationship among factors (permanent, accelerators and aggravating factors) that contribute to this phenomenon. The project involved a diversity of disciplines, including dendrochronology, ecophysiology, soil science, entomology, phytopathology, forest inventory and management, biometry and mapping through Geographic Information Systems (GIS).

Results of this study will be presented, as well as elements of a national strategy that will consider potential actions to be carried out in the short, medium- and long-terms within a perspective of adaptation to climate change.

Key words: Atlas Mountains, *Cedrus atlantica,* climate change, decay, Morocco.

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ID-116

THE SOCIO-ECONOMIC IMPACT OF INDUSTRIAL PLANTATION PROGRAMMES ON RURAL LIVELIHOOD: A CASE STUDY OF COMMUNITIES IN FOREST RESERVES IN NIGERIA

O.R. Afolabi[1] and J.C.Onyekwelu[2]

The dominant mechanism through which climate changes had been attributed over the years to human activities. Evidence has shown that human activity such as deforestation contributes significantly to global warming among others. Policy on plantation establishment and enforcement of bye-law on indiscriminate cutting of forest products are seen by many experts as a panacea via which global warming could be effectively curtail in tropical region of the world. Hence, it is often hypothesized that afforestation will improve the livelihood of the inhabitants.

This study was carried out to assess the socio-economic impact of industrial plantation programme on livelihood of inhabitants in forest reserves in Nigeria. A total of 100 inhabitants from forest reserves in two states (Ondo and Ogun) were used for the analysis. The result of the analysis shows that afforestation program contributes immensely to the socio-economic well being of the inhabitants in term of provision of good roads with about 22km and 53km in Ondo and Ogun States forest reserves respectively. Employment generation for the inhabitants shows that over 27% and 70% of respondents were employed in Ondo and Ogun states. Also about 69% and 89% were permitted to practice *taungya* farming in the plantation site of both plantation programmes respectively. Hence, it is evident that the afforestation program in both forest reserves improved the socio-economic growth of the inhabitants. While it is expected that afforestation will contribute to increased food supply through *taungya* farming in the long run, it is also expected that such program will play a significant impact in minimizing Carbon dioxide emission in Nigeria.

Key words: Forest Reserves, socio-economic, afforestation programs, climate, Nigeria.

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ID-121

FOREST TREE COMPOSITION, FISHERIES AND WILDLIFE STATUS OF OMO BIOSPHERE FOREST RESERVE, OGUN STATE, NIGERIA

Y. Akegbejo-Samsons[1], W.O. Alegbeleye [1] and L.O. Ojo[2]

The vulnerability of most Commonwealth countries to climate change was identified almost 20 years ago. Large areas of the world's forests have been lost or degraded and landscapes everywhere are being simplified by current land-use practices and these actions are contributing to advance the havoc of climate change phenomenon in the developing countries.

This study was carried out in the Omo Strict Natural Reserve (SNR), the oldest and largest SNR in Nigeria, established in 1949 and internationally recognized in 1977 as a Biosphere Reserve. The status of the economic forest trees, fisheries and wildlife resources of Omo Biosphere reserve was assessed with a view towards highlighting the state of the diversity of these resources. *In situ* sampling of trees, fishes and wildlife resources was done. The data obtained were compared to existing data obtained in the last 15 years. Eight of the most economic valuable tree species were observed to be highly depleted and their population reduced by over 45% compared to data obtained 15 years ago. These include *Triplochyton scleroxylon, Nauclea diderichii, Entadrophagma cylindricum, Lophira alata* and *Celtic zenkeri*. Twenty-five fish families and 66 fish species were encountered, out of which 91% were freshwater species and 9% shellfish. There was a marked reduction (28%) compared to the data obtained 10 years ago. Over 31 mammalian fauna species, 8 reptiles and numerous avian species were enumerated. Among these were primates, bush bucks, duikers, squirrels, grass-cutter, and rodents. Reduction in animal population, especially primates, was high compared to the figure of 15 years ago. Occasional/ accidental bush burning, illegal felling and intrusion into the reserve by crop farmers and cattle herders were the major sources of anthropogenic dis-service in the reserve. The major river and floodplains including its tributaries, were observed to have shrunk by over 36% in the last 15 years while the SNR showed strong evidence of the ongoing impacts of climate change on terrestrial and freshwater species, communities and the ecosystems. The paper suggests a more comprehension monitoring programme that will control, eliminate and reduce human activities that trigger off climate change within and around the reserve.

Key words: climate change, forest, trees, fish, wildlife, management.

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ID-217

GENETIC CONSEQUENCE OF HUMAN IMPACT ON DIVERSITY AND RESPONSE TO CLIMATE CHANGE IN TWO TROPICAL TREE SPECIES WITH CONTRASTING SUCCESSIONAL STATUS

A. Akinnagbe[1], O. Gailing[2] and R. Finkeldey[2]

Since genetic diversity plays a critical role in the survival of populations in rapidly changing environments, it becomes important to investigate the impact of human practices on genetic diversity in tree species, especially in the tropics where deforestation rate is high. Such investigation will provide information on the potentials of trees to adapt to future change in environmental condition under adverse human practices. *Mansonia altissima* is a climax tree species, characteristically more abundant in closed forests, whereas *Triplochiton scleroxylon* is a pioneer tree species predominating in open forests. Using leaf samples collected from primary forest, logged forest, plantation, farmland and a geographically isolated forest patch, we analysed the effect of human impact on genetic diversity in these two species using Amplified Fragment Length Polymorphism (AFLP) markers.

The result showed contrasting consequences of human impacts for the two species. For *Mansonia altissima,* the highest genetic diversity was observed in the primary forest where there has been relatively little human impact (H_e = 0.062; PPL = 21.00; B_r = 1.204), while the lowest genetic diversity was found in the forest patch isolated from the primary forest by human activities (H_e = 0.032; PPL = 09.00; B_r = 1.089). Conversely, for *Triplochiton scleroxylon*, genetic diversity estimates were lowest in the primary forest (H_e = 0.249; PPL = 59.07; B_r = 1.211) and highest in the isolated forest patch (H_e = 0.277; PPL = 67.20; B_r = 1.625). Our results suggest that human impacts will decrease the potential of the climax tree species such as *Mansonia altissima* to adapt to changes in environmental conditions but will leave this potential unaffected or even increased in pioneer tree species such as *Triplochiton scleroxylon*.

Key words: AFLP, *Mansonia altissima*, *Triplochiton scleroxylon*, human impact, genetic diversity, tropical rainforest, adaptation.

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ID-105

CLIMATE VARIABILITY AND CHANGE IN NORTH-WESTERN BANGLADESH: ROLE OF SMALLHOLDER AGROFORESTRY IN ADAPTATION TO DESERTIFICATION

M. Alam[1]

Though Bangladesh is predominantly a riverine country, the north-western region is threatened by desertification. In addition to the environmental consequences, desertification is also threatening the livelihood of rural people. This is also one of the forest poor regions of the country. Hence, it is urgently required to increase vegetation cover through development of smallholder agroforestry traditionally adopted by rural people within their homesteads. This agroforestry system in drought-prone areas provides a healthy ecosystem for humans, animals, birds, livestock and miscellaneous flora and fauna. The present study has been conducted to explore the people's perception towards the trend of desertification and identify the role of smallholder agroforestry in adaptation to and mitigation of desertification.

A questionnaire survey among randomly selected householders, key informants' interview and expert level consultation had been administered throughout the study. Results of the study show that planting and maintaining trees and other plants around the living quarters is an age-old practice. In the absence of government forests, rural people are highly dependent on smallholder agroforestry to meet their demand for forest products, including timber, fuel, fruit and non-timber stuffs. The study estimated that about 85% of the timber and 90% of the wood fuel consumed in the area are produced in these agroforestry systems. The study found that the people hold various perceptions towards the trend of desertification in the study area. But they hold a common perception that smallholder agroforestry can play vital roles both in greening this drought-prone region and ensuring an alternative livelihood. The study concludes that household level coping and adaptation strategies may include livelihood diversification through intensification of traditional homestead agroforestry and massive homestead afforestation with indigenous species to increase tree cover. In view of the findings, national policies might focus on promotion of inhabitants' indigenous knowledge regarding environmentally-friendly agroforestry land use in drought-prone areas.

Key words: adaptation, smallholder agroforestry, desertification, livelihood.

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ID-206

SKETCHING FUTURE SEMI-EVERGREEN FOREST OF BANGLADESH CONSIDERING CLIMATE CHANGE SCENARIOS AND ADAPTATION

M. Al-Amin[1] and C. Sultana Khanam

Suitable forest tree species for the future (2050, 2100) will be sketched for semi- evergreen forests of Bangladesh using IPCC predicted climate change scenarios (temperature scenarios) for Bangladesh. Experiments carried out to choose environmentally, ecologically and economically viable forest tree species (indigenous and/or exotic) with intensive (day-to-day) management systems for above stated forest type of Bangladesh. The germination and initial growth performances of the seven economically important tree species of the stated forest type of Bangladesh: *Artocarpus chaplasha*, *Albizia lebbek*, *Albizia procera*, *Gmelina arborea*, *Switenia mahagoni*, *Terminalia arjuna* and *Terminalia belerica* were experimented in growth chambers and temperature regulated growth rooms using different climate change scenarios for 2050 and 2100.

The results depicted that germination of the seeds of the stated species were maintaining between 15% and 40% with high scenario, between 0% and 22% with mid scenario and between 3% and 53% with low scenario. However, the initial existence or growth of the seedlings showed alarming results, *i.e*. *Artocarpus chaplasha* may not withstand with the high scenario of the climate change and found better growth in mid-scenario than the low and high scenario. The research provides the methodologies regarding the germination techniques of seeds and nursery practices by means of experimentations for adapting climate change for future. Above all, the research suggested the choice of species for future using spatial data and experiment results on a GIS platform and presented with the interactive maps.

Key words: IPCC, climate change scenarios, germination, initial growth, forest tree species, Bangladesh.

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ID-043

CLIMATE CHANGE AND POLITICS OF FORESTS: UNDERSTANDING THE RELATIONSHIPS AMONG LAW, MARKETS, ENVIRONMENTAL COMMUNICATION AND GOVERNANCE - CASES FROM CHILE AND SWEDEN

Ferrari Cristián Alarcón[1]

This paper offers an analytical framework for understanding relationships among law, markets, environmental communication and forest governance, in relation to the emerging connections between climate change and politics of forests taking place in Chile and Sweden, two countries that have large and important forest sectors. The relevance of making such connections emerges, among other things, from an increasing body of research pointing out the conflicting objectives and goals concerning production originating in, and based on, the use and management of forests and tree plantations. Since such objectives and goals are connected to what the IPCC report (2007) denominates as societies' needs, there are a number of key and emerging political issues implicated in decision-making processes linked to forest sectors. Therefore, this project aims at developing those issues at a theoretical level, and in doing so, at understanding how law, markets, environmental communication and governance are related to, and developed within, specific politics of forests.

The work is divided into four sections. The first section reviews research findings about diverse goals for forestry production and different objectives of forest use and management within a context of climate change. The second section investigates the ways through which law, markets, environmental communication and governance can be placed within an analytical framework focused on forest sectors and their relations to climate change. The third section explains current dynamics, projections and discussions associated with the forest sectors in Chile and Sweden. The fourth section, uses the analytical framework developed in part II to detail how climate change is incorporated into the forest policies of both the Chilean and Swedish forest sectors.

Key words: climate change, politics of forests; law, markets environmental communication governance, Chile, Sweden.

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ID-369

UTILITY OF BIOLOGICAL EXPANSION FACTORS FOR ESTIMATING ABOVE GROUND COMPONENT BIOMASS OF *PICEA ABIES* L. KARST

Timothy J. Albaugh[1], Sune Linder[2], Urban Nilsson[2], Tomas Lundmark[2], Johan Bergh[2],
H. Lee Allen[1] and Jeremy Flower-Ellis[2]

Biomass expansion factors are developed to estimate climate change effects on forests by providing landscape-level productivity estimates. However, application of these functions across the landscape implicitly rests on the assumption of non-significant site effects. To examine this assumption, we tested for site effects in component (stem, branch and foliage) biomass equations from two sites in Sweden (64° and 57° latitude) where four treatments (control, irrigation, fertilization, irrigation plus fertilization) were applied in extant Norway spruce stands (*Picea abies* L. Karst.) for 18 years and compared the site-specific estimates to those generated using two published functions. Site effects were significant for all components, indicating it would be unlikely to generate a single accurate component biomass equation across the Norway spruce range. Our hypothesis that the published functions would accurately estimate control plot component biomass was rejected. Additionally, the published functions did not compare well with the site-specific component biomass estimates for other treatments; both functions reasonably estimated stem mass up to 25 Mg ha^{-1} beyond which it was overestimated, and both functions over- and underestimated foliage and branch mass. The published functions did not compare well with each other, with stem, foliage and branch mass estimate differences of 12, 55, -8% and 11, 77 and 59% for the southern and northern sites, respectively, when averaged over all treatments and years. Adding limiting resources through fertilization increased stem, foliage and branch mass 57, 11, 18% and 120, 37 and 69% at the southern and northern sites, respectively, by the last year of measurement; thus increasing carbon sequestration and available bioenergy materials.

We recommend more effort in process-based modeling to better predict biomass at a given site and ultimately provide better estimates of the changes in carbon sequestration and bioenergy material production.

Key words: branch, fertilization, foliage, stem.

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ID-340

CLIMATE-SENSITIVE MODELING OF SITE-PRODUCTIVITY RELATIONSHIP

M. Albert and M. Schmidt[1]

The objective of this research project is to extend the well established single-tree growth simulator BWINPro to climate change using a climate-sensitive site-productivity model. This forest growth study is part of the joint research project "Adaptive Strategies on Sustainable Forest Management under Changing Climatic Conditions – Decision Support System Forest and Climate Change" by the University of Goettingen, the von Thuenen Institute and the Northwest German Forest Research Station.

The presented research project aims at (a) modeling the site-productivity relationship and (b) identifying optimum and critical site conditions. For (a), a generalized additive model is used to predict the change in site index as a function of site and climate variables. The effects of the single parameters on site index are quantified. At this point the model is parameterized for spruce (*Picea abies* (L.) Karst.) and beech (*Fagus sylvatica* L.) in Lower Saxony. It will be extended to other species and will cover the entire area of Germany. A first prediction shows the shift of site index under climate change. Identifying optimum and critical site conditions is necessary to derive silvicultural recommendations on the tree species' value of cultivation under climate change. Therefore, a 3D-ecogram is developed, mapping the productivity of species according to temperature in growing season, water available to plants in growing season and soil nutrients. As regards (b), quantile regression is applied, where the additive effects are modeled using regression splines. A prediction of the 10%-quantile of site index and defining an upper and lower limit of desirable productivity yields the optimum and critical site conditions.

Key words: climate-sensitive modeling, generalized additive model, quantile regression, site-productivity relationship, three dimensional ecogram.

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ID-218

TEMPORAL AND SPATIAL VARIATION OF FLOWERING AMONG *PINUS NIGRA* ARN. CLONES UNDER CHANGING CLIMATIC CONDITIONS

P.G. Alizot[1], K. Kilimis[1] and P. Gallios[1]

Flowering initiation, duration, fertility variation and total number of clones used to establish seed orchards were considered up to now as the most important factors affecting economically and genetically the seed crop. Change of climatic conditions is an emerging factor that could prove crucial regarding the flowering and synchronization among clones and thus, the quality and quantity of seed production. The temporal and spatial variation and the duration of flowering were studied in consecutive years in a *Pinus nigra* Arn. seed orchard. Sixty plus trees representing the distribution of the species in Northern Greece and nineteen ramets per clone were used to establish the seed orchard, following the honeycomb experimental design, in order to avoid kinship. Temporal variation among clones as well as spatial variation among ramets within clones, growing at different sites of the orchard were recorded concerning the male and female flowering initiation and duration. The majority of clones synchronized but there was a limited number of clones that were precocious or late flowering. Also, parental fertility differed significantly among clones and thus the parental gamete contribution in the seed crop also differed significantly. The pronounced variability in climatic conditions over years strongly affected the flowering and synchronization among clones, resulting in almost complete asynchrony during the most stressful year.

These results suggest that one of the effects of a warmer and drier climate may be the lack of flowering synchronization, as pollen shedding might be completed before female conelets reach the phase of receptivity, leading to the restriction of male parentage to a limited number of clones and thus, to the severe violation of the panmixia assumption, or even to fertilization failure. Final potential effects on the produced seed might be the reduction of the full seed percentage, as well as the limited genetic diversity in the seed crop.

Key words: climate change, flowering, synchronization, seed crop.

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ID-321

CLIMATE CHANGE IMPACTS ON FOREST HEALTH: FOREST DIEBACK

Gillian B. Allard[1]

Forest health is dependent on climate and associated processes, such as the abundance of insect pests and diseases and the frequency and duration of wildfires. Major changes in climatic patterns are occurring, such as increased temperatures, periods of drought, and frequency and severity of extreme climatic events. These climatic changes and their subsequent impacts on community processes have been increasing the physiological stress on trees and woody plants resulting in increased mortality and incidence of forest dieback. Examples are known from all regions of the world, such as the dieback of *Nothofagus* forests in Chile, *Juniperus procera* in the Asir highlands of Saudi Arabia, *Pinus sylvestris* forests in the Alps, *Pinus edulis* in the southwestern United States, and *Cedrus atlantica* in Morocco and Algeria.

Since these climatic changes are expected to continue in the future, such diebacks will alter forest ecosystem structure and function thereby impacting how forests are managed. Accurate models incorporating all the factors (predisposing, inciting and contributing) resulting in diebacks, such as temperature, drought, insect pests and pathogens, for example, may allow for predictions to be made which can help forest managers respond appropriately. Effective monitoring of diebacks is needed nationally, regionally and globally and there is a need for coordinated actions such as information sharing through either existing forest invasive species networks or through specific networks on the topic of diebacks.

Key words: climate change, dieback, forests.

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ID-382

CLIMATE-INDUCED FOREST DIEBACK: A GLOBAL OVERVIEW OF EMERGING RISKS

Craig D. Allen[1]

Global climate is recognized to be undergoing significant changes in recent years, with substantially greater shifts in climatic patterns projected for coming decades in many regions, including warmer temperatures and increases in duration and severity of extreme drought events. Such climate changes increase physiological stress on long-lived woody vegetation, directly leading to increased mortality and potentially episodes of rapid and extensive forest dieback when tolerance thresholds are exceeded. Such forest dieback may also be amplified by interactions with other disturbance processes, including climate-mediated changes in the distribution and population dynamics of insect pests, forest fragmentation, and increased fire activity. Forest stress and dieback are now becoming apparent in many parts of the world, particularly at species range margins and in semi-arid regions where trees are growing near their physiological limits. Examples of climate-related forest mortality are presented from all forested continents, including Australia, Europe, Asia, Africa, South America, and North America. The substantial forest mortality that has affected ~20 million hectares and many tree species since 1997 from Alaska to Mexico in western North America is highlighted. Assessing the potential for extensive climate-induced forest dieback is a key research topic, since woody plant mortality losses can occur much faster than tree growth gains, with pervasive and persistent ecological effects, including feedbacks to other disturbance processes (e.g., fire, erosion), loss of sequestered carbon back to the atmosphere, and altered biodiversity patterns.

This talk presents a current synthesis of climate-induced forest dieback risk as an emergent global phenomenon, including an international overview from ongoing research and the growing scientific literature. Also highlighted are physiological process drivers of woody plant mortality, information gaps to address for improved broad-scale modeling and prediction of forest dieback, and forest management strategies to foster incremental adaptation of current forests to ongoing climate changes.

Key words: climate change, disturbance interactions, forest dieback, global patterns.

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ID-136

CLIMATE CHANGE MITIGATION: INFLUENCE OF GENETIC STOCK AND SPACING ON CARBON SEQUESTRATION

B.K.M. Amanulla[1], G. Vidyasagar and Hedge Ramakrishna[2]

The concentration of atmospheric carbon dioxide (CO_2) is increasing, with much of the increase often being attributed to emissions from anthropogenic sources. Reduction of carbon dioxide concentration is one of the convenient methods of mitigation global climate change. Forests are considered as one of the important sinks for increased CO_2 which brought greater attention towards afforestation and reforestation activities as a means of removing CO_2 from the atmosphere. In the recent years, improved silvicultural and genetic techniques are being adopted to enhance the productivity of plantations. However, not much information is available on the influence of genetic stock and important silvicultural techniques on productivity and carbon sequestration.

The study was carried out in the clonal trials of *Eucalyptus urophylla* and *Acacia* hybrid established at the Mysore Paper Mills research plantations around Tirthahalli (Shimoga, Karnataka, India) with an objective of assessing the influence of genetic stock and spacing on productivity and carbon sequestration. The present paper discusses the productivity and carbon sequestration of different clones of *E. urophylla* and influence of different spacing on productivity and carbon sequestration of a single clone (*Acacia* hybrid). Estimated wood volume of different clones varied from 322.00 m^3 ha^{-1} to 542.80 m^3 ha^{-1} with mean annual increment of 53.67 m^3 ha^{-1} to 90.47 m^3 ha^{-1}. Estimated carbon stock in different clonal plantations was varied from 118.50 t ha^{-1} to 182.53 t ha^{-1} with a mean annual carbon sequestration of 19.75 t ha^{-1} to 30.42 t ha^{-1}. Influence of spacing on productivity and carbon sequestration was evident. Estimated productivity under different spacing varied significantly from 79.90 m^3 ha^{-1} to 183.10 m^3 ha^{-1} with mean annual increment of 13.32 m^3 ha^{-1} to 30.51 m^3 ha^{-1}. Similarly, carbon stored under different spacing regime varied from 19.98 t ha^{-1} to 45.77 t ha^{-1} with mean annual carbon sequestration of 3.33 t ha^{-1} to 7.63 t ha^{-1}.

Key words: carbon sequestration, clonal variation, productivity, spacing.

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ID-130

COMMUNITY-BASED FOREST MANAGEMENT: A CASE STUDY OF WUDA-TAYE FOREST RESERVE, NIGERIA

T.I. Aneni and D.U. Okali[1]

Global climate change, as a result of climate variability, has far reaching consequences. Nigeria is the most populous country in Africa with a population of over 140 million, and is presently under dire environmental stress with key indicators such as large rural small-holder farmer population and high dependence on natural resources. The objective of this study is to provide current baseline information on Community-Based Forest Management (CBFM) in Nigeria with a focus on experiences, lessons and future challenges. The methods used include a quantitative survey of inhabitants from sampled settlements in the reserve area. The data was aggregated along gender, generational and communal levels allowing comparisons on several dimensions. Specific uses of forest products by different groups, including vulnerable groups, were obtained. Assessments include paired needs ranking, community mapping and problem tree analysis. Climate change-induced desertification is considered to have a serious effect upon livelihood activities.

The residents surrounding the reserve are aware of the importance of appropriate use of the resources, but do not have the capability to abide by best management practices. Overall, climate change adaptation options for a sustainable CBFM strategy must have a sustainable livelihood focus. The local population can be taught how to establish community nurseries and raise seedlings. The livelihoods needs of the local population must be taken care of through the introduction of socially acceptable alternative income-generating activities such as aquaculture; establishment of woodlots and fodder banks; the formation and capacity building of local community caretaker groups is needed as well as benefits targeted to women's groups; institutional-strengthening is needed to improve the ability of the relevant organizations to provide an enabling environment for greater local involvement in forest management; improving the infrastructural base by providing educational, health facilities and stable water supplies would be a good incentive; and the enhanced productivity of existing activities through provision of agro-inputs or improved technologies.

Key words: climate change adaptation, desertification, forest management, livelihood focus.

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ID-028

IDENTIFYING FORESTS SUSCEPTIBLE TO CLIMATE CHANGE BY GIS-BASED FOREST SITE CLASSIFICATION

Norbert Asche[1] andRainer Schulz[2]

In any environment climatic and edaphic conditions form manifold mosaics of different sites and ecosystems. In this context the aim of forest site classification is to record, analyse and evaluate all site factors important to forest growth. Such factors include location, climate, bedrock, soil, vegetation and forest utilisation in historic times. Assessment of all relevant site factors allows for classification of forest areas into a set of forest site types with specific site conditions. In recent years, numerous studies have demonstrated that climate change and other environmental impacts contribute to the accelerated dynamic development of forest sites. Tree stands and ecosystems are thus forced to adapt to dynamically changing site conditions. Consequently, forest management will have to live up to the resulting challenge to continue to cater for the economic and ecological requirements of forest owners and then wider society. Developing new concepts of regional forest management adapted to climate change will be of key importance.

In this presentation, the potential impact of climate change on forest sites and site-adapted tree species will be discussed within the framework of forest site classification. Three scenarios have been calculated with the following climate parameters: increase of mean temperature by 1°C, mean precipitation by 10% (Klima 1), mean precipitation unchanged (Klima 2) and decrease of mean precipitation by 10% (Klima 3). Analysis of scenario results indicate the following forest site dynamics: (1) vegetation period will be extended 12 to 15 days, and (2) the moisture regime of specific sites will change, especially in areas with moisture classes fresh, slightly fresh and slightly dry. Using GIS technology, the spatiotemporal dimensions of scenario results can be visualised in map form allowing for further exploration of potential impacts of climate change on tree species and forest sites. Within the framework of current climate change debates, GIS-based methods of forest classification will be discussed in this paper to detect and evaluate the potential development of forests and site-adapted trees in selected regions of North-Rhine Westphalia, Northwest Germany.

Key words: climate change, scenarios, forest site classification, forest types

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ID-002

TRADITIONAL KNOWLEDGE ON ADAPTATION TO CLIMATE CHANGE WITH REFERENCE TO WOODY SPECIES COMPOSITION AND SOCIO-ECONOMIC ROLES OF TRADITIONAL AGROFORESTRY PRACTICES IN SOUTH EASTERN LANGANO, OROMIYA, ETHIOPIA

Biruk Asfaw[1], Mulugeta Lemenih[2] and Negussie Achalu[3]

Farmers' indigenous knowledge and maintenance of diverse plant species characterizes different forms of traditional agroforestry systems in Ethiopia. Nonetheless, very little of this knowledge has been recorded in the country. Such a basic knowledge of traditional use of vegetation by different socio-economic groups is necessary to support any strategy for adaptation to climate change.

This study was therefore conducted to fill this gap in knowledge on the diversity of woody plants maintained under different forms of traditional agroforestry management and their biophysical and socio-economic roles and benefits to household livelihoods across different Agro-Ecological Zones (AEZs) in south eastern Langano, Ethiopia. A total of 120 households were selected for this study, 30 from each of the four Peasant Associations (PA) located in different AEZs (lowland (1,540-1,680 m asl), transitional zone (1,680- 1,800 m asl), mid-altitude (2,100-2,300 m asl) and highland (2,740-2,800 m asl). A stratified random sampling technique was used, based on wealth categories of social groupings in each PAs. Both informal (RRA and PRA) and formal (questionnaire) survey methods were employed. For inventory of woody species diversity within traditional agroforestry systems, households selected for formal socio-economic surveys were reselected and their farms were inventoried. A total of 88 tree and shrub species belonging to 45 families were found in different traditional agroforestry land-use practices across AEZs. Among these, 72 tree/shrub species were found to be indigenous. On average, each farm had 11 species. The mean evenness and richness of woody species varied significantly ($P < 0.01$) between the mid-altitude and the other AEZs. Farmers deliberately retained tree/shrub species on their farms for multiple uses and ultimately for their socio-economic and livelihood development. Diversity and significance of woody species uses are variable among agro-ecological zones with climate and socioeconomic change. Coupling such information with predictions of climate change and climatic requirements of these plant species will yield information on local vulnerabilities and adaptation needs to climate change.

Key words: traditional knowledge, agro-ecological zone, woody species diversity.

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ID-080

DEVELOPMENT OF THE CARBON MARKET IN PAKISTAN – ISSUES AND OPPORTUNITIES FOR SUSTAINABLE FORESTRY

Malik Amin Aslam[1]

The management, protection and development of forests provide one of the most important measures for adaptation to climate change, especially in a developing country like Pakistan. The paper/presentation provides an overview of forestry management in Pakistan and its evolving linkages with the carbon market within the context of the country's climate change strategy. In this respect, the policy, institutional and technical measures already undertaken in the country for the development of the carbon market are outlined along with the response to this stimulus, so far, within the public/Government, as well as private sectors in the country. This is followed by drawing out the immense opportunities for carbon credit generation present in the country, primarily within the energy as well as forestry sectors especially through extending carbon sequestration based economic benefits to forests in the country. The paper then focuses on the country's experience with forestry management while highlighting the potential utility of carbon finance for reforestation and afforestation in the public and private sectors. Along with identifying the opportunities, the market and non-market barriers which need to be overcome for this latent carbon sequestration potential to be realized in the country are also highlighted. Finally, the paper provides some viewpoints on the international climate policy framework within which all these developments have to materialize, to consider whether the carbon finance/Clean Development Mechanism currently has the potential for promoting sustainable forestry management.

Key words: carbon market, carbon sequestration, international climate policy framework.

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ID-365

THE RIVER BETWEEN: INNOVATIVE FRINGING FOREST MANAGEMENT IN RESPONSE TO CLIMATE CHANGE BY TWO COMMUNITIES LYING ACROSS THE WHITE VOLTA RIVER

J. M. Atibila[1]

The paper presents findings of a participatory research to (a) assess benefits obtained from fringing forests, and (b) explore adaptive forest management policies and practices devised by communities in this era of climate change and climatic variability in the Volta Basin (West Africa). In degraded, semi-arid environments, fringing forests may constitute the only natural vegetation on the landscape. These 'minor forests' have received very little attention by researchers. However, they are crucial ecosystems providing a range of provisioning, supporting, regulating and cultural services that promote national economies and community livelihoods.

The research used a combination of quantitative (field-based ecological studies) and qualitative (semi-structured interviews and focus group discussions) methodologies and found that: (1) communities derive direct benefits from fringing forests; (2) there was evidence of climate change in the study area (changes in hydrological regimes, increased temperatures, winds, and reduced relative humidity) over the past four decades; and (3) one community on one side of the river combined public forest policies with traditional nature conservation bylaws had developed innovative management practices that significantly improved forests health (biodiversity). Forests on the other community were degraded as they had weak traditional authority who failed to apply government policies and local bylaws. The research concluded that integrated public policy and valuable traditional knowledge had promoted adaptive change but the magnitude of future hazards may exceed their adaptive capacity. Gaps for further investigation were identified: How vulnerable are the (i) ecosystems, (ii) communities, to extreme weather events? How resilient are the adaptive management systems to future climate change and climatic variability? What science and technology support do communities require that ensure livelihood security and ecosystem health in the light of environmental risks and hazards? Answers to such questions are vital for science-policy integration to develop resilient fringing forest ecosystems for sustainable livelihoods in the Volta Basin.

Key words: Volta Basin, fringing forests, ecosystem services, livelihoods, adaptive capacity.

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ID-301

CONTINUOUS TREE COVER FORESTS AND CONTINUOUS COVER FORESTRY IN SWEDEN

Robert Axelsson[1]

Swedish forestry has successfully developed systems for sustained yield production of wood. Silvicultural techniques are today completely dominated (96%) by clear-felling methods. By contrast, Swedish natural forests and pre-industrial cultural woodlands were ecologically and culturally diverse, with a substantial proportion having a continuous tree cover (CTC). If forest management systems do not mimic this diversity of disturbance regimes sufficiently well, biodiversity and socio-cultural values might suffer. A key measure to counteract climate change may be to develop and apply suitable alternatives to the dominant clear-felling system in Sweden. To mention some examples, continuous cover forestry could potentially be useful to: increase carbon sequestration, create and use of diverse and thus more adaptive forests, create and maintain climate refugia, avoid further fragmentation and provide connectivity, provide buffer zones for adaptation around protected areas, the practice of low-intensity forestry, produce a more diverse set of wood products and produce slow-growing higher quality wood for products with longer life cycles.

In this study a definition to CTC forest is proposed, estimates of the amount of CTC forests and management suggestions are provided. Local forestry actors were interviewed about their knowledge, the prerequisites for and attitudes towards uneven-aged forest management systems. For the estimates on potential remaining old CTC forests and their management, multiple methods in two large study areas located in the North and South of the Swedish boreal forest were used. The results show that about 10% of the landscapes held CTC forest sites, that only smaller areas of CTC forests remained, and that special considerations for these sites have only recently been adopted (if at all). In the southern study area, local forestry actors were more positive to uneven-aged forest management systems. Although foresters were generally negative to using uneven-aged systems as alternatives to sustained yield production, they were positive to them as a complement to satisfy social and to some extent ecological values. To encourage a diversity of forest management systems to satisfy the principles of sustainable forest management and to adapt to uncertainties like climate change there is a need for more knowledge and landscape approaches were land owners and other stakeholders cooperate.

Key words: continuous tree cover forest, sustainable forest management, uneven-aged forest management.

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ID-342

TREE-RING ANALYSIS USED FOR CLIMATE RECONSTRUCTION AND FIRE FREQUENCY IN MONGOLIA

Nachim Baatarbileg[1]

Since 1995, wood samples from climatically sensitive locations have been collected in Mongolia for temperature and precipitation. From AD262 to 1999, 1,738 years of temperature variability are inferred from tree ring widths of Siberian pine at Tarvagatay Pass, an elevated timberline (2,420 m) site in Mongolia. Over the past thousand years, the warmest conditions are found in the 20th century. The chronologies load closely in principal component analysis (PCA) with the first eigenvector accounting for over 53% of the variance from AD1450 to 1998. The 20 year-interval between 1974 and 1993 is the highest such growth period in this composite record, and 17 of the 20 highest growth years have occurred since 1946.

Most instrumental records barely extend beyond 50 years in Mongolia. Tree ring analyses can be used to reconstruct precipitation and streamflow in the country. The streamflow of the Kherlen River and precipitation for part of the region were reconstructed back to 1651. Spectral analysis showed quasi-solar and lunar-nodal variability, and the extreme drought of 1999-2002 fit the long-term pattern caused by the combination of solar (22 and 11 years) and lunar-nodal (18.6 years) variations.

Increasing intensity and spread of forest fires in Mongolia were observed in the past 15 years, largely attributed to the rise in temperature and decline in precipitation in combination with increasing intensity of land use. The historic forest fire over the past 440 years (AD1559-2005) is inferred from the selected sites in Northern Mongolia. During 440 years, 202 fires were observed in Northern Mongolia, and most of them indicated that early wood fires (spring) were dominated. This study produced valuable tree growth and fire chronologies in the country.

Key words: climate change, fire, Mongolia, precipitation, temperature, tree ring.

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ID-242

CLIMATE CHANGE IMPACT ON SPRUCE (*PICEA ABIES* L.) AND BEECH (*FAGUS SYLVATICA* L.) GROWTH POTENTIAL IN SLOVAKIA

Peter Baláž[1] and Tomáš Hlásny [1,2]

The knowledge of forest/climate relationships allows for the profound understanding of expected climate change impacts on forest ecology, particularly in structure and dynamics. In this study we analyzed tree growth responses to selected climatic variables. Spruce and beech, as dominant forest tree species in Slovakia, were the subject of the analysis. Data from forest inventory plots and historic data on supposed limits of species natural distribution were analyzed. In total, 3 974 spruce trees on 344 plots and 4 064 beech trees on 400 plots were used to derive the growth response functions. The most extreme locations of species' natural distribution represented the physiological limits of their potential distribution.

Growth responses to mean annual air temperature and climatic water balance (precipitation – potential evapotranspiration) indicated species' bioclimatic amplitudes. Subsequently, we applied designed response functions to maps of the mentioned climatic variables. In this way, we visualized the climate-based growth potential of respective species across Slovakia. Finally, we applied a selected climate change scenario to allow for the investigation of climate change impact on species' growth potential. The results indicate significant shifts in the suitability of climatic conditions for growth and the occurrence of both species.

Key words: spruce, beech, growth response, bioclimatic amplitude, climate change.

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ID-072

ECOLOGICAL SUSTAINABILITY OF COMMUNITY FOREST MANAGEMENT – A CASE STUDY FROM THE MIDHILLS OF NEPAL

S.K. Baral and K. Katzensteiner[1]

Over-utilization during the past fifty years have led to severe forest degradation in mid-hill region of Nepal and increased the risk of natural hazards dramatically. The question is, if community forestry (CF) is a proper restoration strategy to enhance ecosystem resistance and resilience against climate change. Though CF has succeeded in improving the forest cover, concerns arise with respect to biodiversity, carbon sequestration, and the nutritional status considering continuously high biomass exports.

The present study compares tree nutrition, soil status and vegetation diversity of a 21 ha community forest and a nearby, municipality owned, less impacted forest of the same size (MF) in the lower temperate, mixed broadleaved vegetation belt. Eight permanent plots (10m x 10m) were established both in the CF and the MF where stand properties (tree species, height, DBH) and ground vegetation were surveyed and soil and foliar samples were taken for chemical analyses. Disturbance was estimated in the field at an ordinal scale (1=low, 4=extreme), based on topsoil and vegetation indicators. Shannon index, Simpson's index and species evenness indicate a significantly higher tree species diversity in MF compared to CF, whereas the understorey is more diverse in CF. Similarly, basal areas and stand densities are higher in MF (38 m^2ha^{-1} and 2725 $n.ha^{-1}$) than in CF (19 $m^2ha^{-1}$and 2525 $n.ha^{-1}$). Topsoil (0-10 cm) bulk densities are significantly lower in MF than in CF, topsoil C and N content are significantly higher in MF. The foliar macro-nutrient contents are higher in trees of MF. There is a negative correlation between Shannon index and soil C and N contents with the degree of disturbance. Given the fact that CF was established only 17 years ago on completely degraded land, it can be concluded that forest products can be supplied sustainably from CF while maintaining species diversity and soil functions up to an intermediate degree of disturbance. Severe disturbed forests are however considered to be less adaptive to changing environmental conditions.

Key words*:* biodiversity, disturbance, forest nutrition, soil status.

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ID-096

PERSPECTIVES ON BOREAL AND TROPICAL TREE PATHOLOGY WITH A CHANGING CLIMATE

Pia Barklund[1], Jane Njuguna[2], Abdella Gure[3], Philip Nyeko[4] and Jan Stenlid[5]

The increasing need for sawn timber, pulp, paper and wood energy has led to the development of forestry built on indigenous species in boreal Scandinavia and to forest plantations and woodlots composed of exotic tree species in tropical East Africa. Intensified forest management in the regions seems to increase the spread of diseases whether it is long or short rotation forestry. Concurrently, climate change will influence disease development. In order to put these influencing forces into perspective, we compare East Africa and Scandinavia with respect to the interaction of forestry and diseases.

Our ongoing studies of severe outbreaks of a canker and dieback disease on *Grevillea robusta* in Kenya, Uganda and Ethiopia have revealed that pathogens of the genus *Botryosphaeria* spp. cause the disease. Also, other tree species, including indigenous and exotics, were found infected by *Botryosphaeria* in the region. Especially alarming is the attack on different *Eucalyptus* species. In severe cases, more than 50% of the trees in a plantation were found to be infected. In Scandinavia, the current situation since year 2000 is an emerging new dieback disease on *Fraxinus excelsior* caused by *Chalara fraxinea*, the most severe outbreaks ever of *Gremmeniella abietina* on *Pinus sylvestris* about 400 000 ha in 2001, and *Cronartium flaccidum* also on *P. sylvestris* about 150 000 ha in 2007.

New emerging or aggravated tree diseases are threatening forestry, and it is important to identify the origin of environmental factors influencing each disease. Disease development can give hints about how to develop adaptive strategies with respect to a coming climate change. Examples and analyses will be presented to underline the need to be careful about finding the real reasons for disease development and to be cautious about using climate change as an overall explanation for new disease outbreak.

Key words: disease on *Grevillea robusta* and *Eucalyptus* spp., pine diseases.

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ID-143

CLIMATE CHANGE, NON-TIMBER FOREST PRODUCTS AND RURAL LIVELIHOOD: A STUDY IN THE DROUGHT-PRONE DISTRICT OF WEST BENGAL

Jyotish Prakash Basu[1]

Forests play an important role in the climate system. Trees are not just carbon stores. Forests are home to the people who are entirely or partly dependent on forests for their livelihood. Of nearly 170 million people living in and around forests in India, more than half of them are tribal and depend on non-timber forest products (NTFPs). The non-timber forest products such as mahua, kendu, mango, jackfruit, sal leaves and seeds, vegetables and roots, food, fuel wood, fodder, mushroom, honey, medicinal herbs, etc., are very important contributors to the well-being or livelihood of villagers. These non-timber forest products are affected by the decrease in its quantity as a consequence of climate change.

The objective of the paper is to examine the likely impacts of the non-timber forest products on the livelihood of forest-dependent people. In addition, this paper also examines the human development indicators like education, sanitation, drinking water and housing, etc. This paper is an empirical study based on data collected through field survey. It covers two villages - Kolaberia and Kalyanpur - located in Sonamukhi forest area in the District of Bankura, one of the drought- prone Districts of West Bengal, consisting of 90 households in 2007. The results of the paper revealed that poverty, the threat wild animals, unemployment, and migration are the common phenomenon for the forest-dependent people. The paper also describes adaptation strategies for livelihood of forest-dependent people. The Government of India has undertaken little policy action to reduce climate-related vulnerability particularly in the drought- prone regions of West Bengal. The Joint Forest Management of Government of India is not an effective tool for improving the well-being of the poor people who are depending on NTFPs. This paper has important policy implications for poverty, livelihood vulnerability and migration.

Key words: livelihood, migration, non-timber forest products, poverty, well-being.

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ID-023

WILDLAND THREAT ASSESSMENT AND MONITORING SYSTEMS ON NATIONAL FORESTS IN THE USA

J.S. Beatty[1] and A.A. Ager[2]

Wildland threat assessment and monitoring systems generate valuable information on spatiotemporal patterns of risk posed by specific disturbance agents and their interactions. A number of threat assessments systems are deployed by Federal land management agencies in the United States to detect and monitor a wide variety of disturbance agents, including insects, diseases, invasive organisms, and wildfire, to name a few. Information from threat assessments are used to identify and prioritize mitigation activities like wildfire suppression, fuel treatments, invasive plant eradication and disease control projects. More recently, long-term data from threat assessments are being used to build and validate models to predict effects of climate change on future impacts of forest disturbance agents.

This presentation will review and compare several spatially explicit threat assessment and monitoring systems currently employed by the U.S. Forest Service, and provide examples of how information generated from these systems are being used to model potential future impacts from specific forest threats under climate change scenarios. The paper will also describe efforts to build a forest threat mapping system to help visualize multiple wildland threats and their interactions.

Key words: wildland threat assessment, climate change, forest health monitoring.

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ID-254

WHY WOOD IS KEY TO GREEN BUILDING

Robert Beauregard[1], Pierre-Olivier Morency[2] and Luc Bouthillier[3]

The climate of planet Earth is changing and it is now well established that this is caused by human activity. Although climate change adaptation is necessary, the need is still there for an efficient agenda to reduce green house gas (GHG) emissions in order to mitigate climate change. The first, second and third anthropogenic sources of GHG are from: the use of fossil fuels to produce energy; deforestation, mainly in tropical countries; and production of concrete. Indeed concrete requires a huge amount of energy for its production and wood appears to be a key substitution material for its use in buildings. This talk will look at the building side of this. It will address the conditions that need to be respected in forest management, wood use and disposal at the end of building life cycle, if we want to be able to claim that wood is a sustainable material for Green Building, for the mitigation of climate change.

Trees - through photosynthesis - have the ability to translocate CO_2 from the air into wood. Through this mechanism and sound forest management, forests can be carbon sinks and wood in buildings a reservoir of carbon. Through the substitution of concrete, wood can prevent the emission of more than one ton of carbon per m^3 of wood used and be the reservoir of almost an additional ton of carbon per m^3. At the end of the building's life cycle, key action must be taken to dispose of wood components through using them as a substitute for fossil fuel in energy production. This has the potential to avoid methane emission from landfill and to reduce GHG from fossil fuel for energy production. A review of forest management practices and Green Building assessment frameworks will be made to assess the conditions that need to be respected for these goals to be achieved. The consequences for public policy will also be discussed.

Key words: GHG emissions, Green Building Policy, wood usage.

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ID-158

BALANCING LIVELIHOODS NEEDS FOR ADAPTATION AND REDUCING CARBON EMISSIONS FROM FORESTS: CASE STUDY OF COMMUNITY FORESTRY IN THE CAMEROON FOREST POLICY REFORM

M.Y. Bele[1], C. Jum[1] and J. Nkem[2]

For the entire colonial period up to the mid-1990s, the forests of Cameroon were managed through a centrally-directed structure and process, which expropriated resources and control over such resources from local communities, and excluded them from accessing forest resources and their economic benefits. As a consequence, this policy led to rapid depletion of natural resources. In 1994, a new forest law was passed in Cameroon with support from the World Bank. The objectives of the new law included not only resource conservation, but also the greater involvement of local communities in managing and sharing the benefits accruing from the forests. Importantly it also created legal provision for community forests. Involving local communities in forest management was perceived as a way of improving sustainable forest management by the communities themselves, therefore reducing carbon emissions from deforestation and forest degradation while enhancing their living conditions. However, several analyses have suggested that this particular intervention be based on an inadequate understanding of the socio-economic forces at play within the forest sector. In particular, it failed to recognize the importance of deeply entrenched and conflicting vested economic interests, and did not reflect "the interests of ordinary people", all of which hampered the policy's implementation.

This paper demonstrates that improvements in the standard of living, in equity and in ecological sustainability, which community forestry intended to produce are delayed and compromised and by some accounts, even served as a source of social conflicts, emergence of new social groups, misappropriation of community forest fees, and degradation of many community forests in the humid forest zone of southern Cameroon. The paper recommends the following if community forestry is to succeed in Cameroon: enforced legal protection from outside 'incursions', community ownership of the management committees and planning process, available technical and management skills, and access to finance.

Key words: Cameroon, carbon emissions reduction, community forests, livelihood.

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ID-129

SIMULATED REGIONAL EFFECTS OF CLIMATE CHANGE ON NET PRIMARY PRODUCTION FOR FORESTS IN SWEDEN

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Emissions of CO_2, and other greenhouse gases, might increase the global temperature and other aspects of the climate in the 21st century. The net primary production (NPP) in temperate and boreal forests is likely to respond to elevated temperature and atmospheric CO_2-concentration [CO_2]. The process-based growth model BIOMASS was used to estimate the effect of elevated temperature and [CO_2] on NPP in Sweden. Two transient regional climate scenarios were used in the simulations. The scenarios were based on two different emission scenarios ([CO_2] = 572 or 726 ppm in the year 2085). The simulations were compared with simulations using the current climate and the results are presented as the relative change in NPP for Scots pine and Norway spruce. Relative change in NPP was also translated into biomass and stem-wood production for stand development for a whole rotation period.

The relative increase in NPP at the end of this century, as mean value for whole of Sweden, was 24% at 572 ppm and 31% at 726 ppm, respectively. The relative change in NPP was larger in northern Sweden (> 35%) compared to southern Sweden. While temperature itself had a small impact on photosynthesis during the growing season, the extension of the growing seasons, as an effect of elevated temperature, increased NPP by 8-20%. Elevated [CO_2] increased photosynthesis, but water deficit during summer reduced photosynthesis in southern Sweden. Based on the regional scenarios used in this study, the production for Norway spruce and Scots pine is, however, likely to increase considerably in Sweden during this century. The increase in NPP by 31%, at 726 ppm, resulted in increased mean volume production by 9% in southern and 15% in northern Sweden. Net present value increased though by 16% in southern Sweden and by 79% in northern Sweden.

Key words: boreal forest, climate change, [CO_2], net present value, photosynthesis.

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ID-163

RESISTANCE OF INTRODUCED *PINUS CONTORTA* AND NATIVE *P. SYLVESTRIS* TO *GREMMENIELLA ABIETINA* (LTT, EUROPEAN RACE) IN SWEDEN

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The fungal pathogen *Gremmeniella abietina* has caused severe damage to pine plantations in Europe, North America and Asia. In Sweden, two genetically separated types are present: Small Tree Type (STT), found on young *Pinus contorta* and *P. sylvestris* plantations in the north; and Large Tree Type (LTT), found mainly on *P. sylvestris* trees of all ages in the south. In 2001-2003, after two exceptionally rainy summers in 1998 and 2000, LTT *G. abietina* caused the largest outbreak ever recorded in Sweden, damaging over 480,000 ha of middle-aged pine stands. Interestingly, damage was prevalent all the way up to Västerbotten in northern Sweden. In Canada, *P. contorta* has shown a high level of resistance to the introduced European race of *G. abietina* (=LTT).

Our objective was to compare the resistance of *P. sylvestris* and *P. contorta* seedlings to LTT *G. abietina* under Swedish conditions. Trials were conducted in gaps of an infected 40-year-old *P. sylvestris* stand. After two years, 45% and 32% of the *P. contorta* and *P. sylvestris* seedlings showed *G. abietina* symptoms, respectively. However, *P. contorta* seedlings had lower mortality, better recovery, and significantly shorter average length of shoot infection. Furthermore, 47% of the infected *P. contorta* seedlings had developed new leader shoots in 2007 compared with 19% of the *P. sylvestris* seedlings. Histopathological examinations of the transition zone of infected shoots showed that both pine species had produced ligno-suberized boundaries between healthy and necrosed shoot tissue. Together with phenol-filled cells, these boundaries completed the compartmentalization process in surviving seedlings. The results indicate that both species are susceptible to infection by LTT *G. abietina,* but *P. contorta* seems more resistant compared to *P. sylvestris.* The results are important for future policy making as we are about to increase the use of the fast-growing *P. contorta* as a complement to *P. sylvestris* to increase production and carbon sequestration in Swedish forestry.

Key words: disease, fungal pathogen, lodgepole pine, Scleroderris canker, Scots pine.

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ID-261

TREE MORTALITY, INCREMENT LOSS AND FOLIAGE RECOVERY IN MIDDLE-AGED *PINUS SYLVESTRIS* FOLLOWING DEFOLIATION BY *GREMMENIELLA ABIETINA* AND SUBSEQUENT ATTACK BY *TOMICUS PINIPERDA*

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The fungal pathogen *Gremmeniella abietina* has caused severe damage to pine plantations in Europe, North America and Asia. One of the two types of *G. abietina* present in Sweden, the Large Tree Type (LTT), was formerly known as a disease agent only in southern parts of the country but has recently been found as far north as Västerbotten. After a severe outbreak by LTT *G. abietina* in 2001, following the extremely rainy growth periods of 1998 and 2000, mortality, diameter growth and recovery were monitored and related to crown defoliation in four middle-aged *P. sylvestris* plantations in northern Sweden during five years. Of the killed trees, 84% were at least 90% defoliated and 15% were 80-89% defoliated the year before they died. Trees with less than 90% defoliation were only killed in the initial phase of the epidemic, in 2001-2002. Small trees died more frequently than larger trees. Two-thirds of the trees that died were killed directly by *G. abietina* and one-third after additional colonisation by *Tomicus piniperda. T. piniperda* galleries were only found in dead or severely damaged trees; 92% of the colonised trees were at least 95% defoliated. Regression analysis indicated that mean defoliation of 2/3 of the crown resulted in a 50% loss in diameter increment, on average, during the study period. Four years after the initial outbreak, no significant foliage recovery was found and the mean defoliation level of living trees was still over 50%.

Our results indicate that a critical range for mortality by *G. abietina* in middle-aged *P. sylvestris* stands is 90-95% defoliation. However, in the initial phases of a severe outbreak also trees with 80-90% defoliation may be killed. Knowledge of tree survival, growth and recovery is important for proper stand management and disease control of diseases, as LTT *G. abietina,* likely to become more severe with a change in climate.

Key words: crown transparency, Fennoscandia, forest pathology, fungal epidemic, growth loss, *Scleroderris canker*, sanitation management.

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ID-260

WILL ADOPTION OF CARBON-LEAN MANAGEMENT PRACTICES LEAD TO INCREASED PEST INCIDENCE?

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Continuous Cover Forestry (CCF) is being used as an alternative to clear felling. These regimes are being adopted in the United Kingdom (UK) as a means of increasing the species and structural diversity of plantation forests, an interesting measure from a biodiversity and a climate change adaptation perspective. CCF is considered a carbon-lean forest management option. One area of limited knowledge is the critical level of below-canopy light for growth of naturally regenerating seedlings. Plant growth beneath canopies can also be influenced by other factors such as herbivory. Sitka spruce (*Picea sitchensis* (Bong.) Carr.) seedlings under canopies have been observed to be more severely damaged by green spruce aphid (*Elatobium abietinum* (Walker)) attack. This study reports on the interactions between light and aphid dynamics on seedling growth, through physiological (chlorophyll fluorescence) and biomass assessments.

At an experimental field, site plots were located across two light regimes typical of CCF conditions in upland UK coniferous forests. The impacts of incident light and natural aphid population dynamics on regeneration was monitored in 2007. A comparison against a common garden (controlled) experiment was made, which mimicked different natural understorey light levels along with artificial aphid infestation using potted trees placed under shadehouses. The controlled experimental site was observed in 2006 in order that 'carry-over effects' be understood.

A clear influence of light was observed upon seedling biomass and photosynthetic turnover, as measured by chlorophyll fluorescence. Aphid population assessments in the common garden experiment showed increased population density under shaded conditions. Aphid impacts were observed in terms of needle retention but effects on plant biomass were masked by the influence of light. Plant architecture changed with different light intensities but was not influenced by the aphid treatment. Guidance on minimum light levels for natural regeneration success can be drawn however the potential cumulative impact of increased aphid exposure under climate change cannot be ruled out.

Key words: CCF, defoliation, *Elatobium abietinum*, fluorescence, *Picea sitchensis.*

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ID-059

ADAPTING TO CLIMATE CHANGE ON NATIONAL FORESTS IN THE UNITED STATES

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The combination of climate change and other environmental changes is expected to alter the future structure, composition, and functioning of ecosystems as well as the goods and services these ecosystems provide. Adaptations - adjustments in human social systems (e.g., management) - that address the anticipated adverse impacts and capitalize on any positive effects of climate change may help maintain or even enhance future ecosystem services. The US Climate Change Science Program (CCSP) is completing 21 Synthesis and Assessment Products (SAP) to better understand climate change and its interaction with other environmental changes to affect biodiversity and the future condition of ecosystems and natural resources. SAP 4.4 reviewed potential adaptation options for climate-sensitive ecosystems that could be incorporated into ecosystem and natural resource management and planning. An important innovation in this SAP was to explore adaptation options by first considering the management context (including desired ecosystem condition and resource management goals) and the processes organizations use to achieve their goals. Using this approach, adaptation options (and potential implementation barriers and opportunities) were explored for six federally managed lands and waters, including US National Forests.

A key conclusion was that many of the best management practices resource managers already use to address 'traditional' stressors of concern (e.g., pollution, invasive species, and fragmentation) will also reduce any exacerbation of these stressors by climate change. Strategic adjustment of these best management practices could enhance ecosystem resilience to climate change. I will present seven general adaptation approaches identified in the report and provide specific examples of adjustments in forest management planning and practices to stimulate discussion on how forest managers might use SAP 4.4 to further develop adaptation efforts. Based on the results of two case studies, I will also discuss how many of the perceived barriers to implementing adaptation could be reframed as opportunities.

Key words: adaptation, climate change impacts, management goals, resilience, stressors.

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ID-249

CLIMATE CHANGE AND NON-TIMBER FOREST PRODUCTS IN GHANA: IMPACTS, VULNERABILITY AND ADAPTATIONS

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Many local and urban communities in Ghana depend on Non-Timber Forest Products (NTFPs) for their livelihood. These NTFPs include, amongst others, bush meat, snails, mushrooms, nuts, rattan species, chew sticks plants for dyes and medicinal herbs. Like most plants, the growth and productivity of these animals and plants which produce the NTFPs are controlled by climatic conditions especially rainfall. Therefore rainfall has impacts on the growth and productivity of the NTFPs and, as a result, this makes the NTFPs and the dependent communities vulnerable to the impacts of climate variability and change. This impact and vulnerability are more intense where there is climatic variability and thus in Ghana this is more so in the transitional areas between the forest and savanna areas where there has been serious variability in climatic patterns.

A study was therefore made to assess impact of climate change on NTFPs and also to determine the extent of vulnerability of NTFPs and socio-economic conditions of the dependent communities. This paper discusses the results of the study, describes the current and possible adaptation measures that have been and can be adopted by local communities to mitigate the impact and vulnerability. Recommendations are finally made on the policies that can be promulgated at the national level to help promote planned adaptation strategies to reduce vulnerabilities to climate change of NTFPs and dependent communities. The policies recommended for enactment include: (i) Promotion of domestication of NTFPs on farm and fallow lands, (ii) Value addition to NTFPs, and (iii) Enhancement of protection of NTFPs within multiple use production forests through exclusion of critical areas from logging.

Key words: climate change and variability, growth and productivity, impact, vulnerability, NTFPs , policies.

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ID-219

ADAPTATION OF FOREST MANAGEMENT AMONG SMALL-SCALE PRIVATE FOREST OWNERS

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More than half of the Swedish productive forest land is owned by small-scale private forest owners. How they manage their forests will influence not only the fulfilment of their private goals but also the fulfilment of common goals. According to the fourth IPCC assessment report, adaptation to climate changes take place through adjustments to reduce vulnerability or to enhance resilience. Results from two separate mail surveys show that adaptation of forest management is taking place among Swedish small-scale private forest owners. The fraction of forest owners who stated that they have adapted their forest management was 11% in 1999 and 19% in 2004.

This study explores (i) whether there is an increase in adaptation or whether the difference between years can be explained by regional differences in sampling between the two studies, (ii) in what ways the forest owners had adapted their forest management and (iii) the motivations for having/not having adapted.

Key words: adaptation, climate change, forest owner.

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ID-140

CLIMATE CHANGE AND THE PROBABILITY OF WIND DAMAGE IN TWO SWEDISH FORESTS

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We estimated how the possible changes in wind climate and state of the forest due to climate changes may affect the probability of exceeding critical wind speeds expected to cause wind damage within two forest management units located in northern and southern Sweden, respectively. The topography of the management units was relatively gentle and the forests were dominated by Norway spruce (*Picea abies* (L.) Karst.) and Scots pine (*Pinus sylvestris* L.). Assuming the site productivity directly proportional to the net primary production (NPP) and using estimated increases in NPP due to climate changes from the literature, we simulated possible future states of the forest under gradual adjustment of the site index in response to climate changes using the model The Forest Time Machine. Global climate change scenarios based on two emission scenarios A2 and B2 and the ECHAM4/OPYC3 general circulation model were used to downscale to the regional level using the RCA3 model for the periods 2011–2041 and 2071–2100 and a control period scenario for the period 1961–1990.

The modified WINDA model was used to calculate the probability of wind damage for individual forest stands in simulated future states of the forest. Calculated probabilities of wind damage were generally higher in the southern management unit than in the northern one and were explained by differences in wind climate and the state of the forests, for example with respect to the tree species composition. Increasing sensitivity of the forest to wind was indicated when the management rules of today were applied. Adding also a changed wind climate further increased the probability of wind damage. The indicated increase in sensitivity of the forest to wind under the current management regime and possibly increasing windiness could make revision of Swedish forest management practices worthwhile.

Key words: climate change, risk, tree growth, wind climate, wind damage.

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ID-094

LONG-TERM TRENDS AND FLUCTUATIONS OF COMMON BEECH AND SESSILE OAK GROWTH IN FRANCE DURING THE 20TH CENTURY AND THEIR COMPARED CLIMATIC INTERPRETATIONS

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The topic of tree species sensitivity to climate and their potential replacement under climate warming was addressed, investigating past growth dynamics of tree species and their relationships to climate, using a statistical modelling approach. Among species, common beech and sessile oak growth over the 20th century was studied in two areas in Northern France. The analysis focused on dominant height as a traditional proxy for stand productivity. Sampling was based on the paired-stands method, associating young/old neighbour stands growing in the same permanent environmental conditions. Dominant height growth curves were reconstructed from stem analyses. Fifty stand pairs and over 500 increments of a mean duration of 7-11 years were available. A modelling approach of growth increments was first used to filter out the effects of stand age and site conditions and estimate the historical evolution in growth. The chronologies revealed sharp positive trends for both species, more acute in North-East France, as well as decadal crises. Some of them were common to species such as the 1940-50's warm and dry period. Conversely, oak and beech exhibited inverse responses to the recent warming period, with huge growth increase and simultaneous drop respectively. The model was fitted again with removal of the calendar date effect. Contribution of past climate to growth variations was assessed by correlating and modelling residuals against climate descriptors, calculated from homogenised centennial time series of monthly rainfalls and minimum/maximum temperatures and soil water capacity measurements. Drought/warm events were pointed out as critical on oak/beech response respectively.

Key words: climatic stress, dominant height, fluctuations, growth trends, modelling.

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ID-032

CLIMATE CHANGE EFFECTS ON SITE INDEX ESTIMATION IN MEDITERRANEAN MARITIME PINE FORESTS

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In the Kyoto Protocol, since 1990, forestry activities are limited to afforestation, reforestation and deforestation. However, sustainable forest management (SFM) could play a major role in the forthcoming second commitment period after Kyoto (2012). Within this framework decision, support tools should implement impacts of climate change to adapt forest management. Silviculture techniques control density, composition and growth of forest to achieve multiple objectives. Any change associated to climate affecting any of these concerns must be incorporated to forest management.

South Europe is expected to suffer hardly the effects of climate change. Increased temperature and decreased precipitation following extreme events could affect forest growth. Forest species could adapt their mechanisms to support these effects but the increasingly speed of climate change limit the natural adaptation, and consequently adaptive forest management must apply, based on plausible impacts on forest growth.

This case study shows how a dominant height growth model, that incorporate climate variables, could serve as an adaptive tool to assess impacts in site index estimation. We modelled site index changes in Mediterranean maritime pine (*Pinus pinaster* Ait.) forests under diverse regionalized climate change scenarios in the Iberian Peninsula.

Key words*:* adaptive forest management, IPCC's emission scenarios, Mediterranean basin, climate change impact models.

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ID-104

THE TroFCCA POLICY RESEARCH FRAMEWORK ON ACTORS, DECISION-MAKING AND POLICY NETWORKS

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Impacts of climate change will affect forest ecosystem goods and services (FEGS) as well as the livelihoods of people dependent on those FEGS. To minimize the risk of growing vulnerability, there is an urgent need for mitigation as well as for adaptation options to respond to existing and projected climate change impacts.

The overall aim of TroFCCA (Tropical Forests and Climate Change Adaptation) as a research project is to mainstream adaptation strategies related to forest ecosystem goods and services into development policies. TroFCCA is working in different regions and countries (West Africa, Asia, and Central America) and on forest goods and services relevant for development topics or sectors defined during stakeholder meetings in the regions. TroFCCA is addressing the coupled biophysical and socio-economic system that characterizes the provision and use of forest goods and services. The vulnerability analysis of such a system is assessed according to the exposure, sensitivity and adaptive capacity concepts following IPCC definitions. The research activities undertaken by TrofCCA's policy research focus strongly on adaptive capacities of the stakeholders involved in the decision and policy making processes across scales and across sectors that are relevant for forests and adaptation to climate change.

A common approach for TroFCCA's policy analysis was developed and is presented here. The paper introduces the approach and the methods and tools (policy network analysis) used in the different regions, related to the regional or country-wise specific topics, levels of activity (regional, national, sub-national, local) and present first results of our on-going research activities. Preliminary results show the need for a comprehensive analysis of the political and institutional context and of the actors involved in decision making and the structural conditions (linkages, bridges, gaps) in the policy arena to achieve a successful mainstreaming of identified adaptation strategies into policy needs.

Key words: adaptation, climate change, decision making processes, multi-stakeholder processes, Policy Network Analysis.

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ID-119

EFFECTS OF CLIMATE, AIR POLLUTION, PESTS AND PATHOGENS ON FOREST HEALTH – AN INTEGRATIVE PERSPECTIVE OF IUFRO

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Recently occurring climatic changes, caused mainly by the air pollution emissions of anthropogenic origin, affect responses of forest ecosystems to abiotic and biotic stressors. Among the most important abiotic stressors are: increasing concentrations of tropospheric ozone and carbon dioxide, elevated levels of atmospheric nitrogen deposition, long-term drought caused by reduced precipitation and increasing temperatures, catastrophic fires and windthrows. These stressors change physiological activity, phenology and growth of trees affecting their susceptibility to the biotic stressors - pests and diseases. Under changing climate and chronic effects of air pollution, forests pests and pathogens alter their development cycles and rates of outbreaks. All these factors, individually and in combination, may affect forest growth, health and sustainability. Various aspects of diagnosis, monitoring, biology, genetics, physiological and genetic changes, resistance mechanisms, biological and applied aspects of tree diseases, environment/pathogen interactions in forest decline, biology and control of forest tree insects, and others will be presented from a perspective of the collective expertise of the forestry scientists gathered in the IUFRO Division 7 "Forest Health". In addition, examples of the currently occurring forest health changes caused by interactive effects of combination of stressors in various geographic areas as well as projections of the future expected changes in forest health will be discussed.

Key words: forest health, climate change, air pollution, diseases, forest pests, plant pathology.

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ID-195

GUYANA'S PROPOSAL FOR GLOBAL CLIMATE CHANGE ADAPTATION AND MITIGATION: THE JAGDEO CLIMATE CHANGE INITIATIVE

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Global warming and climate change implications pose a major threat to humanity. Of several adaptation and mitigation measures, the reduction of deforestation is one of the most attractive. While Guyana has embarked on a number of national initiatives/ strategies, its rich endowment of a very large forested land mass provides a great opportunity for the use of its standing forests as climate change buffer and carbon sinks. The birth of the Jagdeo Climate Change Initiative, first articulated by President Bharrat Jagdeo of Guyana at the United Nations Conference of September 2007, mirrors its forerunner, the Iwokrama International Rainforest Conservation project, initiated by the late President Desmond Hoyte of Guyana in 1989, on a much larger scale and demands global support. The four main tenets of the Jagdeo Climate Change Initiative are:

1. Recognize the contributions of standing forests towards addressing climate change through avoided deforestation, carbon sequestration and ecosystem services;
2. Make urgent change to the current Kyoto Protocol CDM some view as perverse because it rewards afforestation and reforestation without recognizing standing forests and thereby provides a disincentive for standing/pristine forest conservation and protection;
3. In consideration of opportunity costs, develop financial models to provide adequate compensation and incentives for maintaining standing forests through conservation and sustainable use;
4. Provide increased and easily accessible financial resources as well as capacity building for climate change mitigation by developing countries as the current mechanisms, in particular the Kyoto Protocol's Clean Development Mechanism, has not proven to be effective, thus far.

On the basis of these principles, Guyana is committing to conserving its entire neotropical rain forest in the Amazonia for global climate change adaptation and mitigation. This unique initiative provides part of the solution to the global threat of climate change while ensuring alternative local economic activities and livelihoods less dependent on forest degradation.

Key words: adaptation, climate change mitigation, deforestation, ecosystem services, standing forests.

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ID-358

USING RESILIENCE THEORY TO UNDERSTAND AND MANAGE PINE ECOSYSTEM DYNAMICS IN AN ERA OF RAPID CLIMATE CHANGE

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Ecosystem theories, models and forest management policies have focussed on the gradual or incremental responses of ecosystems to changing climate. However, with rapid climate change, forest managers are facing probable increases in the frequency and magnitude of abrupt ecological changes that could generate unexpected ecosystem shifts and pose fundamental challenges for sustainable forest management. In British Columbia, Canada, we are using ecological resilience theory as a conceptual framework for evaluating temperate and boreal forest ecosystem vulnerabilities to climate change and for proposing adaptations to current forest management approaches that could increase ecosystem resilience to rapid climate change. We began by identifying ecological processes and feedbacks that control the persistence of pine (*Pinus* spp.)-dominated ecosystems and tested their sensitivity to climate change. We used bioclimatic envelope, mechanistic and agent-based modelling within a complex systems framework to show how climate change could: (i) alter tree species regeneration niches and affect the capacity of pine ecosystems to reorganize following disturbance, and (ii) increase ecosystem vulnerability to catastrophic disturbance (e.g., expanding insect epidemics, drought-induced forest dieback). We also assessed how climate change impacts may be amplified by other human-caused drivers of ecosystem change (e.g., changes in forest cover, exotic species invasions) and identified management options that could increase ecosystem resilience to climate change so that desirable ecosystem services are maintained.

Our results suggest that over the longer term, and at local spatial scales, management to increase resilience could become increasingly difficult. In these cases, forest managers might consider management approaches that facilitate changes in ecosystem composition through human-assisted migration of trees and mixed-species plantings following stand harvest.

Key words: catastrophic disturbance, ecological resilience, ecosystem transformation, tree regeneration niches.

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ID-325

SPANISH EXPERIMENTAL LONG-TERM NETWORK FOR SUSTAINABLE FOREST MANAGEMENT

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A long-term network of experimental plots was established in Spain in 1964, with the initial objectives to increase the information on wood production for the main Spanish conifer and poplar species, and on silvicultural treatments such as thinning regimes and their interactions with site conditions. Other objectives were later added, such as the use of different species, non-wood forest products (like cork and fruit production), and silvicultural treatments (pruning). As a response to changes of forest policies and societal demands in the last ten years in the Mediterranean basin, other research lines have been added to this network, among them: natural regeneration, biodiversity analysis at different levels (genetic, species, structure and landscape), multipurpose silviculture and, importantly, the effects of climate change in forest dynamics. The objectives and design of the trials have evolved over time, but maintained the foundation principles of sustainable management.

The main species included in this network are: *Pinus sylvestris*, *Pinus nigra*, *Pinus pinaster*, *Pinus halepensis* and *Pinus pinea* as conifer species, and *Populus* sp., *Quercus suber*, *Quercus faginea*, and *Q. pyrenaica* as broadleaves. The size of plots varies between 1,000 and 5,000 m^2. The information from this permanent network is enriched with plot data from other national networks, such as the National Forest Inventory. The information obtained allows us to check climate-induced trends in growth and production. Some dominant height and diameter growth for conifers will be presented here. Also, genetic trials established for different species (mainly at the provenance level) will allow the estimation of performance of the species under different environmental conditions, and to asses the adaptability of the populations to climate change.

Key words: Mediterranean silviculture, monitoring, permanent plots, sustainable management, climate change impacts.

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ID-185

FOREST CONSERVATION IN THE CLIMATE CHANGE: THE CASE STUDY OF PUGLIA REGION - ITALY

Rocco Carella[1]

Puglia is the Region with the lowest rate of forest coverage in Italy. According to the latest forest inventory, Puglia region has 145,889 ha of wooded land and 33,151 ha of other wooded land. In spite of this low level in the forest area, Puglia shows high values in forest biodiversity with peculiar forest types in terms of natural distribution, ecology and composition. Some of these precious forest types could be interested by processes linked to climate change that might alterate in a significant way the particular ecological conditions which allow this rare presences in Puglia.

In the northern part of Gargano Promontory, the common beech (*Fagus sylvatica*) can live at very low altitudes (300 m above sea level) and not so far from the Adriatic sea, in wonderful mixed coenoses where *Fagus sylvatica* lives with the Holm oak (*Quercus ilex*) and sometimes in contact with the Aleppo pine (*Pinus halepensis*) forest fringe. This is a record considering the latitude and the ecological behaviour of common beech in southern Italy. Another important example is represented by the planitial meso-hygrophilous formations of Caucasian ash (*Fraxinus oxycarpa*), very rare in all southern Italy, which in Puglia lives in residual woods on Lato River, in a district seriously affected by desertification.

Puglia hosts Macedonian oak (*Quercus trojana)* coenoses, distributed in all the southern-eastern district of Murgia Plateau. These woods are important for their chorology, since Macedonian oak is the species that, with its abundance in forest areas, shows the evident affinity between Puglia and Balkan Peninsula.

These are just some aspects of forests diversity of Puglia that in an early future could be endangered by the climate change. In this complicate scenery, great importance is played by monitoring forest management, focusing attention on ecological sensitivity to the climate change of the considered forest types.

Key words: conservation, forest diversity, Puglia.

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ID-029

PRESENT VULNERABILITY AND FUTURE TRENDS OF CHANGES FOR *PINUS CEMBRA* L. IN THE ALPS

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Habitat suitability models have been largely used to predict species distribution changes under future climatic scenarios. An interesting aspect related to conservation management under climate change is the evaluation of the degree of affinity between the actual distribution of trees and their natural climatic climax. It is assumed that the more a species grows in its fitted climax the more it will be robust, resulting in higher stability, resistance and resilience under natural disturbance pressure (insects, fungi, wind storm, avalanche and other sources of natural disturbances). Therefore, we should consider the degree to which species are currently fitted to their environment as an estimate of vulnerability before plotting future trends.

In this context we propose a methodology for estimating the fitness of the distribution of *Pinus cembra* L. to its environmental suitability. A relatively rare but dominant alpine tree species was selected because of its limited distribution and potential vulnerability to climate change. Our method requires the construction of a suitability map generated from an ensemble Regression Tree model using the European forest inventory (Forest Focus regulation), together with geomorphologic, bioclimatic and soil predictor variables. The model is built at the European extent to integrate the whole species range, and its output suitability map has a resolution of 1 km. A current distribution map of *Pinus cembra* is computed using a nearest neighbor algorithm and merged to the suitability maps to evaluate the fitness of distribution and suitability. Finally, the IPCC SRES A1B future scenario was applied to the suitability model and we tested trends of vegetation shift for the next century.

Results show that *Pinus cembra* actual fitness has low affinity to its environment in large Alpine areas and will be strongly limited in its future suitability distribution. These trends could force forest management schemes and practices to adapt in a proactive way to climatic change pressures.

Key words: climate change, habitat suitability distribution model, *Pinus cembra*, vulnerability.

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ID-085

IMPACT OF CLIMATE CHANGE ON INDIAN FORESTS: A SHORT- AND MEDIUM-TERM ASSESSMENT

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Global assessments have shown that climate change is likely to significantly impact forest ecosystems, biodiversity and biomass production. However, due to lack of regional climate projections for short- and medium-term, impact assessment is not available. Impacts and vulnerability of forest ecosystems to climate change in the short- and medium-term are very crucial for policy making, as well as for formulating and implementing forest management practices.

The present study makes an assessment of the impact of projected climate change on Indian forest ecosystems for the years 2020 and 2050. Assessment is carried out at the national level for General Circulation Model (GCM) grids. The assessment is based on climate projections of GCM of the Hadley Centre (HadCM3) using A2 (740 ppm CO_2) scenario of the IPCC Special Report on Emission Scenarios and the BIOME4 vegetation response model. The paper assesses likely change in net primary productivity and forest types over the grid sizes of 3.75 x 2.5 degrees across India. The study finds that, under A2 scenario, the Net Primary Productivity (NPP) increases by the year 2020 from -5% to 40% across different Agro-ecological Zones (AEZ). By the year 2050, it increases from 15% to 59%, and by the year 2070 it increases from 34% to 84%, compared to the 1975 base year.

Key words: BIOME, climate impacts, forests, India, Net Primary Productivity.

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ID-304

YIELD AND CARBON SEQUESTRATION POTENTIAL OF WHEAT-POPLAR BASED AGRI-SILVICULTURAL SYSTEM

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The planting of poplar along agricultural crops, specifically winter cereals (wheat), has become an important activity to diversify the traditional crop rotations. The tree-crop inter-planting system has become attractive due to its higher productivity compared to cropping alone. This system also promises higher long-term sustainability under the irrigated agro-ecosystem and will open up new avenues for the farmers for carbon mitigation. However, farmers cannot depend only upon the income generated from the trees in the form of carbon credits.

In this study, we quantify the carbon sequestration potential of poplar-based agri-silvicultural system. After six years, total biomass (above and below ground) in the agri-silvicultural system was 25.2 t ha^{-1}, which was 113.6 % higher than wheat cultivation alone. Poplar tree stems alone contributed 21.99 t ha^{-1}. Net carbon storage (soil + tree/crop biomass) was 34.61 t ha^{-1} in wheat-poplar system compared to 18.74 t ha^{-1} in wheat cultivation alone (soil + crop biomass). After six years of poplar planting, organic carbon increased in the soil (0-15 cm) by 2.46t/ha (35.6 per cent) compared to the pure wheat crop. Although there was substantial loss in wheat crop yield under poplar, the decrease in wheat yield has been compensated by the poplar trees in terms of biomass, economics and carbon mitigation. The results indicate a large productivity potential of the system and large opportunities for carbon sequestration. Moreover, once harvested, some of the wood biomass carbon will be retained in durable wood products.

Key words: carbon allocation, poplar, system-productivity, wheat.

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ID-205

THE DETERIORATION OF THE ATLAS CEDAR (*CEDRUS ATLANTICA*) IN ALGERIA

Haroun Chenchouni[1], Abdelkrim Si Bachir[2] and Athmane Briki[3]

Following the planet climatic warming, Algeria is affected by the deterioration of various forest ecosystems (pine, Cedar and oak plantations), in particular those situated in the semi-arid bioclimatic areas, which are influenced by the climate of the Algerian desert.

The Atlas cedar (*Cedrus atlantica*) is an endemic species of the North African Mountains (Algeria and Morocco). It is an Algerian rare ecotype, occupying a total area of 30,000 hectares. Currently, this species crosses a long period of dryness due to climatic variations, at the origin of its deterioration and degradation of its floristic succession. This process may also be the cause of the disappearance of many animal species, such as the Crimson-winged Finch, the African Lynx and the Barbary sheep.

Several studies were undertaken in order to know the origin of this decline and propose solutions to recover degraded forests. However, these studies remain fragmentary. This communication is a synthesis on this regressive natural phenomenon, which is affecting from 40 to 60% of the Algerian natural cedar plantations. It highlights the advanced hypothesis that it could be in fact, the result of the interaction of several factors governed by biotic and physic natural stress, behaving in a consecutive or concomitant way namely: (i) Factors of predisposition, which weaken the ecosystems (climate warming, reduction in precipitations); (ii) Factors of incentive, which support the appearance of the imbalance symptoms. They act in an intense way over a short period, can be of physic origin (extreme climatic events) or of biotic origin (defoliator insects *Coleoptera*: *Acleris undulana*, *Epinotia algeriensis* ; *Lepidoptera*: *Thaumetopoea bonjeani*, *Thaumetopoea pityocampa)* or cryptogrammic agents (*Hypodermella* sp., *Lophodermium cerina, Verticillium* sp., *Armillaria* sp.); (iii) Factors of contribution that accentuate the disturbance: Abiotic stresses, xylophagous coleopters (*Buprestidae*, *Scolytidae*, *Cerambycidae*, *Curculionidae*, *Bostrychidae*), fungus causing rot, etc.

Key words: Algeria, *Cedrus atlantica,* decline, global warming.

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ID-018

VALORISATION OF THE FAUNA COMMUNITIES IN THE ALGERIAN FORESTS: CASE OF THE NATIONAL PARK OF BELEZMA (ALGERIA, NORTH AFRICA)

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and AbdelHafidh Hamchi[2]

The national park of Belezma is located in North Eastern Algeria (North Africa), close to Batna (300,000 inhabitants) and covers an area of 26,250 ha. The park contains a rich biodiversity, which presents scientific, economic and aesthetics values, of national and international importance and confers them a biosphere statute. Climate change poses a particular threat to biodiversity by partially decoupling the climatic and physical environments. An assessment biodiversity is a necessary first step in the evaluation of vulnerability to climate change and the development of adaptation measures.

A much-tormented relief with narrow valleys and peaks culminating up to 2,138 m characterizes Belezma National Park, situated in the semi-arid with fresh winter Mediterranean bioclimate. The trees characterizing forests of the Park are *Cedrus atlantica*, *Pinus halipensis*, *Quercus ilex*, *Fraxinus xanthoxyloide*, *Juniperus phoenicea*, *Acer monspelanium*, *Juniperus oxyceduis* and *Olea europaea*. They constitute various vegetable formations: artificial groves, garigues, maquis and afforestations. This area is currently crossing a multiannual dryness period, which is at the origin of disturbances in the biological communities, in particular the deterioration of the Atlas Cedar (*Cedrus atlantica*).

The inventories revealed a settlement containing the majority of the species of Northern Algeria with 397 species, 1 shellfish, 241 insects, 2 fish, 5 amphibians, 19 reptiles, 111 birds and 18 mammals. The few number of the censed invertebrates is far to be exhaustive. Whereas in vertebrate (153 species) the Amphibians, the Reptiles, the Birds and the Mammals censed represent respectively 38.5%, 65.5%, 27.3% and 16.8% of the national populations for each class.

In the present communication, we will highlight the biological richness concealed in the forests of the Belezma National Park and its dynamics, with specific recommendations for the safeguard of the endemic and endangered species in the context of climate change. We will also highlight the various ecological statutes of the species, populations, communities and settlements of flora and fauna sheltered by the Park, for a sustainable management and wise uses of forest resources.

Key words: Algeria, biodiversity, fauna, flora, forest, National Park of Belezma.

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ID-019

SIMULATION OF PHOTOSYNTHETIC PRODUCTION OF BEECH (*FAGUS CRENATA*) TREES AFFECTED BY TEMPERATURE OSCILLATION AMPLITUDE

Y. Chiba[1], C. Migita[1] and Q. Han[1]

Global warming may cause various climate changes, including extreme weather events in different regions of the world. Much effort should be made to understand and predict the responses of forest ecosystems to such environmental changes. Although global warming apparently means the increase of mean air temperature, other effects may include changes in seasonal and diurnal pattern of air temperature, depending on regional and altitudinal locations.

This study addresses the understanding of effects of various temperature changes on carbon sequestration into forests, using a process-based model of canopy photosynthesis. Employing a photosynthesis model (e.g. Farquhar *et al.,* 1982), the key parameters related to the model (V_{cmax}, J_{max} etc) show seasonal changes along with air temperature. They also exhibit the spatial variations according to the leaf positions reflecting light environments in a forest canopy. Thus, the photosynthesis parameters can be expressed as functions of air temperature and solar radiation. The 3D light environments in a forest canopy are also considered to simulate leaf photosynthesis. In a secondary beech (*Fagus crenata*) forest (mean tree height and stand age were ca.20m and 80 years, respectively), the tree attributes such as tree height, DBH, and foliage distribution were formulated to describe stand structure. Considering such variations of micrometeorological conditions and photosynthetic parameters within a forest canopy, the effects of temperature changes on canopy photosynthesis were simulated. Since foliage mass of individual trees as photosynthesis apparatus differ in a forest stand, dominant trees should perform higher carbon gain. However, global warming may decrease photosynthesis particularly in summer. This could be remarkable for smaller trees with less foliage mass, specifically when the amplitude of temperature oscillation increases. The reason for this is the increase of respiration of all tree organs with higher temperature. Higher temperature, particularly in summer, may exert critical effects on survivorship of smaller trees in a forest.

Key words: air temperature, forest dynamics, global warming, seasonal change, stand structure.

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ID-144

CHILLING REQUIREMENTS OF ASH (*FRAXINUS EXCELSIOR* L.) AND CLIMATE CHANGE

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Trees growing today and in the future face unprecedented rates of climate change. In Great Britain, the question arises as to whether native tree populations will be robust enough to regenerate and grow well to harvestable age or whether we should look further south for germplasm more likely to perform better under warmer climates. Common ash (*Fraxinus excelsior*) is a deeply dormant species whose seed requires chilling pre-treatment to ensure germination. Timing of spring leaf-flush is also influenced by winter chilling and is important as new shoots are highly sensitive to frost, leading to forking and poor form. Given predicted increases in temperature for southern England of 3-5ºC warmer by 2080, there is concern that chilling requirements of local populations will not be met. We present results from studies of chilling requirements for seed germination and leaf flushing in the context of predicted climate change.

1. Seed from ten populations of ash were collected along a latitudinal transect (60°N-48°N) and given increasing periods of cold pre-treatment. Populations from more southerly latitudes germinated with minimal chilling (12 weeks cold pre-treatment) whereas populations from higher latitudes required increased chilling for germination (24 weeks cold pre-treatment). As a consequence Scottish populations of ash may face serious restrictions in their ability to regenerate naturally under future climates.

2. Dormant twigs were collected from six populations (latitudinal range 55°N-47°N) growing in a provenance trial in southern England and assessed for flushing after different lengths of time in a cold store. For flushing to occur in approximately half the twigs, populations from Great Britain and Haute-Saône (France) required 43 days of chilling; populations from Normandy (northern France) needed 29 days chilling and those from Romania required only 15 days chilling. Impacts with respect to growth and the production of quality ash timber will depend on both winter temperatures and the continued incidence of late frosts.

Key words: chilling requirement, dormancy, *Fraxinus excelsior*; germination tests, phenology.

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ID-271

CLIMATE CHANGE AND INDIGENOUS COPING RESPONSES IN WEST AFRICA

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Climate change is already affecting people across West Africa and presents the greatest challenge to the attainment of the Millennium Development Goals. Climate plays a role in generating weather conditions that drives drought, floods, fire and pest outbreaks, increasingly affecting forest resources and agriculture productivity. Declining rainfall and great uncertainty about its distribution in time and space have had considerable impact on agriculture and forest productivity. It is generally accepted that ability to adapt to climate change depends on the level of development. Underdevelopment limits adaptive capacity because of lack of resources to hedge against extreme but expected events. A distinctive characteristic of West Africa is its extreme poverty. Out of the 49 least-developed countries, 14 are West African States, that is all except Ghana, Nigeria and Côte d'Ivoire.

The question is how are the communities in this region coping with climate variabilities? Indigenous communities in the region have survived through adjustments to year-to-year climate uncertainties. The strategies adopted have their own strengths and have helped to withstand some of the pressure posed by climate change. The strategies include using environmental cues to predict expected events such as rainfall, drought, fire and pest outbreaks; changes and adoption of management practices that modify threats, and prevent effects; diversification of livelihoods and sharing losses. It is suggested that an inventory and analysis of local adaptation strategies related to climate variability be undertaken with the aim of identifying best practices for dissemination at the regional level.

Key words: climate change, coping responses, indigenous communities, underdevelopment.

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ID-146

WINTER TEMPERATURE RISING IN COLD MEDITERRANEAN AREAS: A NEW CHANCE FOR THE EVERGREEN OAK SPECIES?

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During the last 50 years, the area under Mediterranean influence in the Iberian Peninsula has experienced an increase in air temperature and evapotranspiration, a greater frequency of severe summer droughts, and a decrease in relative humidity. Winter deciduous oaks (e.g., *Quercus faginea* Lam., *Q. pyrenaica* Willd.) have been proposed as the dominant species under transitional phytoclimates between the strictly Mediterranean and the Nemoral types. Winter cold stress in the Nemoro-Mediterranean phytoclimates favours the establishment of these species in exchange for evergreen oaks, where distribution is limited by minimum temperatures. However, during the last winters of the century, deciduous oaks, which formed dense forests in the Mediterranean mountains at mid elevations, have been progressively replaced by the evergreen *Q. ilex* subsp. *ballota* (Desf.) Samp. Phytoclimatic simulations have shown that the replacement of deciduous oaks by evergreen oaks could be either a consequence of temperature rising associated with climate change or intense soil degradation. Probably, both factors operated synergistically in the past. In high mountains with poor and superficial soils in the coldest and most humid areas of the Mediterranean region, *Q. ilex ballota* may replace deciduous oaks in the most northern Mediterranean areas. In numerous areas, the low water storage capacity of poorly developed soils would explain the current dominance of *Q. ilex ballota*, due to its high drought resistance and plastic response to low water availability. The substitution of winter deciduous by evergreen species implies, from an ecophysiological point of view, the existence of a new stress period that cannot be avoided by leaf shedding. However, in winter, *Q. ilex ballota* develops photoprotection mechanisms to endure low temperatures associated with high light levels in the most continental and mountainous regions of the Iberian peninsula. We therefore suggest that increased temperature in continental Mediterranean areas could be beneficial for the spread of the drought-resistant evergreens if maximum summer temperatures are not limiting for growth.

Key words: evergreenness, winter, photoprotection, drought, *Quercus.*

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ID-269

GUIDELINE FOR CLIMATE CHANGE VULNERABILITY ASSESSMENT OF FOREST ECOSYSTEM SERVICES IN ADAPTATION OF WATER RESOURCES IN WEST AFRICA

Yacouba Noël Coulibaly, Monica Idinoba, Elke Verbeeten and Johnson Nkem[1]

Water resource for human activities is a recurrent limiting resource, particularly in the Sahel where drought is prevalent. Major water sources are located in catchments under forest cover that are severely affected by degradation and deforestation. As climate changes, forests further degrade and so does the water resource. The vulnerability of the water resources to the climatic change in West Africa is identified to be significant. Several actions and strategies are being put in place. But the role of forest ecosystem in these adaptation strategies seems to be ignored. However, forest ecosystem plays an important role in the regulation of the hydrological cycle. It is therefore urgent to put in place adaptation strategies which take into account the role of forests so that these forests continue to provide their services in the regulation of hydrological cycle. This is even urgently needed in West African Sahel where tropical savanna forests are degraded by frequent recurring droughts, climatic fluctuations and anthropogenic pressures. Effects of this degradation of savanna forests are observed on the quantity and quality of water resources in major transboundary rivers in West Africa.

This paper proposes a specific methodology for assessing vulnerability of water resources to the climatic change in relation to the forest ecosystem. This specific methodology aims to contribute to ongoing adaptation strategies in West Africa by evaluating climate change and variability impacts on forest ecosystem services contributing in the regulation of water resource and therefore on surface water resource in terms of quality and quantity.

Key words: West Africa, climate change and variability, vulnerability assessment and adaptation, forest ecosystem services, water resources, methodology, quality and quantity.

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ID-027

DEALING WITH ERROR: WILL CLIMATE CHANGE HAVE A SIGNIFICANT EFFECT ON PREDICTIONS FROM EMPIRICAL GROWTH AND YIELD MODELS?

S. Coulombe[1], P.Y. Bernier[1] and F. Raulier[2]

The empirical growth and yield (G&Y) curves used in most timber supply models assume that growth conditions will be invariant over time, which may not be correct given projected future climate. However, prediction errors in G&Y models can be quite large and we therefore wanted to know the probability of detecting climate-change-induced growth anomalies as a significant departure from current G&Y predictions. The work was carried out in a boreal forest experimental area in Eastern Canada, where *Picea mariana* (black spruce) is the dominant species, using a field plot-based methodology inspired from operational timber supply projection methodology. Uncertainty in current G&Y projections was quantified through the inclusion of both sampling and model errors in successive bootstrap re-sampling schemes that yielded a percentile distribution of possible G&Y curves. Climate change effect on growth was represented as correction factors applied to current G&Y curves, the correction factors being based on comparative process-based modelling of growth under current and predicted climate. Uncertainty was then obtained by comparing yield curves for projected climate to the percentile distribution of possible G&Y curves under current climatic conditions.

Climate change assumptions yield an average projected increase of productivity of 29% for the overall black spruce strata across the experimental area. For the overall experimental area (all species), the probability of the climate-change modified G&Y prediction of being significantly different from the current G&Y projection is of 83% when considering sampling error alone, and of 69% when both sampling and modelling errors are included. For specific black spruce strata within that area, for which the initial inventory precision is greater than 70%, the probability increased to 95% and 83% for sampling error and combined sampling and modelling error respectively. These results, therefore, suggest a medium to high confidence in a departure of future growth curves from current projections based on empirical G&Y models. They also show the need to incorporate the notion of error in the generation of inference about the detection of climate change effects on forest growth.

Key words: uncertainty, growth projection, boreal forest, black spruce.

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ID-240

CARBON SEQUESTRATION IN BROAD-LEAVED AND KOREAN PINE MIXED FORESTS BY DIFFERENT HARVESTING PRACTICES IN CHANGBAI MOUNTAIN, NORTHEAST CHINA

L.M. Dai, L. Zhong, L. Zhou and D.P. Yu[1]

Forest harvesting practice affects the forest ecosystem carbon (C) storage in aboveground biomass, forest floor and soil C pools. The effect differs with forest type, harvesting practices and time since disturbance. Broad-leaved and Korean pine (*Pinus koraiensis* Sieb. et Zucc) mixed forest is the typical forest in the Changbai Mountains, northeast China. C sequestration over the 30 years after harvest in this forest is unknown.

Eight 1-ha study sites were selected and investigated in August and September 2007. Samples plots include four harvesting types (A: 30-years ago × 100%-cutting; B: 30-years ago × 30%-cutting; C: 15-years ago × 30%-cutting; and D: control - primary forest) and two sites selected for each type. The aboveground biomass pool contains all living vegetation; the forest floor pool contains all woody debris and the soil pool contains soil organic carbon to a depth of 50 cm. C storage in these pools was calculated by biomass and carbon densities. Total ecosystem carbon content (biomass, woody debris and soil) of the each type was A<B<C<D (9.7, 14.6, 15.2 and 22.1 kg C m-2), and significantly most of the total C is stored in living vegetation at the A type (61% *vs.* 47%, 41% and 25%). A type lost the most soil C than other types (12.2 *vs.* 8.7, 5.4, and 0 kg C), and the losses were much lower in the 30-50 cm layer of the soil in harvest sites. Overall, harvesting practices cause C loss (vegetation>wood debris>soil). With the vegetation recovering, C storage can increase (vegetation>wood debris and soil). Evidence for loss of soil C during harvest and gain during succession to soil depths of 0-20 cm is presented.

Key words: carbon sequestration, Changbai Mountain, harvesting practices, Korean pine and Broad-leaved mixed forest, Northeast China.

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ID-182

UNRAVELING THE INFLUENCE OF TEMPERATURE, LATITUDE AND LOCAL ENVIRONMENT ON THE REPRODUCTION OF SIX FOREST HERBS ALONG A LATITUDINAL GRADIENT

P. De Frenne[1], A. Kolb[2], K. Verheyen[1], M. Hermy[2] and B. Graae[3] *et al.*

Evidence of climate change and influence on natural ecosystems are increasing worldwide. We wanted to provide insight in the effect of climate change, and more specifically temperature compared to latitude and local environment, on reproductive traits and herewith associated colonization ability of perennial herbaceous forest plant species along a 1500 km SW-NE European latitudinal transect. We collected data in forest plant populations along a latitudinal gradient. Seed production was quantified as Resource Investment in Reproduction (RIR), i.e. the product of seed number and seed mass. Germination was quantified as Germinable Seed Output (GSO), i.e. the product of seed number and germination percentage.

We show that for all investigated species, the accumulated temperature explained 28% and 55% of the variation in RIR and GSO, respectively. The sign of the effect depended on the phenology of the species. For species flowering in early spring, RIR and GSO increased with increasing temperature, whereas RIR and GSO of late flowering species decreased. For the latter species, local environmental variables were also important to explain the variation in RIR

We conclude that the impact of climate warming on the reproduction of herbaceous forest plant species will be most obvious for spring blooming species. Our results demonstrate that the impact of climate warming on the sexual reproductive traits of herbaceous forest plant species will be positive for spring blooming species and negative for late summer blooming species. This suggests that both the seed production and germination step of the recruitment cycle of spring bloomers can improve when climate gets warmer, whereas late summer blooming species can become more vulnerable. Therefore, climate change adaptive forest management (e.g. design of dispersal corridors, assisted migration) should take these findings into account.

Key words: climate change, herbaceous forest species, latitude, temperature.

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ID-095

EFFECT OF GLOBAL CLIMATE CHANGE ON RARE TREES AND SHRUBS IN THE SOUTHERN UNITED STATES

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In the past, climate has fluctuated with periods of cooler, warmer, drier or wetter weather than at present. Plants have been able to adapt, but widespread, rapid warming could be disastrous for rare trees and shrubs. Rare plant and rare plant communities often exist as relicts of times past, and have survived locally due to very particular combinations of environmental conditions.

This paper underlines some of the challenges faced by conservation efforts for the maintenance of rare plants and rare plant communities in general, and of rare trees and shrubs in particular. A drier climate could be stressful for rare plants, but a wetter climate would cause flooding. Wetlands are already degraded and will be vulnerable to drying out in a warmer atmosphere. Rare trees and shrubs in the southern United States will likely be more vulnerable to extinction as a result of climatic warming. One third of rare plants occur in mountainous regions and many of these may find refuge by ascending in elevation. Many rare species have characteristics that place them at risk, such as small populations, being habitat specialists or being endemics with limited geographic ranges. A number of these are confined to areas spanning 100 km or less in latitude and very few have continuous distributions with no disjunctions of more than 100 km. In many areas, development has restricted the options for adaptation by rare species. Lower elevation plant communities are vulnerable to rising sea levels, and exotic plant and animal species will be a problem. Many rare trees and shrubs will probably become extinct in the absence of human intervention.

Key words: endangered species, rare shrubs, rare trees.

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ID-279

ROLE OF COMMUNITY-BASED FOREST MANAGEMENT TO ADDRESS CLIMATE CHANGE PROBLEM: A CASE OF NEPALESE COMMUNITY FORESTRY

M. Dhakal[1] and M. Masuda[2]

Forests have central roles in climate change. The conservation of forests sequesters carbon from the atmosphere and also regulates the carbon cycle. However, knowingly or not, the world's forests are being deforested and degraded annually at the rate of 0.18% and their carbon emitted to the atmosphere. The IPCC (2007) reported that deforestation and forest degradation accounts for one fifth of the total carbon emission, which is second in proportion to fossil fuels. Since 1.6 billion people depend to varying degree on forests for their daily livelihood, not all deforestation is undesirable. Therefore, to conserve forests and find livelihood opportunities for forests surrounding people is a prerequisite to address many climate change problems, especially in developing countries, and is a growing concern to forestry researchers, planners and policy makers.

The study examines the role of community-based forest management in carbon mitigation and adaptation, taking the examples of Nepal's community forestry program. In the program, the Government hands over a part of national forests to local communities with sole forest management authority. However, the Government retains ownership rights on forestland. Local communities, organized through a local institution called Community Forest User Group (CFUG), manage the forests. They also form an operational plan with technical prescriptions and a constitution with forest management rules and regulations. The implementation results showed that the CFUGs are not only effective in organizing local people and constructing a local institution for forest conservation and management activities, but also they are able to collect a community fund from the sale of forest products and carry out various community development activities. These development activities have roles to improve the livelihood of forests surrounding people and eventually to address climate change problems.

Key words: Nepal, community forestry, local institution, climate change.

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ID-184

IMPACTS OF CLIMATE CHANGE ON FOREST RECREATION AND TOURISM AND THE LIVELIHOODS OF COMMUNITIES THAT DEPEND ON THIS INDUSTRY

Alison T. Dimond[1], Perry Brown[2] and Wayne Freimund[3]

Research suggests that climate change will have significant impacts on forest ecosystems, including changes in fire and other disturbance regimes, species distributions, and hydrology. These changes to forest ecosystems will have significant impacts on forest-based recreation and tourism, and on the communities whose livelihoods depend on this industry. Understanding these impacts is important to forests' and forest managers' ability to adapt to climate change.

This paper will provide a review of current research on this topic including: (1) how the impacts of climate change on forests may impact tourism and recreation opportunities; (2) possible changes in tourist and recreator demand due to climate change impacts on forests; and (3) impacts on the people and communities whose livelihoods depend on forest-based tourism and recreation. Existing research on the impacts of climate change on forest-based recreation and tourism suggests there may be a short-term increase in demand in some areas, especially during spring and fall "shoulder seasons." However, in the long term, tourism and recreation demand is likely to decline as changes in temperatures, precipitation, species distribution, and related recreational opportunities occur. Winter recreation could be especially negatively impacted. This paper will also review research on how past disturbances and weather events similar to those predicted under climate change have impacted forest-based tourism and recreation. This research suggests that past disturbances, such as increased fires, result in significant decreases in tourism and recreation demand and local revenue.

The paper will review research on adaptations to climate change proposed for forest-based tourism and recreation. Finally, the paper will discuss how forest-based recreation and tourism experiences may play a role in influencing people to support climate change mitigation and adaptation actions. It will focus on research from forested mountain regions of the Northern Hemisphere, though many of the findings will be relevant to other regions.

Key words: climate change, tourism, recreation.

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ID-228

FORECASTING MANGROVE FOREST RESPONSE OF THE FLORIDA EVERGLADES TO SEA-LEVEL RISE UNDER CLIMATE CHANGE

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The near sea-level elevation and flat slope of the protected Everglades ecosystem, in Florida, United States of America, accounts for one of the largest contiguous tracts of mangrove forests found anywhere in the world and punctuates their potential vulnerability to rising sea level and freshwater management. Mangroves are highly productive tropical ecosystems and provide valued habitat for fisheries and shorebirds. Mangroves are halophytes and can, therefore, tolerate the added stress of waterlogging and salinity conditions that prevail in low-lying coastal environments influenced by tides. A landscape simulation model, SELVA-MANGRO, was developed for neotropical mangrove forests to investigate the potential impacts of climate change on the quality and distribution of future mangrove habitat. The SELVA model administrates the spatial articulation of the landscape composed of habitat classifications (forest, marsh, aquatic) and any forcing functions that predict changes in hydrology and climate. MANGRO is an individual-based model composed of a set of species-based functions predicting the growth, establishment, and death of individual trees. MANGRO predicts the tree and gap replacement process of natural forest succession as influenced by stand structure and environmental conditions. Sea-level rise was modeled as a function of historic sea-level conditions at Key West, Florida, based on mean annual tide records (1940 to present) projected into the 21st century with the addition of curvilinear rates of eustatic sea level expected from climate change.

Model results show that mangroves will overtake freshwater marsh and swamp habitat with increasing tidal inundation across the simulated landscape for all sea-level rise scenarios. The greater the rate of sea-level rise the faster or more extensive the encroachment of mangroves onto the Everglades slope. Increased freshwater outflow of proposed hydrologic restoration projects and structures are expected to offer little relief to sustained sea-level rise. Mangrove habitat will increase over the next century under climate change and conversely, freshwater marsh/swamp is expected to decrease.

Key words: forest modeling, mangrove, sea-level rise, tropical forest management.

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ID-355

TREES FOR ENERGY: A BETTER BET FOR BIOFUELS

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Although concern about continued reliance on non-renewable energy sources has brought attention to the use of biofuels, they are only a better alternative if they can be produced sustainably. Unlike growing corn for ethanol, which many fear will destroy natural habitats or replace land used to grow food crops, forest biomass is a renewable resource. Using forest biomass to produce biofuels is a potential source of clean energy, and can also play a beneficial role in managing for desirable forest structural conditions. Forest managers in the United States face the challenge of restoring forest ecosystems that have become densely stocked through decades of fire suppression, which requires the removal of large quantities of small-diameter and low-quality wood. In some cases, this woody biomass can be used to create biofuels. One common barrier to using forest biomass is a lack of complete information on potential yields. In this respect, the U.S. Forest Service has an advantage: access to comprehensive forest inventory data through the Forest Inventory and Analysis (FIA) program, which provides consistent forest cover and volume data for all forest lands, including total tree growth, mortality, removals, and wood production rates. Using this data, the Forest Service sought to identify areas large enough to support commercial-scale wood processing facilities based on fire hazard reduction treatments.

A recent assessment of 12 western states found that within the 24 million hectares of densely-stocked timberland currently at risk of stand replacement fire, 9.7 million hectares have the potential to offset treatment costs through biomass revenues. The areas offering the most promising opportunities are located near existing wood processing facilities. Through these types of analyses the U.S. Forest Service has the opportunity to achieve multiple goals: to promote ecological restoration by removing dangerous fuel build-ups, while also helping mitigate the impending effects of climate change.

Key words: biofuels, biomass utilization, climate change, forest management, restoration.

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ID-192

REACTION OF GROWTH AND LITTERFALL OF *FAGUS SYLVATICA* TO CLIMATIC VARIABILITY

Johannes Eichhorn[1], Inge Dammann and Uwe Paar

Tree reactions to different environmental impacts are normal phenomena in forest ecosystems. However, these reactions can also detect disturbances and be used as key indicators of forest ecosystem health and vitality. It is necessary to improve our knowledge on tree reactions, especially to identify and quantify disturbances caused by climatic stressors, including concepts of vulnerability or resistance and adaptability of trees.

As a result of more than 20 years of forest monitoring (ICP Forests), data on tree reactions to climatic variability are available in Hesse and Lower Saxony. The study analyses time series data from seven plots of intensive monitoring of beech (*Fagus sylvatica*) and within the systematic 8 x 8 km net of the Forest Soil Survey II in Hesse. Parameters cover growth patterns, branching habit, litterfall measures such as leaf and fruit biomass, leaf loss and discoloration, pests and diseases, and tree mortality.

In Hesse, 2003 was an outstandingly warm and dry year, particularly during summer. It was therefore chosen as test year for investigating the influence of climate on beech trees. In 2004, 2005 and 2007, the height of shoots was remarkably low. Because of climatic conditions, 2004 showed the highest fructification of beech within the monitored period. Compared to other tree species, annual mortality of beech is rare.

Comprehensive analysis of tree and stand growth patterns proved to be appropriate tools to provide findings on the impact, especially climate variability patterns. The behaviour of trees in stress situations can also be considered in the light of a cost/benefit analysis of a plant's capacity to capture energy, the tree's carbon allocation gains importance. Data collected on tree reactions, especially long term time series, are fundamental elements and firm basis of later modelling exercises and should inevitably have a high priority in any forest ecosystem related monitoring and research.

Key words: branching habit, *Fagus sylvatica*, litterfall, tree growth.

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ID-013

ASSESSING INDIGENOUS KNOWLEDGE FOR EVALUATION, PROPAGATION AND CONSERVATION OF INDIGENOUS MULTIPURPOSE FODDER-TREES TOWARDS ENHANCING CLIMATE CHANGE ADAPTATION IN NORTHERN ETHIOPIA

Edem A. Eniang[1,2] and Mulubrhan Balehegn[2]

Recognizing that northern Ethiopia will be exceptionally susceptible to climate change and its associated potential impacts as observable from years of repeated cycles of drought, a study of indigenous methods for Evaluation, Propagation and Conservation of indigenous multipurpose fodder-trees (IMFTs) was conducted to assess the role of traditional knowledge in fostering climate change adaptation in a sensitive and fragile agro-ecological system upon which livelihoods depend. An intensive study of communities and forests was made, using Ecological surveys and Rapid Rural Appraisal methods to document indigenous strategies for evaluation, propagation, conservation, current forest stock and health, while creating awareness of global climate change impacts and adaptation measures. Analysis of accumulated data was made, using SPSS 14.0. Results indicate that some communities of northern Ethiopia have a rich indigenous knowledge handed down over generations and have been cultivating IMFTs for diverse positive values (cultural, medicinal, fuel, environmental and livestock feed). Feed value of IMFTs was ranked first, followed by timber quality, biomass production, fencing value, soil and water conservation, ever-greenness and spiritual value, drought resistance and absence of allelopathic effects on crops. In comparing its multipurpose consumptive qualities, *Ficus thonningii* scored 8.39, out of 10, followed by *Cordia africana* (7.03), *Eucalyptus cameldulensis* (6.85), and *Acacia ethabica* (6.71). Appreciating these immense values and threats from changing environment, natives intensified propagation to averages of 5-10 cuttings per household per year and have perfected an indigenous protocol for evaluation, propagation and conservation, including care at different stages of growth. This practice has created a forested island and wildlife habitat in the midst of a highly denuded dryland landscape. Therefore, preferred IMFTs should be recognized as main-stream fodder plants and keystone species and adopted in agrosilvopastoral systems for enhancing opportunities offered by indigenous people towards adaptation and mitigation (carbon sequestration) in vulnerable regions.

Key words: climate change, drylands of Northern Ethiopia, indigenous knowledge, indigenous multipurpose fodder-trees.

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ID-296

CLIMATE CHANGE, RESETTLED COMMUNITIES, FOREST RESOURCES CONSERVATION AND LIVELIHOOD OPTIONS AROUND KAFTA-SHERARO FOREST RESERVE, TIGRAY REGION, ETHIOPIA

Edem A. Eniang[1,2], Genet F.Mengistu[2] and Teshale Yidego[3]

Recognizing that Ethiopia is exceptionally susceptible to climate change and its associated potential impacts observable from years of repeated cycles of drought, a study of the resettlement of Adigoshu, Globel, Idris and Menakeya communities to the fringes of Kafta-Sheraro Forest Reserve, which hitherto was highly reputed for its rich biodiversity and habitat, was conducted to investigate the subsequent interface of increased population, livelihood options and management objectives of the Reserve, with a view to evaluate the implications of this policy on forest health, management and conservation. Intensive surveys of both Reserve and communities were accomplished, using ecological surveys combined with Broad-Sweeps, Rapid Rural Appraisal methods and Focal Group Discussions to document impacts of resettled populations on adjourning landscapes and Reserve.

An analysis of accumulated data was made, using SPSS 14.0. The result showed a rapid increase in forest resources exploitation and destruction by communities while large mammalian wildlife species (Elephants, Kudus, etc) suffered increased poaching. Escalating demand for grazing land among other needs portends higher risks of conflicts, food shortages, habitat destruction and susceptibility to climate change impacts. Overall, illegal occupation, overgrazing, poaching, bush fires, fuel-wood and timber harvesting posed increasing threats to forest conservation. For livelihood options, 23 forest plants are regularly exploited. Fourteen species (61%) are harvested as livestock fodder but are also feed resources of wild herbivores, while10 species (44%) are harvested for timber. These findings highlight inherent risks of unplanned internal displacement of populations on climate change adaptation measures and call for an integrated people and environment approach for future policy and planning to enable communities to increase forest stocks while securing livelihoods. Ineffective planning and inadequate follow-up monitoring of developmental projects impacting on forest reserves is inimical to sustainable forest management and should be shunned by policy-makers and forests managers in this era of global climate change reality.

Key words: climate change, Forest Resources Conservation, Kafta-Sheraro Forest Reserve, Ethiopia, livelihoods options and resettled communities.

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ID-268

ANALYSIS OF THE SHIFTING OF PHENOPHASES OF COMMON BRITISH WILD PLANTS IN RESPONSE TO CLIMATE CHANGE

Arif M. Faisal[1], Anthony J. Davy[2] and Tim Sparks[3]

This study examines changes in the phenophases of 21 plant species recorded by a natural historian in United Kingdom over a 30-year period (1976-2006) in response to climate change. The trends in 30 phenophases were investigated against four climatic variables (air temperature, soil temperature, rainfall and sunshine), revealing not only that air temperature in preceding months significantly advanced the spring phenophases but also that soil temperature was responsible to a considerable extent for the advancement of spring phenophases in some species. However, rainfall and sunshine hours exerted only a very small influence on spring phenophases. On comparing the events with monthly maximum air temperatures and soil temperatures, 25 of the 30 phenological events were found to be significantly negatively related to air temperature, and four were significantly negatively related to soil temperature.

The investigation of temporal linear climate trends showed that air temperature and soil temperatures have increased by 0.45°C/decade and 0.63°C/decade respectively, reflecting rapid warming of the climate in the study area and resulting in an advance of spring phenophases by -6.4 days/decade over the study period. Analysis showed that an overall increase of 1°C air temperature would advance spring phenophases such as leafing and flowering by 4-16 days and delay autumn phases such as fruit ripening by 3-4 days. The current findings were found consistent in most cases with the previous findings. It can be concluded that winter and spring phenophases will get progressively earlier while autumn phenophases will be delayed as the climate warms.

Based on UKCIP02's 'low and high emission' scenarios, it was projected that most of the spring phenophases will dramatically advance, becoming 1-4 weeks earlier compared with the present time, if the current climate warming continues, raising concerns for the monitoring and conservation of woodland species and native wild flora in the United Kingdom.

Key words: phenophases, air and soil temperature, low and high emission scenarios, climate change.

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ID-178

CLIMATE CHANGE SCENARIOS FOR ARGENTINIAN FOREST AND PROTECTED AREAS

L.C. Fernández[1] and F. Alcobé[1]

The ability to predict what areas of the country will undergo the most drastic changes can be useful to conservation programs. The purpose of this work is to determine what areas of Argentinian Forest will be most greatly affected by changing temperatures and precipitation, in analyzing the results of MM5-CIMA regional model future scenarios in important areas for forest conservation and Forest National Protected Areas.

Baseline maps were created for a 30-year period between 1961 and 1990 using Climate Research Unit (CRU) databases. The base of information includes, among others: (a) monthly average temperature (°C*10); (b) rainfall monthly average (mm/day*10); and (c) radiation monthly average (W/m2). The information is in a global resolution cricket of 0,5° length. For future climate, data utilized the MM5-CIMA model results, that projected the climate change (2081-2090) for A2 and B2 IPCC scenarios, by calculating the differences in temperature and rainfall on ten years average between control and future model runs data. A geographical information system was established, using the projected climate scenarios, the National Forest Inventory Maps and information about important areas for forest conservation. Climate change scenarios were classified in nine categories related to the combination of high, medium and low temperature and precipitation. With this classification, more drastic changes projected on the important areas of forest for conservation were identified. Also, a rank of exposure to national forest protected areas was created, using season average data. From these maps, the work concludes focusing on the areas of the Argentinian forest most affected by climate change and identified priority sites for implementing projects that could include actions for mitigation and adaptation to climate change. It is possible to conclude that the forest ecosystems presenting more dramatic climatic change scenarios are those in the northwest of the country, particularly the cloudy mountain forest.

Key words: Argentina, climate change impacts, MM5 model, National Forest Inventory, protected areas.

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ID-302

BIOMASS EQUATIONS FOR *EUCALYPTUS GLOBULUS* IN PORTUGAL: AN ASSESSMENT OF CARBON INVOLVED IN FOREST HARVESTING

L. Fontes[1], M. Tomé[1] and M. Baptista Coelho[1]

Operational forest harvesting collects merchantable volumes from forest plantations. Such merchantable volume is often defined by technical measurements based on an upper stem diameter value. For Multifunctional Sustainable Forest Management (MSFM) in the context of climate change, it is interesting to evaluate not only the output of forest in terms of harvested merchantable volume but also in terms of the total stem carbon involved in such operation. Although merchantable volumes involved in forest harvesting have been widely studied for *Eucalyptus globulus* in Portugal, the information on the amount of carbon involved in such operation is scarce.

We therefore developed allometric biomass equations for *Eucalyptus globulus* in Portugal from which stem and crown (foliage and branches) biomasses can be estimated using an upper stem diameter value. The equations were adjusted using an existing dataset obtained by destructive sampling in plantations covering the Portuguese *Eucalyptus globulus* distribution. From the estimates of these biomass equations, the amount of carbon is estimated based on existing conversion factors which were obtained by destructive sampling with the study of the chemical composition of different components (wood, bark, branches and foliage). The system of equations will be used to estimate carbon removal from eucalyptus stands with different harvesting intensities.

Key words: stem biomass, carbon, merchantable volume, *Eucalyptus globulus.*

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ID-331

ADJUSTMENT OF AN EMPIRICAL GROWTH AND YIELD MODEL TO ACCOUNT FOR EFFECTS OF CLIMATE CHANGE ON FOREST PRODUCTION

M. Freeman[1], P. Wikström[2] and B.O. Elfving[3]

In forest management planning, it should be possible to handle that climate change is currently altering the environmental conditions for forest growth and will continue to do so in the future. Traditionally, empirical growth and yield models based on historical growth data and historic environmental conditions have been used to reliably predict forest timber production. The weakness of these models is, though, that they do not incorporate a mechanistic description of the interaction with the environment and, thus, their predictions in a changing climate become less reliable.

We present a method using process-based modelling for adjusting an empirical growth and yield model to be responsive to climate change. The relative effect of climate change simulated by the process-based model is used to adjust the prediction of the empirical model for every 5-year period according to actual stand condition. The responsiveness is primarily based on simulations driven by GCM-scenario data; ECHAM4 and HadAM3 with emission scenarios A2 and B2 from IPCC's SRES, regionalised by the Swedish Meteorological and Hydrological Institute. The study area is Sweden but the principles are general. Effects of elevated CO_2 and temperature, changed patterns of precipitation, as well as feed back on tree growth from soil fertility and soil water availability, are considered. The end-use of the adjusted empirical model does not require any additional data to those already found as input or output in the original empirical model. This is in contrast to many other methods in literature, where requirements of substantial amounts of additional input data represent a hinder for its practical use. The method of adjustment that we present is applicable to stands, whether they are already present at the year of inventory, established at the year of inventory, or planned to be established in the future. The response of forest stands to changes in climate predicted by the adjusted empirical model is sensitive to management. For stands already present at the year of inventory we show the importance of stand management history for the predictions of future growth.

Key words: climate change, empirical growth and yield model, forest management planning, process-based modelling, scenarios.

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ID-154

LAND-USE/LAND-COVER CHANGE, DEFORESTATION AND FOOD INSECURITY IN ETHIOPIA

E. Garedew[1,2], M. Sandewall[2] and U. Söderberg[2]

Poor people living under harsh dryland conditions are vulnerable to sudden environmental and climatic changes affecting their subsistence agriculture. When forest cover decreases, they often lack safety nets to compensate food shortage. Increased population pressure and reduced access to common lands add to this effect.

This paper addresses the complexity of land-use/land-cover (LULC) change and its impacts on human and ecological security in a tropical semi-arid region, the Ethiopian Middle Rift Valley. In the study, remote sensing and participatory field point sampling were used to estimate LULC changes and identifying the driving forces of those changes, while qualitative and quantitative methods were used to assess farmers' non-farm activities, their general perceptions of food insecurity and examine the determinants of food insecurity.

Over the past three decades, there has been a dramatic change of LULC (deforestation and cropland increase) in response to a combination of climatic variability, demographic, economic and institutional conditions. Farmer's dependency on off/non-farm incomes has increased. In Ethiopia, like other least developed countries, seasonal variability of both production and consumption is characterizing the farming systems. A remarkable proportion (23%) of households was subjected to food insecurity, even in a year of good rains (quantity and distribution) as 2006. Food insecurity condition was attributable to population pressure, low possession of livestock and shortage of cropland, low-income level in non-farm activities, limited capacity to invest agricultural inputs and early sell of part of the products to return loans and for other household expense.

Key words: climate variability, Ethiopia, participatory point sampling, remote sensing, Rift Valley.

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ID-197

EXPERIMENTAL FROST AND DROUGHT AFFECT FINE ROOT DYNAMICS AND CARBON INPUT TO THE SOIL IN A SPRUCE FOREST

Dirk Gaul, Dietrich Hertel and Christoph Leuschner[1]

Fine roots represent a small but functionally important element of ecosystem carbon cycling. Assuming that fine roots live and die within one year, fine root turnover is estimated to transfer about 30% of the global net primary production to the soil. However, the impacts of global change on fine root dynamics are very uncertain. Meteorologists predict temperature increases as well as stronger and more frequent summer droughts for many regions of Central Europe. However, climate change might also produce some unexpected effects. In that context, decreasing snow cover in winter may result in stronger soil frost at higher latitudes and in mountainous regions even though average winter air temperatures are increasing.

In our study, we investigated the effects of experimental soil frost and soil drought on fine root production, mortality and decomposition of Norway spruce (*Picea abies* (L.) Karst.) in Southeast Germany. In order to simulate these extreme meteorological conditions, we applied a replicated snow removal experiment during winter 2005/06 and a replicated throughfall exclusion experiment during summer 2006. We used two different methods (minirhizotron observations and sequential soil coring) to monitor root production and mortality in the organic layer and the upper mineral soil of treatment and control plots. Fine root decomposition was investigated in a root-litterbag experiment.

The results showed that fine root mortality was significantly increased by both, experimental frost and drought. However, enhanced fine root production at the treatment plots compensated for the root loss caused by these extreme meteorological conditions. As a consequence of increased fine root death, we estimated that experimental frost and drought led to an additional carbon input to the organic soil layer in the studied spruce stand of 21 and 26 g m^{-2}, respectively. Our root-litterbag experiment indicated that fine root decomposition was significantly reduced during soil drought. We conclude that increased frequencies of freeze-thaw and drought-rewetting events in the frame of climate change will enhance the carbon sink strength of Norway spruce fine root systems. However, compensatory root production may draw on the carbohydrate reserves of the spruce trees, thereby possibly reducing their above-ground productivity.

Key words: climate change, minirhizotron, fine root mortality, soil coring, throughfall exclusion.

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ID-040

MODELING DIAMETER GROWTH IN OPEN OAK WOODLANDS USING GAMMA REGRESSION

G. Gea-Izquierdo and I. Cañellas[1]

It has been shown how global warming is affecting Mediterranean species, including *Quercus ilex* L. (holm oak), by modifying the growth period and increasing sensitivity to climate. Modelling growth in open woodlands is likely to be different than in closed forests, as competition, particularly for light, is reduced or absent.

In this study we model diameter increment growth for holm oak, the most important tree species in open oak woodlands from the West Iberian Peninsula and one of the most widespread broadleaf species in the Mediterranean Basin. There are no models in the literature for this species in the area, despite its ecological and economical imprtance. However, it is necessary to develop models and simulate holm oak growth for multipurpose forestry in these woodlands. This is due, among other reasons, to the secondary importance of holm oak timber in the agrosilvopastoral systems we study, and to the difficulty of estimating age and growth from either cores or wood sections in the species. For this reason, it is interesting for management to propose age-independent models, as an alternative to age-dependent formulations. Classical gaussian log-transformed models were compared to Gamma Generalized Linear Models (GLM), which were unbiased, more parsimonious and with lower errors. Thus, we used Gamma GLMs to model diameter increment growth in age-dependent and age-independent formulations. The variable explaining most variability was age, and in age-independent models, diameter at 1.30 m, as a substitute of age. This was reflecting the absence of reduced aerial competition. However, density was also selected in the final models, which shows that there is root competition, at least in the highest densities. These models are important tools to manage West Iberian open oak woodlands and can be utilized in combination with other previous growth models proposed to model the system and run simulations. Climate change could modify the response of trees to density and competition in woodlands. Therefore improved growth models analyzing the effect of competition are a necessary tool to manage these open woodlands under the threat of warming and increasing drought stress.

Key words: competition, 'dehesa', agroforestry, generalized linear model.

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ID-183

PROJECTED FORESTED LANDSCAPES UNCERTAINTIES AND THEIR SOURCES OF UNCERTAINTY

George Gertner[1] and Chonggang Xu[2]

For real world systems, projections made with the simplest to the most complicated model have statistical errors and uncertainties. For many ecological and environmental models, there can be hundreds of sources of uncertainties due to measurements, sampling, knowledge gaps, parameter estimates, multiple temporal and spatial scales, etc. By accounting for errors and uncertainty, a so called "error budget" can be developed. An error budget shows the overall precision of estimates/predictions made with a system, divided according to different types of error sources within and outside of the system.

The emphasis for the presentation will be geospatial systems used for modeling climate impacts on forested landscapes. As an example, a case study will be presented where a large transitional forested area located between the boreal and temperate regions in the north central United States of America is projected through time with a spatial dynamic forest landscape model system, LANDIS-II. The primary drivers for this modeling system come from an ensemble of Third and Fourth IPCC climate scenarios and model prediction profiles of CO_2, temperature, precipitation, and photosynthetic active radiation. Spatially identifying the sources of uncertainties, modeling their accumulation and propagation, and finally, quantifying them locally and globally. Optimal error management will be discussed.

Key words: error budgets, forest landscape, global climate change, uncertainty.

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ID-125

INTEGRATION OF CLIMATE ADAPTATION AND MITIGATION MEASURES IS CO-BENEFICIAL FOR FOREST DEVELOPMENT IN ARMENIA

Artur Gevorgyan[1]

So far international initiatives have mostly focused on mitigation of climate change through a reduction of greenhouse gases (GHG) emissions. The UNFCCC and the Kyoto Protocol (KP) aim at stabilizing greenhouse gas emissions at a level that would prevent dangerous anthropogenic interference with the climate system, applying legally-binding measures. By elaboration of the national GHG inventory system for the LULUCF lately, it has been possible to reveal a number of areas aiming at the enhancement of the carbon sink and sequestration nationally. Improved forest management, together with Afforestation/ Reforestation (A/R) activities, offers considerable climate change mitigation potential. Recently, it has also been recognized by the Parties of the Convention that the adaptation to climate change and its adverse effects is an issue of higher priority for all countries. Therefore, while advancing forest management practices and fostering A/R initiatives, some core adaptation measures should be implemented simultaneously. Identifying and planting drought-tolerant tree hybrids and species, controlling undesirable plant species through forestry treatments, maintaining biodiversity by planting species that are better able to adapt to future climate change, are some actions in response to anticipated climate impacts in the country.

Those considerations have been taken into account while developing the Community Small-Scale A/R CDM Project in Lori region of Armenia under the "Technical Assistance to Armenia, Azerbaijan, Georgia and Moldova with respect to their Global Climate Change Commitments" Regional TACIS Initiative in 2006. Although forest ecosystems will adapt naturally, the human dependence on forest resources to satisfy a variety of social, economic and environmental demands are influencing the process to a certain degree. Adaptive actions will help to affect the rate and direction of ecosystem changes and decrease the risks by preparing the forest sector of Armenia for adverse climate change effects and sustain forest-related mitigation activities more efficiently.

Key words: climate change, forest adaptation, mitigation.

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ID-041

STUDIES ON POPULATION STRUCTURE AND REGENERATION OF WOODY SPECIES IN DRY AFROMONTANE FOREST, SOUTH EASTERN ETHIOPIA

A. Girma[1] and R. Mosandl[2]

Under the framework of a project entitled "Silvicultural contributions towards sustainable management and conservation of forest resources in the highlands of Ethiopia", a study was conducted at dry afromontane to evaluate the present situation of the natural regeneration, composition and structure of the forest, in line with the recent trend in climate change and design sustainable management strategy (SMS).

Floristic composition, structure and regeneration at different altitudes ranging from 2,090 to 2,303 m were assessed. A total of 100 quadrates were systematically laid, each with an area of 900 m^2 each. DBH, height and other parameters were measured. In addition, regeneration status of woody plants was also assessed. A total of 36 woody species were recorded representing 35 genera and 28 families. Woody species density was about 712 stems/ha, and the total basal area was 9.5m^2 /ha. Species were prioritized for conservation using importance value index (IVI), population structure and regeneration status as criteria. Five types of population structures were found.

The height, diameter and IVI distributions of the overall forest indicated differences in species population structure. Although the regeneration of the forest as a whole looks good, the regeneration of some of the commercially valuable species, including *Aningeria adoifi-fried*erici and *Olea hochstetteri,* was very poor or absent. There was also poor uniformity in the growth pattern of individual species. This could be attributed to the recent trend in climate change, inherent growth capability of the species, site condition, man-made disturbances and herbivores. The results show the consequences of ecological crisis and depletion of the flora genetic diversity due to change in climate, human intervention, including selective logging and uncontrolled grazing.

Key words: climate change, dry afromontane forest, population structure, regeneration, sustainable management strategy.

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ID-350

QUANTIFYING THE HEIGHT GROWTH-TEMPERATURE RELATIONSHIP OF PLANTATION TAIWAN SPRUCE

Biing T.Guan[1], Chih-Hsin Chung[2] and Shu-Tzong Lin[3]

The future of the endemic Taiwan spruce (*Picea morrisonicola* Hay.) under climate change is of great concern, both globally and locally. It is the southernmost species of the genus and its current distribution is limited to high altitudes of Taiwan. As a first step toward assessing the impact of future temperature changes on the species, we quantified the effects of past temperature regimes on the height growth of plantation Taiwan spruce based on nonlinear mixed-effects growth analysis. The temperature variables examined included the monthly mean values of temperature, maximum temperature, minimum temperature, and temperature range. Our findings showed that monthly mean temperature had the greatest influence on height growth rate, and monthly mean temperature range had the least influence. Within each temperature variable, at least half of the monthly means showed some effect on height growth rate. A rising temperature regime of the previous month of July had the greatest influence on current year height growth. An increase in the monthly mean maximum temperature during the active height growth period had a positive effect on current year height growth, whereas an increase after that period usually had a negative effect on the following year's height growth. An increase in the monthly mean minimum temperatures usually had a negative effect on height growth.

This study showed that Taiwan spruce responded not just to the mean temperature, but also to the temperature extremes. Past temperature changes had both positive and negative effects on the height growth of the species. If the established height growth-temperature relationship holds, the influences of climate change on Taiwan spruce height growth will depend on the timing of the temperature increases, both on a daily and a monthly scale, as well as on the trees current heights and ages. Thus, when assessing the impact of climate change on tree growth, we should consider the effects of an entire temperature regime.

Key words: height growth, nonlinear mixed-effects regression, *Picea morrisonicola,* stem analysis.

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ID-161

LOW-ENERGY WOOD-FRAMED BUILDINGS HEATED WITH BIO-BASED CHP PLANTS

Leif Gustavsson and Roger Sathre[1]

Efforts have been made to reduce the energy needed for the operation of buildings by improved insulation, reduced leakage through the house envelope, and by heat recovery of ventilation air. These measures result in an increased material use and hence increased energy use in the production and construction phases. As the energy used for operation decreases, the relative importance of the other life cycle phases increases, and together influence an optimization aiming to minimize the total life-cycle energy use and net CO_2 emission. The focus of most low-energy houses, including "passive" houses, has generally been on minimizing energy use in the operation phase, while the energy use of the other phases is sometimes neglected. Hence, for such houses, the choice of structural material becomes more important for the total energy use. Wood-framed construction requires less energy and emits less CO_2 during their lifecycle than other materials. Primary energy use is also affected by the choice of energy supply system. The life-cycle primary energy use of a building depends on the energy supply systems for electricity and heat, including fuel, end-use heating systems and large-scale heat and power supply. When optimising the energy use of buildings, it is necessary to apply a life-cycle perspective to both the buildings and the energy supply.

Environmental impacts can then be reduced in a cost-effective way, by considering life-cycle building costs, including external costs. In general, wood-framed constructions with low operational energy use together with energy-efficient biomass-based energy supply systems result in low life-cycle primary-energy use and CO_2 emissions. When a low energy wood-frame building is heated with an efficient energy supply system such as bio-based CHP plants, the CO_2 emission of both production and space heating during the building lifetime can be negative. This requires that the biomass by-products from the wood production chain be used to replace fossil fuels.

Key words: combined heat and power, low-energy buildings, wood construction material.

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ID-362

PERSISTENCE OF THE FOG-DEPENDENT FRAY JORGE FOREST IN SEMI-ARID CHILE DURING THE PAST TWO CENTURIES

Alvaro G. Gutiérrez[1], Olga Barbosa[2], Duncan A. Christie[3], Ek del-Val[4], Holly A. Ewing[5], Clive G. Jones[6], Pablo A. Marquet[2,7], Kathleen C. Weathers[6] and Juan J. Armesto[2,6,7]

The persistence of relict rainforest patches at Fray Jorge National Park (FJNP) in semi-arid Chile (30°40'S), a region receiving fog water inputs and only ~150 mm rainfall annually, seems uncertain in the face of climate change. An evaluation of forest structure and regeneration dynamics is critical to understanding the response of forest patches to climate change because they are likely to be dependent on water inputs from fog. We evaluated structural attributes in six forest patches (0.2–22 ha) in FJNP using 0.1 ha plots, and compared tree regeneration in three different habitats along a fog-input gradient within each patch. We used tree-ring analysis for the dominant canopy tree species, *Aextoxicon punctatum* (Aextoxicaceae), to assess establishment periods and growth trends, and their relation to climate.

Radial growth and establishment of *A. punctatum* were only weakly correlated with rainfall and El Niño Southern Oscillation Index (ENSO). However, vertical heterogeneity of the canopy was positively correlated with the abundance of *A. punctatum* juveniles, and tree regeneration followed a marked pattern of decline in association with decreased fog inputs. The importance of forest structure for fog interception as well as in the spatial pattern of recruits suggests a potentially important ecological role of fog water interception. Forest patches have regenerated continuously for at least 250 years, despite large fluctuations in annual rainfall driven by ENSO and a regional decline in rainfall during the last century. However, the persistence of the small rainforest patches is uncertain if recruitment becomes limited due to changes in rainfall or, more importantly, fog inputs.

The case of the FJNP is likely typical of fog or cloud-dependent forests in tropical, subtropical and semi-arid regions of the world, and whose survival depends on a set of particular conditions often linked to an interaction between local topography, soils and climate. Prediction of their vulnerability will need to incorporate multiple dimension of climate change. Preservation of forest structure may be critical to patch hydrology under any future climate scenario.

Key words: tree regeneration dynamics, temperate rainforest, Chile, fog, climate change.

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ID-272

COPING WITH CLIMATE CHANGE: HOW LOCAL COMMUNITIES USE TRADITIONAL KNOWLEDGE IN RURAL GHANA

B.A. Gyampoh[1], S. Amisah[2] and M. Idinoba[3]

Indigenous or traditional people often inhabit economically and politically marginal areas and their livelihoods depend on natural resources which are directly affected by climate change. Such people have immense knowledge of their micro-environment, having lived with it for millennia. But their knowledge is usually neglected in academic, policy and public discourses on climate change and adaptation. Coping with increasing climate variability and climate change is a major challenge in rural, less resourced, natural resource-dependent, low technology communities in the Offin River basin in Ghana.

In this paper, an overview is given of coping strategies by rural communities in the Offin River basin in Ghana to changing climate. Data was collected in 2007 through questionnaires, focus group discussions, interviews and field observations in 20 rural communities in the moist semi-deciduous forest region of Ghana. Key questions examined include people's observation of changes in their local climate, effects of the changes on their livelihoods, strategies adopted to live with the changes, how successful the strategies are, challenges in using the strategies, and what they think is the way forward. The study identifies current observed climate changes and impacts of such changes, particularly on local livelihoods; livelihood resources, and human resources of communities in the Offin River basin; and the extents to which these resources help the people to conduct their livelihoods and cope with the impacts of climate change. The coping strategies include water rationing, rainwater harvesting, indigenous knowledge in agriculture and water management, and traditional taboo/forbidden days when no one is to go to the riverside. These strategies, mainly based on traditional norms and practices, are less expensive and easy to implement but face serious challenges due to modernisation. This calls for support and integration of modern scientific and traditional knowledge in coping with effects of climate change.

Key words: climate change, coping strategies, indigenous communities, Offin River basin, traditional knowledge.

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ID-168

DESIGNING ADAPTIVE STRATEGIES FOR FORESTS UNDER CLIMATE CHANGE USING RISK MANAGEMENT

M. Hanewinkel[1] and S. Hummel[2]

The paper addresses the problem of how to incorporate risk assessment results that are incomplete or scale-dependent into climate adaptation strategies for forest management. After a short outline of the risk management process under changing climatic conditions, the paper covers the principal methodological approaches of risk assessment and modelling for the main natural hazards for forests (storm, snow, insects, fire). We summarize evaluation methods like statistical models, as well as expert systems and mechanistic models, and rate them according to their ability to be included in adaptive forest management strategies under climate change. Different levels of risk analysis, from the regional to the single-tree level, are discussed in the light of available databases and the most suitable risk models for these different scales are outlined.

In addition to the main natural hazards and their secondary effects - such as insect damage after storm events - and how to model these effects under climate scenarios that predict an increase of extreme events, the paper also takes into account economic effects associated with climate change. As an example, we evaluate the economic consequences of a shift in the major tree species in Europe under different climate scenarios and we propose management strategies to mitigate these effects. One way to deal with these effects may be diversification. The paper ends with a general theoretical framework for modelling risk in long-term forest planning and management with special emphasis on climate change. The framework includes the use of large-scale inventory data and the simulation of the effects of different climate scenarios using comprehensive simulation tools. The sensitivity of the results is evaluated and the outcomes of different strategies are ranked.

Key words: risk management process, climate change, simulation, risk modeling.

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ID-270

A DECISION SUPPORT SYSTEM TO DEAL WITH THE EFFECTS OF CLIMATE CHANGE ON FORESTS IN SOUTHWEST GERMANY

Marc Hanewinkel and Konstantin v. Teuffel[1]

The paper presents a large interdisciplinary research project dealing with the effects of climate change on forests in Southwest Germany. Central goal of the project is the development of a decision support system (DSS) that will help relevant decision makers to find adaptive management strategies under a variety of climate change scenarios.

The first phase of the project deals with a comprehensive vulnerability assessment based on the analysis and modelling of multiple risks. Biome shifts for the main tree species will be modelled using a Generalized Linear Model (GLM) approach based on NFI data and regionalized climate data for the main IPCC scenarios. A model for the risk of storm damage has been developed, based on NFI data using a GLM and a generalised additive model (GAM) that accounts for spatial effects of different wind speeds of the large storm event Lothar in 1999. Potential drought stress is modelled with the help of a water balance model based on monitoring data and genetic stress markers for main tree species are investigated. The risk of insect damage is modelled based on statistical data on salvage cuttings and a thermo-energetic model. Potential loss of habitat for endangered animal species is modelled using niche models. The multiple risks are combined into a spatially explicit vulnerability index for forest stands using decision rules and user preferences as well as attitude towards risk that are assessed in a survey. In the second phase of the project adaptive management strategies will be developed and evaluated using Multi-Criteria-Decision-Making (MCDM) methods. The paper presents first modelling results for biome shifts for Norway spruce and shows how storm damage probabilities will be used to define management strategies. A methodological approach how the vulnerability index will be compiled and how the results of the survey will be integrated in the system is presented.

Key words: climate change, risk modelling, biome shifts, storm damage, decision support system.

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ID-073

WAS THE LATEST OUTBREAK OF *GREMMENIELLA ABIETINA* IN SWEDEN CAUSED BY CERTAIN CLIMATIC SEQUENCES?

P. Hansson[1] and M. Ottosson-Löfvenius

National meteorological data for temperature and precipitation during a 17-year period (1985-2001) were used to characterize the weather five years before the outbreak of the forest pathogen *Gremmeniella abietina* in 2001-2003, affecting 480 000 ha *Pinus sylvestris* in Sweden. Furthermore, climate indices relevant to spore spread (length of growing season, precipitation and temperature sum) and disease development (winter temperature sum above -6ºC) were formulated and correlated to disease severity in adjacent plots sampled by the National Forest Inventory. The period preceding this largest known *Gremmeniella* outbreak in Sweden was characterized by a cold and wet growing season in 1998, followed by a mild and long winter period 1998/99 and then an extremely wet growing season in 2000. The precipitation during the growing seasons was the most important indicator. Furthermore, the disease was most severe in areas with relatively high precipitation also during the generally dry growing season in 1999.

The results from the current study and the general value of analyzing climatic sequences preceding historical fungal outbreaks to estimate effects of climate change on fungal epidemics are discussed. The study shows the unique possibility for large-scale investigations using high quality long time series of forest inventory data and climate monitoring.

Key words: climate, monitoring, weather, precipitation, temperature sum, disease, fungal pathogen, Scleroderris canker, Scots pine.

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ID-274

PROSPECTS OF AFFORESTATION AND REFORESTATION (A/R) PROJECTS IN INDIA FOR MITIGATING CLIMATE CHANGE

M.S. Haque[1] and K.G. Karmakar[2]

In India, estimates of the area of degraded lands that can be rehabilitated through Afforestation and Reforestation (A/R) activities under the Kyoto Protocol vary between 66 and 130 million hectares. However, hardly any projects are forthcoming due to strict land eligibility criteria, forest definition, additionality, high risks, low cost of Carbon Emission Reduction (CER) and complex methodologies involved for claiming carbon credits. Only recently, an A/R project was started for implementation in Orissa and Andhra Pradesh States. The World Bank has agreed to purchase the CERs at US$ 4.05. The 3,500 ha land area belongs to 2,800 farmers. The trees species planted are: *Eucalyptus tereticornis* and *Casuarina equisetifolia* clones. The contracted CERs represent 276,000 tonnes of CO_2. ITC, another agro-based company, had submitted to the United Nations an A/R project for rehabilitating 4,155 ha degraded lands owned by 4,725 farmers. The trees species are: *Eucalyptus camaldulensis* and *E. tereticornis* clones. The expected CERs are 20 tonnes CO_2 per ha per year. Both the plantations are managed intensively and will be harvested in a rotation of 4-5 years. The timber will be purchased by the companies and the CERs will be purchased by the World Bank. The non-permanence will be addressed by raising additional plantations. The planting materials are clonal, hence vulnerable to climate change.

The National Bank for Agriculture and Rural Development (NABARD) is trying to provide subsidized credit to poor farmers. Some of NABARD's activities in the watershed may be eligible for carbon benefits and are being studied. Results show that huge opportunities exist in A/R projects for combining mitigation and climate change adaptation, but there is an urgent need to evolve simple systems for claiming carbon credits. To make forestry projects more attractive, it is recommended that the European Union start purchasing CERs.

Key words: CER, climate change, forestry project, NABARD.

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ID-186

EFFECT OF WARM WINTER TEMPERATURES AND GENOTYPE ON BUDBURST OF DOUGLAS-FIR

C.A. Harrington[1], J.B. St. Clair[2] and P.J. Gould[3]

Many boreal and temperate tree species have a chilling requirement which prevents budburst during warm periods in mid-winter. The annual timing of budburst can vary with the amount of chilling and the timing of forcing temperatures after the chilling requirement has been fulfilled. Warmer temperatures in winter and spring have the potential to either delay budburst due to fewer chilling hours or accelerate it due to more forcing hours. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) grows naturally under a wide range of climates, and populations of the species are strongly adapted to their local environment; this suggests that there may be genotypic differences in chilling requirements. In this trial, we obtained seed from 10 Douglas-fir families in each of 12 regions (coastal, low elevation inland, and high elevation inland at 4 latitude bands ranging from 38 ^{o} to 47^{o} N). Seedlings were grown for one growing season, then subjected to four winter temperature regimes designed to alter the amount of time plants would experience temperatures considered optimum for chilling (0-5^{o}C). Our study suggests that there is a greater range in the chilling requirement than previously reported, and that the interaction between temperatures in and above the optimum range in promoting budburst is complex. High elevation sources from California (40°N latitude) and Oregon were the first to burst bud while north coastal genotypes were the last to burst bud. Some families began budburst first in the treatments with the lowest amounts of chilling but the rate of budburst was fastest in treatments which experienced high numbers of chilling hours. Understanding these relationships is key to predicting what will happen if winter temperatures increase in the future, and to choosing seed sources that will be optimally adapted to future climates.

Key words: budburst, chilling requirement, genetics, winter warming.

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ID-056

MOUNTAIN PINE BEETLE ATTACK IN IMMATURE LODGEPOLE PINE STANDS IN CENTRAL BRITISH COLUMBIA, CANADA

Chris Hawkins and Kyle Runzer[1]

The central interior of British Columbia, Canada, is currently experiencing its largest recorded outbreak of mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopkins). The current epidemic has been attributed to two exacerbating factors: climate and host availability. In the past 60 years, the mean annual number of days with temperature below -20°C has decreased from 40 to less than 15 days. Prolonged low winter temperatures serve to regulate MPB populations. The amount of mature (≥80 years) lodgepole pine (*Pinus contorta* Doug. ex Loud var. *latifolia* Engelm.) has increased from 2.5 to 8 million ha in the past 90 years. Historically MPB only attacked larger (dbh >15cm), mature pine. However during this outbreak, MPB have attacked trees as young as 15 years with dbh ≤7.5 cm. We have surveyed 235 immature (≤60 years) stands (are they really plantations?? Canada does not have plantations according to its reports to FAO) in three ecological units in the central British Columbia interior covering an area >17,000 km^2. Attack differed among ecological units. Landscape level MPB attack rates (all species included) (these plantations have many species.??..)in age classes 1 (≤20 years), 2 (21-40 years) and 3 (41-60 years) were respectively 6.4%, 45.4% and 48.2%. Attack reduced the residual live dbh. At the landscape level, mean dbh by age class before and after attack were respectively 11.87 → 11.67 cm, 13.29 → 11.78 cm, and 13.01 → 10.91 cm. The proportion of pine in stands decreased with increased age. MPB attack rates in only pine by age class were respectively 7.3%, 53.3% and 61.6%. Clearly the MPB has significantly impacted age class 2 and 3 stands and had little impact on age class 1 stands. The crucial management issue is what, if anything needs to be done to age class 2 and 3 stands, in order for them to contribute to the planned timber supply in the next 10 to 50 years? Potential management options will be discussed.

Key words: climate change, lodgepole pine, mountain pine beetle, timber supply.

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ID-006

PRECISION FORESTRY – A KEY CONCEPT TO MAKE ADAPTIVE MANAGEMENT OPERATIONAL?

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Global change has been facing society with increasing uncertainty how ecosystems will behave and look like in the future. This rises the question what will be the best management strategy to cope with an uncertain future. Adaptive management is a systematic process of continually adjusting policies and practices by learning from the outcome of previously used policies and practices. Each management action is viewed as a scientific experiment designed to test hypotheses and probe the system as a way of learning about it. However, there is no well-defined approach how the concept of adaptive management could be made operational for forest management.

Our hypothesis is that the theory of feedback-control (control theory) provides a framework to develop an adaptive management concept which has been starting to emerge, Precision Forestry. Precision Forestry coordinates and controls three types of processes, (1) biophysical, (2) technical, and (3) administrative, by semi-automatic or automatic control systems in order to concurrently damping the effects of external disturbances and maximizing biological and technical effectivity. The term Precision Forestry appeared in 2001, but is still lacking of consistency.

Three pillars are building the foundation of feedback-based forest management: (1) dynamic models of relevant processes (biophysical, technical, administrative), (2) sensors to measure decisive process state variables, and (3) actuators to influence process behaviour. Those pillars will be illustrated by Biolley's management concept for uneven aged forests ("control method", developed in the early 20th century) and reformulated by the mechanisms of feedback-control. The paper presents a systematic of processes that could serve as a common denominator to make Precision Forestry develop from a buzzword to a guiding management concept.

Key words: adaptive management, feedback-control, global change.

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ID-379

NATIONAL INVENTORY OF LANDSCAPES IN SWEDEN (NILS) AS A PLATFORM FOR MONITORING IMPACTS OF CLIMATE CHANGE IN THE SWEDISH MOUNTAIN AREAS

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The northern latitudes are expected to experience a disproportionate and rapid warming as a consequence of global climate change. In the subarctic regions, climate change can have considerable impacts on environmentally-sensitive ecosystems, as well as the location of treeline, biodiversity and means of livelihood. Accurate vegetation inventories are required for the environmental monitoring and adaptation of natural resource management to climate change. The National Inventory of Landscapes in Sweden (NILS) is a nation-wide environmental protection program for monitoring the conditions and changes in the Swedish landscape and influence of these changes on conditions for the biological diversity.

In this project, we aim to study how the sampling design of the NILS program could be used as a platform for monitoring the impacts of climate change on vegetation in the treeline ecotone in Swedish mountain areas. The methodology is based on the visual interpretation of the colour infrared aerial photographs from the 2000s and the late 1970s/early 1980s. The modern imagery is complemented by field inventory. More specifically, we compare methods for monitoring changes in vegetation attributes, particularly in tree cover, in the treeline ecotone and analyze the technical prerequisites for aerial photography. Several methodologies are evaluated at test sites and selected methods applied for analyzing changes in vegetation and treeline over a larger number of sites in Swedish mountains. The results will be used for evaluating possibilities and costs for the larger-scale monitoring study. The preliminary results show that visual interpretation of aerial photographs provides one potential method for analyzing vegetation changes in treeline ecotone in Swedish mountain areas.

Key words: aerial photography, climate change, treeline ecotone.

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ID-169

OPTIMIZING TIMBER SUPPLY AND CARBON SEQUESTRATION PLANNING FOR FUTURE SPRUCE BUDWORM OUTBREAKS IN NEW BRUNSWICK, CANADA

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Spruce budworm (*Choristoneura fumiferana* Clem.) severely defoliates balsam fir (*Abies balsamea* (L.) Mill.) and spruce (*Picea* spp.) in large periodic outbreaks throughout central and eastern North America and, with climate change, is projected to expand further north in Canada. Defoliation eventually kills trees, reducing carbon (C) sequestration and storage as dead trees decompose. This also reduces harvest rate and C transfer from forest to wood product storage.

We developed a framework to integrate (i) stand-level budworm-caused mortality and volume reduction (projected using the STAMAN stand growth model), (ii) C dynamics for live biomass, soil, and off-site storage in products and landfills (derived using the Carbon Budget Model and Forest Products Sector sub-model of the Canadian Forest Sector), and (iii) a forest estate timber supply optimization model (Remsoft Spatial Planning System). This was applied to a 210,000 ha forest in New Brunswick, Canada. The integrated modeling approach uses linear optimization to simultaneously optimize harvest schedules with salvage and aerial applications of biological insecticides to reduce harvest loss to budworm and/or maintain C in living biomass. Scenarios were simulated exploring moderate and severe spruce budworm outbreaks beginning in 2007, and optimal combinations of foliage protection and harvest strategies to reduce timber and C impacts. Carbon in live fir-spruce biomass and merchantable timber inventories was projected to be reduced by 18% (870,000 tons of C) and 26% (3.3 million m^3) from 2007-2016 for a moderate outbreak, and by 23 and 32% for a severe outbreak scenario. Optimized salvage and harvest re-scheduling were projected to reduce future harvest losses by up to 30%, while optimized insecticide application reduced area sprayed by up to 35%. Optimized harvest re-planning and spatial allocation of foliage protection can help adapt management to minimize volume and C reductions and insecticide use during future insect outbreaks.

Key words: carbon, forest management, optimization, spruce budworm, wood products.

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ID-225

ADAPTING TO CHANGE: FOREST TENURE IN CANADA'S BOREAL PLAINS ECOZONE

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The forest industry in the Boreal Plains Ecozone in Canada (Alberta, Saskatchewan and Manitoba) will be significantly affected by changes in climate that in turn affect the occurrence of wildfire, insects and disease and, ultimately, forest productivity. This is important to communities in the region given that the economy is partially reliant on the timber industry. To remain economically viable in the long run, it will be important for the forest industry to adapt to changes using new and innovative management techniques.

Forests in this region are owned and managed by the provincial governments who grant rights to industry through a variety of tenure agreements that define forest management operations. Understanding the relationship between industry and the provincial governments is an important step to assessing the industry's adaptive capacity to climate change and the degree to which it is able to engage in adaptive management.

We met with industry in each of the provinces to determine their knowledge of climate change and its effect on the boreal ecozone, and their ability to respond to change within the current policy framework. Similarly, we examined forest tenure arrangements and associated rights and responsibilities to assess the degree to which industries could adapt.

Our findings indicate that the rights and responsibilities granted under the current tenure arrangements are not sufficiently flexible to enable industry to operate with a view to long-term profitability. Such agreements were found to increase costs and restrict adaptation with respect to harvesting and timber supply management.

Key words: adaptive capacity, forestry, tenure, Canada, climate change.

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ID-075

CLIMATE CHANGE IMPACTS ON POPULATION DYNAMICS OF *IPS TYPOGRAPHUS* (L.) USING FINE SCALE CLIMATE CHANGE SCENARIO

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The problem addressed is to assess the impact of the forthcoming climate change on the European Spruce Bark Beetle (*Ips typographus*: Coleoptera: Curculionidae) voltinism in Slovakia and to validate the proposed model. Bark beetle is one of the major biotic disturbances in Norway forests of spruce - *Picea abies* (L.) Karst.. Development of its stages is strictly regulated by temperature. Stage specific developmental thresholds, required sums of effective temperature, and other parameters related to the beetles' development have already been documented by several authors.

Using this information, we identified areas with climatic conditions allowing for the full development of a certain number of bark beetle generations in the temporal scales 1995-2000 and 2000-2005. This period appears suitable for such an analysis, because extensive mostly biotic agents driven spruce decline occurred in several regions of the country (expressed via sanitary felling). The areas where the increased number of generations is supposed to develop are expected to suffer from the radical change in forest disturbance regime. This presumption has been validated using data on sanitary felling due to bark beetle. This has been supported by the analysis of changes in spectral characteristics of vegetation using LANDSAT and MODIS satellite imagery.

ALADIN/ARPAGE A1B 2020-2050 scenarios recently developed within the 6FP project CECILIA (Central and Eastern Europe Climate Change Impacts and Vulnerability Assessment) were used to assess the impacts of climate change on bark beetle voltinism. The 2020-2025 and 2045-2050 time scales have been investigated. We identified areas with a supposed increase in the number of bark beetle generations across Slovakia. The actual distribution of spruce, as the bark beetle host tree, was considered to remain stable up to the year 2050. The results are discussed.

Key words*:* climate change, *Ips typographus* voltinism, sanitary felling, satellite imagery, Slovakia.

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ID-084

CANADIAN EXPERIENCES IN LARGE-SCALE MONITORING OF CLIMATE-RELATED DISTURBANCES CAUSING FOREST DIEBACK AND MORTALITY

E.H. (Ted) Hogg[1] and Werner A. Kurz[2]

Canada has a long history of monitoring the state of its vast forest area (~4 million km^2). Monitoring programs for national reporting of Canada's forest inventory and natural disturbances (fire, insects and diseases) are coordinated through partnerships among agencies of the Canadian Federal government and Provincial/Territorial governments. The need for large-scale disturbance monitoring has increased as climate change is contributing to larger disturbance impacts. A major recent development has been the integration of the databases from these monitoring programs into a national modeling and analysis framework for estimation and international reporting on CO_2 uptake and release by Canada's managed forests. Research networks involving Canadian universities and Federal government collaborators on the topics of sustainable forest management, forest carbon cycling, and prairie droughts contribute to monitoring and research. Since 2000, there have been several episodes of massive forest mortality that have heightened concern for Canada's forest sector. The unprecedented expansion of mountain pine beetle in western Canada is causing extensive mortality of pine forests over 130,000 km^2. This may be part of a subcontinental pattern of recent, climate-related increases in eruptions of several species of bark beetles that have devastated large areas of conifer forests from Alaska to Arizona. Large-scale mortality of aspen (and other tree species) has also been documented along the northern edge of the Canadian prairies following the severe drought of 2001-2002.

Canadian experiences with these dieback episodes show the value of integrated, multi-scale monitoring systems for early detection and reporting of impacts, coupled with process-based research to determine the causes of tree mortality and develop appropriate management strategies. In situations where large-scale mortality cannot be prevented, economic and climate mitigation benefits may be derived from salvage logging for wood products or bioenergy, which also generate benefits in the substitution of fossil fuel emissions.

Key words: monitoring, drought, insect damage, forest health, climate change, carbon.

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ID-368

EARLY-WARNING DETECTION AND ASSESSMENT OF DROUGHT-INDUCED DIEBACK AND MORTALITY OF ASPEN (*POPULUS TREMULOIDES*) FORESTS IN WESTERN CANADA

E.H. (Ted) Hogg[1], M. Michaelian[1], R.J. Hall[1] and E.J. Arsenault[1]

Drought-induced forest dieback has emerged as a global issue over the past decade, and GCM projections suggest this will escalate in future. Forests in the dry interior of western North America are considered especially vulnerable, based on recent observations of large-scale forest dieback following severe drought and associated increases in insect damage. Since 2000, we have been monitoring aspen forests annually at 150 plots across west-central Canada as part of a study entitled Climate Impacts on Productivity and Health of Aspen (CIPHA). During 2001-2002, the region was affected by a severe drought that subsequently led to massive dieback and mortality of aspen forests, resembling fire effects in some areas. Drought severity and extent was quantified using a simple climate moisture index (CMI), and the drought's impacts were assessed using plot-based and remotely-sensed measures, in combination with tree-ring analysis. Results demonstrated that aspen productivity, dieback and mortality were governed mainly by moisture variation (CMI). Furthermore, during and following this drought, there has been an increase in wood-boring insects along with persistently high mortality of aspen over at least five years (2002-2007). A spatial analysis of impacts showed an estimated 50 MT of dead aspen mass across a 100,000-km^2 area along the northern edge of the prairies where the drought was most severe.

The methods used in our multi-scale analysis of this dieback episode show how monitoring programs can be applied in vulnerability assessments and as "early warning" systems that would enable timely implementation of adaptation strategies. Specifically, it should be possible to predict major dieback episodes one or more years in advance, through operational tools based on near real-time monitoring of climate, remotely-sensed greenness indicators and forest plot networks. There is also a need for innovative strategies and practices to respond effectively to the likelihood of more severe droughts in future across large areas of the world's forests.

Key words: boreal forest, aspen, drought, productivity, dieback, decline, climate change.

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ID-108

CAN EXPERIENCES OF CARBON SEQUESTRATION IN SWEDISH FORESTS OVER THE PAST CENTURY BE REPLICATED?

Peter Holmgren[1]

Carbon storage in Swedish forests has approximately doubled over the past century following systematic investments in forest management, mainly to secure industrial wood supply. Current international negotiations towards a post-Kyoto agreement under the Framework Convention on Climate Change are expected to lead to some form of financial mechanism that would pay for climate change mitigation in land use and/or forestry. In this context, the development in Sweden provides an interesting example for other countries and regions, indicating a major potential market opportunity.

This paper examines some similarities and differences between the historical Swedish case and current forest and land management situations in developing countries, focusing on the potential for increasing carbon storage in vegetation and soils under the assumption that the biological production potential *per se* is not a limiting factor. The paper does not consider additional mitigation effects that may arise from increased biomass production and subsequent substitution of fossil fuels with bioenergy. It is concluded that one important driver behind the increased carbon stock in Swedish forests – the reduced dependency on marginal small-scale agriculture following economic growth and urbanization – is replicated today in many developing regions. Further, the financial mechanisms currently negotiated could fill a similar role as the historic large-scale subsidies in Sweden that stimulated silviculture and rural employment. Beyond the forest, it is likely that sequestration through tree planting and soil management in agricultural landscapes could be very significant. On the other hand, large-scale agriculture continues to expand in some regions, converting forests and reducing the carbon stock. Future increases in demand for land for food and energy production will significantly reduce the net sequestration potential. Conclusively, an unprecedented opportunity may exist for land managers worldwide to market an environmental service that the global community is prepared to pay for. The post-Kyoto negotiations will largely determine the rules for this marketplace.

Key words: climate change, mitigation, carbon sequestration, forest management, investment.

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ID-364

SIMULATING TREE GROWTH UNDER CLIMATE CHANGE USING ALTITUDINAL SHIFT AS PROXY

M. Huber and H. Sterba[1]

Climate change is expected to alter the species distribution, the growth and the structure of forest stands. In this study, the individual-tree growth simulator PROGNAUS is used to describe these changes by using altitudinal shift as a proxy for climate change. In the forest management of Litschau district, sites dominated by beech have been changed by clear cuts, planting of Norway spruce and invasion of Scots pine. We use 22 plots in stands with different proportions of Norway spruce and Scots pine to forecast their development by the individual-tree simulator PROGNAUS for 1,000 years. The standard tropospheric linear temperature gradient of -0.65°C per 100 m elevation increase attended to translate the following temperature scenario: Linear increasing mean annual temperature up to +4°C by 2100 and afterwards exponential approximation to +5°C. For both the constant climate and the climate change scenario, all plots show a maximum volume per hectare after approximately 100 years, which is higher and later under constant climate. Afterwards a constant volume per hectare seem to emerge whereas the mean volume over the last 100 years is 426 ± 34 $m^3\ ha^{-1}$ under constant climate and 410 ± 45 $m^3\ ha^{-1}$ under changing climate. Concerning tree species the emergent composition is dominated by Norway spruce with admixed Silver fir, common alder and ash species for the constant climate scenario. Under changing climate oak species, maple species and common alder are dominating with equal amounts. For both scenarios the amount of common alder is higher at the moister sample sites in addition to missing Silver fir.

Key words: climate change, elevation, PROGNAUS, tree growth simulator.

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ID-338

A FRAMEWORK FOR VULNERABILITY ASSESSMENT OF NON-TIMBER FOREST GOODS FOR PLANNING ADAPTATION TO CLIMATE CHANGE AND VARIABILITY IN WEST AFRICA

M.E. Idinoba[1]., J. Nkem[1]., F. Kalame[1] and Y. Coulibaly[1]

The importance of forest ecosystems in the provision of both goods and services in developing economies and for rural livelihoods support is well documented. Current and projected climate shocks and stresses are expected to render such economies highly vulnerable or have a devastating impact on livelihoods of forest-dependent families. These assumptions are particularly pertinent to West Africa where forest ecosystem still provides valued goods and services for rural and urban dwellers. Already, some local communities indicate significant reduction in the availability of forest goods, high variability in their productivity and, in some cases, complete extinction of some species as evidence of climate change in the region. However, responding to the current and future threats posed by climate change is not that straight forward.

First, an understanding of which sector(s) of forest ecosystem is vulnerable, the level of current and projected vulnerability, and the importance of such sectors to national economies and livelihoods of communities is required. Secondly, methods for assessing sectoral vulnerability of forest ecosystems goods and services are not common and their developments are urgently required. These seem the necessary conditions for planning the right adaptation and initiating suitable actions amongst the various stakeholders. As a result, the EU/CIFOR-funded project on Tropical Forest and Climate Change Adaptation (TroFCCA) aims to assess forest ecosystems goods and services whose vulnerability will provoke concomitant vulnerability of national economies and livelihood systems.

Thus, this paper presents a framework for sectoral scoping and vulnerability assessment. It identifies relevant forest sectors and prioritizes issues that have cross-boundary regional importance with the participation of national stakeholders in a dual regional and national expert deliberations and a rapid community appraisal of vulnerable forest sectors based on stakeholders perceptions. The framework also provides insight on linking local issues of forest ecosystem sectors vulnerability with those identified and prioritized at national and regional levels for planning future adaptation.

Key words: adaptive capacity, forest ecosystems, livelihoods, non-timber forest goods, vulnerability.

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ID-044

ADAPTING FOREST ECOSYSTEMS TO CLIMATE CHANGE: IMPLICATIONS FOR PARTICIPATORY LEARNING AND ACTION RESEARCH PLATFORMS IN BRIDGING FOREST SCIENCE- POLICY- PRACTICE INTERFACES

P.A. Idinoba[1], T. Defoer[2], M.E. Idinoba[3] and J. Nkem[3]

The discourse on climate change and its potential impact on forests ecosystems function, provision of goods and services and the possible undesirable consequences on economies and livelihoods have not abated. Adaptation to climate change is a popular consensus amongst scientists, policy makers and donor organizations as veritable pathway to securing the future of ecosystems and livelihoods. This is especially relevant for sub-Saharan Africa where forest ecosystems resources and rural livelihoods are intertwined; institutional and economic capacities are weak and diverse. Also in these regions, natural gaps often exist between science, policies and actual practices of institutions and rural communities that implements policies and programmes. The result has been low success rate of forest ecosystem and other natural resource management endeavours. Therefore, mainstreaming climate change adaptation into policy and practice seems an insurmountable challenge in the light of the elusive interfaces between forest science, policy and actions which are themselves not only dynamic but nebulous in developing countries. However, adaptation science encompasses vulnerability assessment to know what and where sensitivity and exposures are likely, planning and implementation of feasible strategies, embedding same in policy action, as well as the monitoring and evaluation of adaptation measures. A sure way of ensuring the success of this complex interdisciplinary endeavour would be a concurrent participation and learning processes of multi-stakeholders at different levels, from the local to regional.

This paper examines the manageability of the challenge of adapting forest ecosystem to climate change through a bottom-up observation, analyses and facilitated actions that are hinged on stakeholders' participatory learning and action research approaches, from vulnerability assessment to monitoring and evaluation of planned measures. It also highlights the divide between forest science-policy-practice and the role of the different stakeholders, the agency of actors in practice and the potential of action research in facilitating innovative platforms, as well as evaluation of organizational and institutional changes arising from the process.

Key words: action research, climate change adaptation, forest ecosystems, multi-stakeholder participation, innovation

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ID-026

IMPACTS OF CLIMATE CHANGE ON HYDROLOGICAL ECOSYSTEM FUNCTIONS IN MESOAMERICA

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Terrestrial ecosystems provide an array of hydrological functions important for human well-being. Hydrological regimes will be affected by climate change with impacts on the distribution of ecosystems and the pattern and variability of precipitation and temperature. We aim at evaluating the impacts of climate change on forest ecosystems hydrological functions in Mesoamerica.

For this purpose, we calibrated and validated the Mapped Atmosphere Plant Soil System (MAPSS), a static soil-vegetation-atmosphere (SVAT) model, to map potential changes on vegetation parameters relevant for the water balance and runoff patterns and under future climatic scenarios. MAPSS operates on the fundamental principle that ecosystems will tend to maximize the leaf area that can be supported at a site by available soil moisture or energy, and therefore simulates potential vegetation. The model calculates the leaf area index (LAI) of both woody and grass life forms in competition for both light and water, while maintaining a site water balance. Model validation was made with LAI product (MOD15A2) from Collection 5 of MODIS Terra sensor, and runoff data from selected watersheds in the region. The validation step is crucial for creating confidence in the model to simulate future scenarios.

Results show how climate change will affect the distribution of life forms, its leaf area density as well as runoff patters across a tropical region. This study sets the basis for further analysis of the impacts of climate change on ecosystems and water availability.

Key words: climate change, ecosystem functions, Mesoamerica, Central America, hydrology.

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ID-126

MODELLING IMPACTS AND ASSESSING THE WILLINGNESS TO ADAPT TO THE IMPACTS OF CLIMATE CHANGE IN WESTERN CANADA

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While much attention in western Canada has recently focused on the impacts of the Mountain Pine Beetle, other impacts of climate change are materializing, such as a large-scale outbreak of the spruce beetle (*Dendroctonus rufipennis*) in the southwest Yukon. In many parts of the region, strong environmental gradients, combined with the relatively high latitude, mean that impacts of climate change on forests are likely to be considerable. This has been confirmed by modeling for a region in south-central British Columbia, which suggests that if biodiversity is to be conserved successfully, major changes in management planning is required. These changes are not currently occurring, and an analysis of the views of practitioners in the southwest Yukon, where the spruce beetle has already killed almost 400,000 ha of forest, reveals that there is a complex relationship between the state of knowledge of practitioners and their readiness to adapt.

The most favoured management adaptations are those that will simultaneously enhance management objectives, as laid out in criteria of sustainable forest management (such as those of the Montreal Process). This will create a 'win-win' situation for managers, encouraging adaptation at a time when considerable uncertainty still exists.

Key words: adaptation, climate modeling, *Dendroctonus rufipennis*, vegetation modelling, Western Canada.

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ID-200

FIRE IMPACT ON COMPONENTS OF FOREST ECOSYSTEMS OF CENTRAL SIBERIA, RUSSIA

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Boreal forests are globally important as they constitute one of the world's major carbon pools and contain relatively undisturbed ecosystems. An expected climate change-induced increase in fire activity is likely to result in heavier fire effects and increasing area burned. Fire can become a key factor prerequisite for ecosystem existence under ever changing environmental conditions. Considering predicted climate warming and increasing fire frequency, modeling of fire intensity, impacts, and area burned has become crucial for estimating boreal forest contribution to global carbon budget and understanding fire influence on forest sustainability and health.

This study focuses on collecting quantitative data and modeling influences of fires of varying intensity on fire emissions, carbon budget, and ecosystem processes in larch Scots pine stands of central Siberia. In effort to assess fire influence on carbon balance, emissions and forest ecosystem sustainability, experimental fires aimed at modeling fire behavior were conducted in Scots pine stand of central Siberia as a part of Fire Bear Project. Fire influences all forest ecosystem components, including the overstory, living ground vegetation, soil structure, micro-organisms, and invertebrates. Our long-term experiments allowed us to identify vegetation succession patterns in central and southern taiga Scots pine stands after fires of known behavior. Ground vegetation on Scots pine plots was determined to degrade after fires of any intensity, where it was dominated by small shrubs, lichens, and feather moss. The initial post-fire succession stage is known to depend on site conditions, pre-fire forest type, and the last fire type and intensity.

Key words: forest fire, fire intensity, boreal forests, post-fire succession.

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ID-263

ESTIMATION OF EVAPOTRANSPIRATION USING MODIS PRODUCTS AT FLUX MEASUREMENT SITES IN NORTHEAST ASIA

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Evapotranspiration (ET), the sum of evaporation from soil and transpiration from vegetation, is of vital importance in the hydrologic cycle and must be taken into consideration in assessing the water resources of any region. ET is also important to climate dynamics and terrestrial ecosystem productivity because it is closely related to energy transfer processes. Recently, satellite remote sensing, especially MODIS, offers a promising technique for estimating ET. In this study, we used atmospheric and land products of Aqua-MODIS as inputs to predict and to estimate ET under clear daytime conditions over a rugged deciduous forest in Japan and Korea; a heterogeneous farmland in Korea; and a temperate grassland in China. MODIS ET algorithm modified from Mu *et al.* (2007) was applied to predict at flux measurement sites.

Our preliminary results showed good agreement with ground-based observations at Korea Flux Network (KoFlux) sites from 2004 to 2006. Incident solar radiation was underestimated for both sites with RMSE of 50-87 W m-2 at forest site and 44-60 W m-2 at farmland site. Net radiation was underestimated at forest site with RMSE of 58-81 W m-2 but overestimated at farmland site with RMSE of 39-47 W m-2. ET generally showed overestimation at forest and farmland sites with RMSE of 86-96 W m-2 and 73-108 W m-2, respectively. This study indicates that MODIS can be applied to monitor land surface energy budget and evapotranspiration with reasonable accuracy. More extensive parameterization and evaluation are necessary across various biomes and climatic regimes.

Key words: Aqua-MODIS, evapotranspiration, incident solar radiation, net radiation.

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ID-267

EFFECT OF SOIL TEMPERATURE FLUCTUATIONS ON ROOT RESPIRATION UNDER GLOBAL WARMING

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Global warming, although mostly associated with the warming of atmospheric temperatures, will also be causing a warming of soils which may influence site carbon retention through plant growth and decomposition. This study was done on the growth of woody species on landfill sites in which soil temperatures differed markedly. Its objectives were to measure how among-site differences in seasonal soil temperature variation affected root respiration, on sites with poor growth and on sites with good growth, and to document the underlying causes of growth differential among sites. The soil biochemical environment was investigated for leguminous species (*Robinia* pseudo-acacia and *Lespedeza bicolor*) and salix species (*Salix koreensis*), which showed different growth vitalities, respectively. Overall, soil temperature increased in time from May to July, and decreased after July. Reduction of photosynthetic rates and chlorophyll contents and different antioxidant enzyme activities (APX and GR activity) of trees in sites with poor growth suggest that their own physiological traits compensated for inadequate environment conditions.

In other words, poor growth sites showed lower soil respiration and higher soil temperature than sites with good growth. Our results show that the increasing of soil temperature up to 30℃ was closely related to the increasing of soil respiration. However, soil respiration started to decrease when soil temperature became greater than 30℃. The change of dehydrogenase and phosphatase activities reacted sensitively to the fluctuation of soil temperature. We suggest that high temperature negatively affects root growth, microbial activities and thus soil respiration. In the terrestrial ecosystem cycle, soil warming could have, due to climate change, an indirect negative effect on plant growth by depressing root growth and germination of plant species and a direct negative effect in the long term by lowering soil fertility

Key words: landfill, photosynthetic rate, antioxidant enzyme activity, soil respiration, dehydrogenase activity, phosphatase activity.

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ID-317

FOREST REGENERATION AND CHANGING CLIMATE

Kalev Jõgiste and Marek Metslaid[1]

The change in climate conditions is modifying the regeneration and growth environment of forest tree species. Changes in regeneration dynamics alter the composition and rotation cycles of future forest stands, leading to queries on mixed forests, new species and species decline. The suitability of geographical and ecotypical provenances of common species in various conditions is also important. Adapted regeneration techniques can provide an improved basis for forest management planning, but information is still needed on how new trends in forest management practices and changes in disturbance regimes may alter the regeneration processes.

The aim of the study was, therefore, to create a conceptual model of forest regeneration. For this purpose, we have compared the development patterns of tree species in the case of natural and man-made disturbance agents as captured in two studies in Estonia. The first study describes the regeneration of forest areas damaged by windstorms without salvage logging after the event, while the second describes the advance regeneration development after clearcuts in commercial forest. The model describes the proportion of main tree species in regeneration phase, which is based on registered seedlings in permanent sample plots. Growth projection is based on yield and growth tables. The areas of heavy windthrow showed greatly varying micro-relief and higher proportion of hardwoods.

The results of the studies show that regeneration is driven by biological legacies from earlier forest and physical environment. Expected increase of frequency of windstorms obliges foresters to find silvicultural adaptation tools to alleviate the damage in commercial terms. Guidance for decision-making is provided by adequate models. Natural regeneration after disturbances is one option to increase hardwood proportion.

Key words: forest disturbances, legacies, regeneration.

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ID-147

INCREASING THE RESILIENCY AND CARBON SEQUESTRATION POTENTIAL OF GULF COAST FORESTS IN THE UNITED STATES

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Residual damage from Hurricane Katrina is reducing C sequestration of Gulf Coast forests approximately equal to the total U.S. net annual forest C sink. *Pinus taeda* L. has frequently been planted to replace cutover *Pinus palustris* L. stands in gulf coast forests. Increasing the use of longleaf pine in Gulf Coast forests has great potential for increasing C sequestration and decreasing losses due to damaging agents including wind, disease and insects. The frequency and severity of insects, disease and hurricanes likely will increase with climate change. On much of the Gulf Coast, longleaf pine can outgrow other pine species by and beyond 25 years, may capture more C belowground, and may have higher wood specific gravity; all of these factors potentially increase C sequestration.

In a common garden experiment in Mississippi, after 45 years of growth across fertilized and non-fertilized plots, *Pinus palustris* had 32% greater above-ground biomass than *Pinus taeda*. Differences in coarse root biomass were similar. Hurricane Katrina damaged 7 percent of the *Pinus palustris versus* 29 percent of the *Pinus taeda* trees in the experiment. The combined results of differences in growth rate and damage resulted in that, following the hurricane, *Pinus palustris* has more than three times the standing biomass than *Pinus taeda*.

Key words: *Pinus taeda* L., *Pinus palustris* L., Hurricane Katrina, growth rate, damaging agents, C sequestration.

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ID-066

ADAPTIVE CAPACITY IN PUBLICLY-OWNED FOREST LANDSCAPES: FORESTRY INSTITUTIONS IN CANADA

Mark Johnston[1], Tim Williamson[2] and Hayley Hesseln[3]

Forest management in Canada falls under the jurisdiction of Provincial governments, with more than 75% of managed forest land in public ownership. Forest management is administered through agreements with forest industry in which a forestry company is given rights to harvest timber and carry out forest management activities on a defined land base. In addition to provincial legislation and regulation, several national and regional policy instruments provide guidance to forest managers. These include: Forest certification schemes (Sustainable Forest Initiative, Forest Stewardship Council, Canadian Standards Association's National Standard for Sustainable Forest Management); Criteria and Indicators for Sustainable Forest Management developed by the Canadian Council of Forest Ministers as adapted from the Montreal Process; Principles of adaptive forest management; and Canada's National Forest Strategy, developed from extensive consultation with forest stakeholders and updated every five years.

We analyze the degree to which these forest management policies and institutions either support or hinder the development of climate change adaptive capacity. This analysis is based on extensive discussions with government and industry forest managers in the Boreal Plains Ecozone of central Canada. These discussions were designed to determine their adaptive capacity and to identify technical, policy or institutional barriers to adaptation.

We find that the tools for developing adaptive capacity exist within the Canadian forest management community, and that managers generally feel they have the technical capability to successfully adapt. However, while these tools and abilities are available to forest managers, they are not always implemented due to policy barriers or lack of resources. In addition, some institutions, such as forest certification schemes, have the potential for providing a framework for assessing and encouraging adaptive capacity, but will need to be modified in order to realize that potential. Forest management policy generally supports adaptation, but may limit the implementation of adaptation options in cases where the required innovation lies far outside of business-as-usual activities.

Key words: adaptive capacity, Canada, climate change, forest policy, institutions.

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ID-153

ELASTICITY OF TREE RADIAL GROWTH TO ENVIRONMENTAL STRESS

Hans-Peter Kahle[1]

Elasticity of tree growth to environmental disturbances is an important component and determinant of forest ecosystem resilience. It is also an important information for modellers of forest growth under future climate regimes who need to capture in their models how tree growth is affected by extreme events. This paper focuses on statistical analyses of the growth response kinetics of Norway spruce (*Picea abies* L. Karst.), silver fir (*Abies alba* Mill.) and common beech (*Fagus sylvatica* L.) trees to environmental stress under field conditions. The analyses are based on retrospective growth data of forest trees from selected sites in south-western Germany. Long-term tree-ring time series are analysed using super-posed epoch analysis, and response surface models are parameterized to determine growth elasticity as a function of the initial stress intensity and the elapsed time since the stress event.

Over all data sets the maximum recovery time after severe stress was between 2.5 and 5 years for spruce, 3 to 4 years for fir, and around 4 years for beech. At low elevation sites and low initial stress intensity, recovery of beech and fir was distinctly faster than of spruce. At high elevation sites and at more severe stress intensity, recovery of spruce was faster than of beech and fir. Older spruce trees showed higher rates of growth elasticity than younger trees at low stress levels; at high stress levels it was reverse. Growth elasticity of spruce varied by eco-region and was also not constant between time periods.

Most of the years with severe growth depressions coincided with drought events. Thus the results particularly refer to the impact of drought on tree growth. Modelling approaches linking process-based knowledge with insights from long-term retrospective empirical studies are considered to have a high potential for a more reliable assessment of the impacts of extreme events on forest ecosystems.

Key words: dendroecology, drought stress, growth elasticity.

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ID-160

USING FOREST ECOSYSTEM GOODS AND SERVICES FOR CLIMATE CHANGE ADAPTATION IN BURKINA FASO AND GHANA: POLICY GAPS AND CONSTRAINTS

Fobissie B. Kalame, Maria Brockhaus, Johnson Nkem, Monica Idinoba and Markku Kanninen[1]

Forest resource governance through the formation and implementation of policies determines the forest ecosystem goods and services (FEGS) communities and sectors can act upon to adapt during climatic hazards. Many communities in West Africa have been, and are still using forest ecosystem goods and services to adapt to climate hazards, while sectoral policies, programmes and projects on FEGS have also been put in place as response measures to climate related disasters—especially since the Sahelian droughts of the 1970s and 1980s. Despite all these efforts, these communities and sectors are still vulnerable to impacts of climate change, as indicated by the National Adaptation Plan of Action and the First National Communication documents submitted to the Climate Change Convention.

This paper, therefore, analyses policy obstacles related to the utilization of FEGS by communities and sectors for adaptation to impacts of climate change in Burkina Faso and Ghana. Findings of the policy analysis revealed that major limitations to which, when and how FEGS can be used by communities and sectors to achieve higher responsiveness during adaptation to climate hazards depend on the nature of participation in decision making, nature of access to and tenure rights over resources, incentive schemes, and the policy and political context. Literature has shown, however, the need for a better appreciation through awareness raising of the role of FEGS for community and sectoral adaptation, a climate change adaptation objective in current forest policy and programmes, improvement in the coordination of adaptation activities and synergies between sectors, as well as adequate financial and human resources to implement and enforce existing policies.

In conclusion, we recommend more flexibility in the formulation and implementation of policies on FEGS, taking into account future opportunities in climate change adaptation response to foster national development activities alongside the special needs of vulnerable communities and sectors.

Key words: adaptation, community, climate hazards, forest policy, goods and services.

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ID-141

MONITORING VEGETATION PHENOLOGY AND BIOPHYSICAL VARIABLES USING MODIS PRODUCTS

Synkyu Kang[1], Keunchang Jang[1], Sohee Kim[1] and Bora Lee[1]

Moderate resolution imaging spectroradiometer (MODIS) onboard both the Terra and Aqua satellites provides a potential tool for the periodical monitoring of vegetation phenology and land surface biophysical variables, including various radiation components, evapotranspiration (ET), and net primary productivity. Since MODIS sense all over the earth nearly twice a day during daytime, it is useful to monitor dynamic nature of daily ecosystem variations in regional and global scales. The applications to landscapes with heterogeneous land cover and complex topography are however hindered by relatively coarse spatial resolutions of MODIS (250, 500 and 1,000 meters).

We explored the potential applicability of MODIS products for monitoring vegetation phenological onset, ET, and primary productivity in heterogeneous and topographically complex landscapes, widely distributed in Korea. MODIS-derived onset agreed well with field phenological data after careful site-screening process. Sources of errors in estimating land surface energy balance were identified from two contrasting landscapes: heterogeneous crop land and complex forest terrain. Daily ET derived from MODIS was well related with flux tower ET measurements but indicated the importance of a careful modeling and parameterization on surface resistance. Our scaling approach using ecohydrological model provided a useful method to bridge a gap of spatial scales between field plot data and MODIS product. The model-based up-scaling produced useful insights to evaluate MODIS-derived primary productivity in a complex terrain, especially in terms of seasonal drought effect on productivity. Although our explorations showed some bright aspects of MODIS applicability, more rigorous efforts to develop and evaluate MODIS algorithm in coordination with multi-scale field measurements are necessary, especially for complex landscapes.

Key words: MODIS, phenology, evapotranspiration, productivity, complexity.

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ID-238

PROMOTING THE PLANTATION OF TREES WITH LOW-DENSITY WOOD AS A STRATEGY TO REDUCE FOREST DEGRADATION IN INDONESIA

L. Karlinasari[1] and N. Nugroho

Timber still plays important roles in providing raw materials for various purposes. Many advantages can be obtained from timber since it is renewable, machinable, and attractive. Sustainable utilization of timber in Indonesia is at risk due to depleting forest resources and increasing demands for raw material. This situation has created shortage of raw material or limited commercial wood supply, which usually originated from natural forests, dominated by dipterocarps. Attempts to limit degradation of natural forests need to be undertaken because they are important stores of carbon. Domestic demands can be met through promoting the use of other promising species which are abundant and have good properties, especially in strength.

Our investigation of wood properties in a wide range of tree species showed that the substitute species which mostly come from plantation forests, including community forests, generally have properties of low densities (≤ 0.6 g/cm3) and low durability. However, some species basically still have suitable properties in strength and durability and their properties need to be explored further. Investigation showed that mangium (*Acacia mangium*) can be considered to be used as structural materials. Other species which offer prospects include manii or African wood (*Maesopsis eminii*) and jackfruit wood (*Heterophyllus* sp.). They are easily treated for wood preservation, have a good appearance, and are known as light construction materials. Promoting sustainable utilization of wood from these promising plantation species offers a key strategy to reduce the dependency on wood from natural forests and thus reduce forest degradation.

Key words: timber, renewable, plantation, wood, community forest, dipterocarps.

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ID-299

LOCATING FOREST FIELD EXPERIMENTS ACCORDING TO PRESENT AND FUTURE CLIMATE

K. Karlsson[1]

Forest field experiments provide a solid basis for studying the effects of environment changes. Due to increasing costs of establishment and management of experiments, the importance of using existing experiments has increased. In order to support cooperation, increase cost-effective use of resources and provide synergetic values to research, Nordic researchers started to build a database of forest experiments in the year 2000. This 'Noltfox' database has now listed over 11,000 experiments and has expanded to Baltic countries and the United Kingdom. In this database experiment locations are expressed with coordinates – latitude and longitude.

Climate data has not been included in Noltfox, so this study was made to look at the possibilities to use publicly available datasets to complement experiment information. Past and future climatic data was obtained with a spatial resolution (pixel size) of 10 minutes covering all of Europe. Future climate was described using four modeling approaches at four levels providing a total of 16 climate scenarios 2000–2050.

Processing all datasets in the ArcGis program resulted in a combined dataset that could be used for spatial queries, e.g. using both experiment information and climate data as search criteria. Experiments were located both regarding to extreme conditions and according to specific gradients. Examples will be presented on the poster. According to maps produced climate change is expected to be relatively moderate in many areas of northern Europe. Still, research with subjects concerning genetics, stand treatment and ecosystem research could benefit from a location approach (sampling) like this.

Forest researchers in most European countries have more accurate climate data available of their own territories compared to these generalized datasets. However, combining those at a larger scale would set big demands on computing capacity. These datasets are already quite large, but can be handled on personal computers and with basic software.

Keywords: database, climate, climate change, forest experiment, GIS.

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ID-086

EXTENSIVE MORTALITY OF SPRUCE FORESTS IN ARKHANGELSK REGION: SATELLITE IMAGE ANALYSIS

H. Kauhanen[1], T. Wallenius[1], T. Kuuluvainen[2], T. Aakala[2] and K. Mikkola[3]

Tree mortality is an important process causing forest structural and compositional changes. In north-western Russia, old-growth spruce forests have experienced increased mortality in recent years. The present extent and severity of the dieback was studied in the intact Dvinskoy forest, between Northern Dvina and Pinega Rivers, Arkhangelsk region. Field data were collected for determining the volumes of living and dead trees. Coverage of field and ground layer was used for supervised classification of Landsat satellite image. The oldest trees of every sample plot were cored for estimating the ages of the sampled stands. Field data gave evidence of two episodic dieback pulses during the last few decades. In the younger patches, the dead trees were still standing. Canopy gaps, 0.5-2.0 ha in area, created by recently fallen trees, were also common. Elevated mortality rates associated with the recent dieback appear to have lowered considerably in the most recent years.

We suggest that, for the recent dieback, summer drought weakened spruces and favoured beetle population growth.

Key words: Dvinskoy forest, mortality, satellite image, spruce.

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ID-248

LCA ANALYSIS OF TIMBER HOUSE CONSTRUCTION IN JAPAN FOCUSING ON CALCULATING LCCO$_2$ IN BASIC MATERIALS

A. Kawanabe[1], N. Akita[2], T. Seike[3], Y. Iijima[4] and K. Tarata[5]

This study describes the environmental impacts of basic timber components in housing construction in Japan, focusing on CO_2 emission. Several types of building models with domestic and imported timber products are analyzed using a case study approach based on fieldwork. The aim of this study is to identify the leading contributing factors to total CO_2 emission in home construction. It is necessary to know how environmentally-friendly materials are, because Japan has a serious challenge to reduce the amount of CO_2 emission in the construction industry.

Firstly, we show the process from forest to construction site using four models. Models A and B were used by one of Japan's largest construction companies, utilizing Fenno-Scandinavian logs. Model A is Swedish, model B is Finnish. Models C and D are from a small building company utilizing Japanese logs. Model C is in a forestry area, model D is in Tokyo. Secondly, we explain the requirements of the various activities; logging, sawing, drying, remanufacturing and transportation. Lastly, we estimate the CO_2 emissions of each phase and total them to compare each model using a cumulative LCA method.

The models do not vary greatly on the total volume of CO_2 produced, but show differences in two phases. The biggest is in the kiln-drying phase. Model A has a lower emission count because it is able to deduct the electricity consumption from the real spending due to choosing biomass-based electricity instead of fossil-fuel based. The other area is the transportation phase - Models A and B have higher emission levels because their long-distance marine transportation consumes more fuel.

The results suggest areas where CO_2 emission can be improved, i.e. selecting local products and using energy-efficient production systems.

Key words: building material, environmental impact; LCA (Life Cycle Assessment), LCCO$_2$ (Life Cycle Carbon Dioxide), timber products.

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ID-118

MATHEMATICAL ANALYSIS OF CHANGE IN FOREST CARBON USE EFFICIENCY WITH STAND DEVELOPMENT: A CASE STUDY ON *ABIES VEITCHII*

Ogawa Kazuharu[1]

Owing to lack of theoretical backgrounds, changes in carbon use efficiency (CUE), which is defined as the ratio of net primary production (NPP) to gross primary production (GPP), were analyzed for *Abies veitchii* Lindl. forests with respect to stand development by developing a simple mathematical model incorporating data on physiological variables and leaf mass ratio. A decrease in CUE with stand development was successfully expressed as a function of stand biomass (y) based on the following three assumptions: (1) a power functional relationship between mean respiration and mean individual tree mass, (2) a power-law relationship between mean gross primary production and mean individual tree mass, and (3) self-thinning relationship between stand biomass and density. Based on this model, a parameter of CUE-y relationship was detected, and it was clarified that CUE decrease with stand development is caused not by the ratio of specific respiration rate to specific gross photosynthetic rate, but by leaf mass ratio. Since CUE is high in young forests, helpful information on selecting woody species when planting seedling was provided from the viewpoints of reducing CO_2 in the atmosphere and global warming.

Key words: *Abies veitchii* Lindl., carbon use efficiency, global warming, gross primary production, net primary production.

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ID-003

THE RISK OF ABIOTIC FOREST DAMAGES WILL ALTER UNDER THE CLIMATE CHANGE IN THE BOREAL CONDITIONS

S. Kellomäki[1], A. Kilpeläinen and H. Peltola

Impacts of climate change on the temporal and spatial patterns of risks of wind-, snow- and fire-induced damages to forests in Finland for the next 100 years is addressed based on model simulations. This was done by employing: i) national level forest inventory data, ii) climate scenarios for current and changing climate (1990-2100), iii) a forest growth and yield model, and iv) mechanistic wind and snow damage model and the model used to identify the climatic potentials of risks for forest fire.

Assuming the current wind climate, the changing climate will enhance the forest growth and development, and affect tree species composition with a decrease of dominance of Norway spruce in southern Finland. Following these changes, we identified a likely decrease in risk of damage. This will be the case especially in southern Finland, because Scots pine or birch are less susceptible than Norway spruce to wind damage. The risks could be further reduced if the final cuts are done at an earlier age. Any increase in the frequency of high wind speeds will increase the risk of damage.

The risk of snow-induced damage and the frequency of damaging snow decreases from today onwards. This reduction is highest in north-western and north-eastern Finland, and the highest stocks of young stands at risk were found in central, north-eastern and north-western Finland. The risk of snow-induced forest damage is equally reduced by changes in critical weather events and the development of growing stock. Delayed thinning will remain the main reason for snow-induced damages. The risks of wind and snow damage will also increase regardless of tree species due to the reduced period of soil frost with poor anchorage of trees.

The risk by forest fires will increase towards the end of this century, due to the fact that the evaporative demand will increase more than precipitation. The relative increase of annual number of forest fires until the end of this century is predicted to be of about 20-30%, especially in the southernmost part of Finland. There is an increasing demand to consider the fire risks in the future management. Fire prevention and fire-fighting policies should also be revised in order to have proper responses to the increasing fire risks.

Key words: abiotic, damage, fire, snow, wind.

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ID-156

CLIMATE CHANGE CONSIDERATIONS IN MANAGEMENT OF MANGROVE FORESTS: REVIEW AND RECOMMENDATION FOR SUNDARBANS RESERVE FOREST, BANGLADESH

M.S.I. Khan[1]

Sundarbans is the largest natural mangrove expanse and oldest mangrove area to come under management practices since 1860s. The area in Bangladesh is declared Reserve Forest with three wildlife sanctuaries designated as ‘world heritage site’. Sundarbans Reserve Forest (SRF) provides timber, industrial wood and range of non-timber products such as fuelwood, thatching material, and honey. Even though there is no formal management plan in practice, the whole resource management is focused towards commercial sustainability, that is the long-term supply of timber and non-timber marketable products. Now eco-tourism and biodiversity conservation is also in priority. However, there is no consideration for climate change mitigation and/or adaptation. SRF is shouldering frequent and fierce tornadoes, cyclones and tidal surges and thus emerged as vital ‘tool’ for overall country adaptation to climate change. Climate change consequences are also observable through increased water salinity and rise in frequency, duration and level of tidal flooding. The possible adverse impacts on integrity of the Sundarbans ecosystem induce the need for climate change considerations to be incorporated in future management directives. Review of previous management and their observed impacts provides the basis for management prescriptions under changed climatic conditions. It is recommended that a clear policy on SRF management be adopted. From adaptation perspective, ‘selection-cum-improvement with natural regeneration’ remains the best choice as silvicultural system. However, regeneration of desired species such as sundri (*Heretiera fomes*) should be sustained where necessary. No interventions should be made after natural disasters. Measures should be taken to increase freshwater flow towards SRF. From mitigation perspective, carbon should be considered as ‘non-timber forest product’. Rotation/selection should promote timber utilization in furniture making or construction as ‘ultimate carbon sink’. Brushwood should be directed towards industrial utilization such as paper making, rather than as fuel. Specially, personnel from policy makers to field managers should be sensitized about considering climate change issues in SRF management.

Key words: climate change, forest management, mangroves, Sundarbans/SRF.

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ID-347

MODELLING THE DYNAMICS OF VEGETATION DIVERSITY UNDER DIFFERENT FOREST MANAGEMENT REGIMES AND CLIMATE CHANGE SCENARIOS

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V. Shanin[2] and S. Bykhovets[2]

Climate change scenarios for boreal and temperate forests in Central European Russia generally predict warmer and slightly drier conditions. The aim of our study is to quantify the effects of both climate change and forest management on forest vegetation diversity. We have earlier proposed to estimate the dynamics of ground vegetation diversity on the basis of plant functional types along the outputs of forest ecosystem simulations. We have used the EFIMOD model of the forest growth and element cycling in the forest-soil system to simulate the dynamics of forest ecosystem parameters, and we have used the model BioCalc to simulate the dynamics of forest types, dominating plant functional types and ranks of species diversity. An area of 190 forest stands in Kostroma region (the southern taiga forest zone) has been chosen as a case study. Two scenarios of silvicultural regimes were compiled: a natural development scenario with no forest management, and a scenario with clear cutting usual for the local forest practice. A set of scenarios with climate change using HADCM3 model was compiled for the simulation. EFIMOD and BioCalc applications show that the harvesting has more effect on ground vegetation diversity than the climate change. For the case study area, clear cutting leads to decrease in species and ecosystem diversity independently of the climate scenarios. The forest protection regime leads to increase in vegetation diversity due to the gradual development of species-rich coniferous-broad-leaved forests dominated by spruce and lime in the overstorey and nitrophilous and nemoral herbs in the understorey.

According to the model results, climate warming has no effects on biodiversity under the clear- cutting regime used in the case study area, but it leads to a light decrease in species diversity in the unmanaged (under the protection) regime due to the small change of dominating plant functional group in the understorey: from the nitrophilous group to the nemoral one. We conclude that a forecast of the effects of global climate change on biodiversity should account for multiple causes of change in biodiversity and integrate other human impacts as well.

Key words: BioCalc model, EFIMOD model, forest type diversity, plant functional types, plant understorey diversity.

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ID-332

A PHENOLOGY MODEL TO PREDICT SPRING CANOPY ONSET OF VEGETATION IN KOREA USING MODIS

Sohee Kim[1], Sinkyu Kang [1] and Jong-Hwan Lim[2]

Timing of canopy onset indicates initiation of growing season with rapid increase in exchange rates of carbon dioxide and water vapour between vegetation and atmosphere. Especially, timing of canopy onset is essential to many ecosystem models to simulate vegetation growth and exchange rates of carbon and water fluxes between land surface and atmosphere. However, field observations of canopy onset are rare and insufficient in Korea. Also, the species-specific or site-specific model which is commonly used to predict phenological events is difficult to apply to a broad range of plant species and environmental conditions.

In this study, we developed a phenology model to predict spring canopy onset of vegetation using moderate resolution imaging spectroradiometer (MODIS) products (e.g., LAI and NDVI) together with climate data of national weather stations in Korea. Data from 2004 to 2006 were utilized for the model development and the model was evaluated using data from 2001 to 2003. The model was divided into two steps to consider bud physiology: the first step was breaking of rest period described by chilling requirement (Cr), and the second step was overcoming quiescence period described by heating requirement. The model assumed that chilling requirement and heating requirement had the same magnitude of opposite direction. MODIS-based onset was utilized to derive the model parameter (Cr). The estimates of parameters ranged from -73 to -214 chill days in threshold temperature of 6℃. The mean error (ME) between the model predicted and MODIS-based onset was 2.7 days on average. Our study implicates that onset date derived from MODIS is useful to develop regional scale onset models showing reasonable accuracy. The developed model can be inserted as, or substitute a phenological module of complex ecosystem model for simulating future ecosystem carbon and water budgets.

Key words: canopy onset, Leaf Area Index, MODIS, phenology.

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ID-258

BIOCLIMATIC CLASSIFICATION FOR CLIMATE CHANGE IMPACT ASSESSMENT: IMPLICATION FOR FOREST CONSERVATION

T.K. Kim, B.H. Yoo, M. Kim, J.H. Lee, S.M. Lee and S.J. Lee[1]

This study was conducted to investigate the methodologies to assess the impacts of climate change on the ecosystems and biodiversity of the Korean Peninsula. For this purpose, the spatial variability of climatic variables of biological importance was estimated using principal components analysis (PCA) and a hierarchical cluster analysis for the Korean Peninsula. Four principal components were produced from the PCA, which together explained nearly 94% of the variation within the 67 variables of the data set. Examination of the relationships between the principal components and the original bioclimatic data set indicated that PC1 and PC4 were related to temperature variables, and PC2 and PC3 to precipitation variables. Using the hierarchical cluster analysis, classification at the 21-class level was selected. These classes varied greatly in size with the largest classes occurring in the central inland areas of South Korea. The class in mountain areas tended to be smaller and more fragmented. Twenty national parks, 23 provincial parks, 33 county parks and other conservation areas were studied to determine bioclimatic classification.

Study results served as a reference point when examining climate change scenarios during the following studies. The results will be used to prioritize forest conservation policies in relation to the impacts of climate change.

Key words: bioclimatic classification, climate change, forest conservation.

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ID-256

MANAGING FORESTS IN AN ERA OF CLIMATE CHANGE: PERSPECTIVES FROM THE U.S. FOREST SERVICE

Abigail R. Kimbell[1]

The U.S. Forest Service has been addressing climate change through its research programs for about 20 years. Beyond research, we manage the National Forest System, which covers 77.2 million hectares, about 20 percent of the forests in the United States. In these forests, we have been addressing climate change - without calling it that - for as long as we have been writing silvicultural prescriptions. We also work in partnership with states, tribes, municipalities, and other federal agencies to sustain the health and resilience of all forests nationwide. These forests provide a range of ecosystem services to our people, including supporting services (such as nutrient cycling and soil formation), provisioning services (such as fiber, forage, and freshwater), regulating services (such as flood control and water purification), and cultural services (such as spiritual and educational experiences). By disrupting ecological processes, climate change can damage or destroy the health and resilience of our forests, preventing them from supplying ecosystem services to our people.

The Forest Service has developed a strategic framework for addressing climate change. The framework is built around two basic approaches: adaptation and mitigation. In various ways, we can help forest ecosystems adapt to the stresses associated with a changing climate. For example, we can thin forests to increase their tolerance of drought and their resistance to wildfire and insects. We can help species migrate to suitable habitat, partly through wildlife corridors. And we can take advantage of disturbances such as wildfires by planting different species or genotypes more resilient to a changing climate. As forest managers and conservationists, we can also mitigate climate change in various ways. For example, we can conserve energy; use alternative fuels; sequester more carbon in forests, soils, and wood products; substitute for more energy-intensive materials; and increase the use of energy from wood.

Key words: adaptation, ecosystem services, energy, mitigation, U.S. Forest Service.

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ID-380

NATIONAL PROGRAMMES ON MONITORING AND MINIMIZATION OF CONSEQUENCES OF FOREST MORTALITY

Mikhail Kobelkov[1]

Forest Health Monitoring in Russia is done as part of the State Forest Inventory (FSI) whose multi-agency implementation is ultimately under the responsibility of the Federal Forest Agency (Rosleshoz). FSUE “Roslesinforg” provides information on forest divisions, forest properties, forest management and utilization and thematic maps. FSI “Avialesookhrana” provides information on wildfire and collects data of from remote sensing. FSI “Roslesozaschita” provides information on forest health, outbreaks of forest pests and diseases, and also on salvage cutting and thinning, and treatments against forest pests. All data are aggregated into the «Uniform Information System UIS - Rosleshoz». An important element of UIS is the Forest Health Monitoring, which is conducted both of remote control and ground forest inspection methods.

The Forest Health Monitoring is based on the forest zonation of the forests within three levels of severity of forest health problems: weak (338 million ha under threat), medium (260 million ha under threat) and high (76 million ha under threat). Specific operations of forest health monitoring and of forest protection operations correspond to each zone. In the zone of weak threat to forest health, basically a remote survey (satellite photographs and aerial survey) is used and ground tree inspection in the damaged forests. In the zone of medium and high threat, routine ground forest surveys are implemented by selective methods complemented with remote sensing. Satellite image interpretation of medium- and large-scale allows for a prompt estimation of large-scale forest damages. Specialists of the central office of FSI “Roslesozaschita” chart forests damaged by wildfires, hurricanes and windstorms, and also areas of high insect defoliation. Interpreted photographs are transferred to FSI “Roslesozaschita” divisions. Specialists of sub-offices of FSI “Roslesozaschita” carry out the ground surveys for assessing the Forest Health Status, identifying the cause of forest injuries and estimating the area of impacted forest.

All data gathered from remote sensing and field surveys are used to make a comprehensive analysis and assessment of the Forest Health Status, to determine the causes and areas of forest decline for every region of the Russian Federation and for Russia in general. Using this information and climate data, specialists make short-term forecasts of Forest Health Status and trends in forest pest populations.

The Forest Health Monitoring Database provides the information for supporting decision-making processes and planning salvage cutting and thinning, suppression treatment of forests against forest pests directed at minimization of losses. For example, timeliness in carrying out treatments of stands in the forest pests outbreaks on the area of 145.8 thousand ha has permitted to prevent forest mortality on a 13 thousand ha area and has prevented losses of nearby 820 million rubles.

Key words*:* Forest Health Monitoring, State Forest Inventory, remote sensing, forest mortality.

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ID-372

CAN INTENSIVE THINNING REGIMES MITIGATE DROUGHT EFFECTS ON NORWAY SPRUCE?

M. Kohler, G. Nägele and J. Bauhus[1]

Against the background of a predicted increase in drought frequency and intensity in central Europe, it is a key silvicultural question whether the drought resistance of forest stands can be enhanced by altering the stand structure. To investigate whether the drought resistance of individual trees can be increased through the provision of more growing space, a thinning experiment established in 1974 on 26 year-old spruce stands in the Alpine Foreland of Southwest Germany was analyzed. In 2007, tree ring widths were quantified for increment cores, as well as for stem discs, from 37 trees from stands representing three different thinning regimes. All trees sampled were of a co-dominant to dominant canopy status. The measured ring widths were transformed into ring area series.

Data analysis was carried out using the software program ARSTAN from the Dendrochronology Program Library provided by the University of Arizona. In a first step, each individual ring area series was detrended applying an exponential growth model. Autocorrelations, sensitivities and relative growth indices were calculated. In a further step, the data were pooled at the stand level by applying a robust estimation of the mean value function to eliminate endogenous growth variability. The similar growth decline of individual spruce trees during extreme drought events such as in 1976 or 2003 showed that the resistance against drought stress can not be significantly improved by thinning. However, it appeared that the resilience, the recovery of basal area growth, was more rapid in trees from heavily thinned stands.

Key words: Norway spruce, drought response, thinning regime, time series analysis.

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ID-247

ADAPTATION MEASURES TO CHANGING CLIMATE IN DIFFERENT EU COUNTRIES

Marja Kolström[1], Marcus Lindner[1], Jordi Garcia-Gonzalo[1],
Sylvain Delzon[2] and Antoine Kremer[2]

The human influence on the earth's climate is becoming more and more obvious. Climate observations prove the existence of a global warming trend: global temperature has increased by 0.8°C since 1900 and the 12 hottest years observed since 1880 have occurred between 1990 and 2005. Forests are particularly sensitive to climate change, because the long life-span of trees does not allow for rapid adaptation to environmental changes. Unlike in agriculture, adaptation measures for forestry need to be planned well in advance of expected changes in growing conditions because the forests regenerated today will have to cope with the future climate conditions of at least several decades, often even more than 100 years.

The projected impacts of climate change and the adaptive capacity of forests and forestry together determine the vulnerability to climate change. To respond to projected risks and to exploit possible opportunities, adaptation measures need to be explored at different levels from practical forest management to national forest policy making. A comprehensive review of potential adaptation options for forests and forestry in Europe was undertaken. In addition, a survey was carried out to compile existing and planned national strategies for adapting forests and forestry to climate change in the 27 Member States of the European Union. A questionnaire was distributed to member states and a large number of European forest research institutions.

The presentation will summarize the most suitable adaptation measures available to European forestry and document the existing adaptation measures in different countries. Based on this, conclusions and recommendations for improved adaptation strategies for forests and forestry in the EU 27 member states will be presented.

Key words: adaptation measures, impact, survey, climate change.

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ID-099

MODELLING SOIL ORGANIC MATTER DYNAMICS AND FOREST NUTRITION UNDER CLIMATE CHANGE

A. Komarov, A. Mikhailov, V. Shanin and S. Bykhovets[1]

Projected climate change scenarios for the boreal and temperate forests of the Central European Russia generally show warmer and somewhat drier conditions. Consequently, a problem of quantification of climate change effects on forest growth and changes of carbon and nitrogen turnover in the forest-soil system as well as harvesting on C budget in forest ecosystem has arisen. The forest ecosystem model EFIMOD has been undertaken for mixed coniferous-broadleaf forests in central Russia. The model was developed on the basis of Russian concepts and experimental data, and has been extensively tested and applied in Finland, Germany, the Netherlands, Czech Republic and Russia. The EFIMOD integration of both vegetation and soil processes into a forest-soil model permits feedback between the vegetation and soil. This provides a dynamic representation of vegetation and soil parameters and allows for a simulation of carbon and nitrogen dynamics with stand development.

Two case studies have been chosen near Moscow and in Kostroma region (400 km north-east from Moscow). Two scenarios of silvicultural regimes were compiled: natural development, and cuttings in correspondence with local forest practice. A set of scenarios with climate change using HADCM3 model was compiled for the simulation. EFIMOD application shows that climate warming and harvesting significantly influence the pools of tree biomass and soil C. In general forest productivity grows and soil resource decreases. Increasing of soil nutrition due to more intensive deliverance of mineral nitrogen to vegetation as a result of climate change is the main reason for this new balance. Difference between dynamics of forest and soil carbon is more distinct at natural development. Species composition at natural development in both case studies is shifting to the most nitrophilous trees. Cuttings are smoothing these processes. The detailed results show that climate change has indirect impacts to the processes in forest-soil system.

Key words: carbon and nitrogen dynamics, EFIMOD model, harvesting, simulation model, soil nutrition.

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ID-128

BURNING REGIMES AND DYNAMICS OF THE SUDANIAN SAVANNA ECOSYSTEMS: THE CASE STUDY OF KATIALI, CÔTE D'IVOIRE

M. Koné[1], T.J. Bassett[2] and J.N. Nkem[3]

Biomass burning is considered as an important source of greenhouse gas and aerosol emissions contributing over 40% of gross carbon dioxide emitted each year. African savannas with mixed dry forests are viewed as one of the "burn centers" of the planet with the burning assumed to be taking place in the middle and late-dry seasons. This paper reports the investigation of biomass burning at local and regional scales in the Sudanian savannas of Côte d'Ivoire. The case study in the Katiali region examines changes in fire intensity, frequency, and efficiency in relation to different periods of burning. The study uses a political-ecological approach to expand the understanding of burning regimes and to present a more accurate assessment of land use and land cover change in the Sudanian savannas.

In contrast to the views in the environmental change literature that depict savanna fires as intense and highly destructive, recent development in land use and land cover changes related to the expansion of cashew and mango orchards and livestock raising have led to changes in fire regimes. Currently, local resource users increasingly burn in late October and early November. Farmers use early fires as a management tool to protect their cashew and mango orchards while herders burn early in the dry season (mid-October/mid-May) for new grasses that are more palatable to cattle. Furthermore, farmers and pastoralists usually set fires early in the morning or in the evening, when the wind speed is low, to avoid highly destructive burnings. Early dry season burning is less intense and less efficient, and over the years favors the expansion of woody vegetation in the Sudanian savanna. Less intense burning also produces lower gas and aerosol emissions. The resulting increase in vegetation cover could potentially sequester more carbon dioxide than is presently attributed to the system.

Key words: biomass burning, burning regimes, farming and pastoral activities, political ecology, savanna ecosystems.

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ID-196

LEARNING TO DEAL WITH CLIMATE CHANGE AND CATASTROPHIC FOREST DISTURBANCES

Doug Konkin[1]

A succession of warm winters has contributed to the largest mountain pine beetle epidemic in British Columbia's (BC's) recorded history. In BC, the beetle has affected more than 13 million hectares, an area the size of England. By 2015, the beetle is expected to kill three quarters of the mature pine in the province, affecting jobs and communities across BC's interior. In partnership with the Canadian government, British Columbia is tackling a myriad of related issues, including impacts on mid-term timber supply, loss of critical wildlife habitat, and changes to hydrological cycles. The province is taking action to adapt, reduce future risks, and capitalize on emerging opportunities.

British Columbia is the most biologically and ecologically diverse province in Canada and climate change is adding to the complexity of forest management. Climate change researchers have provided us with scenarios of how changes in temperature and precipitation might affect our varied ecosystems. The challenge these scenarios present is what we are working to address by adapting forest management to ensure healthy, resilient forests that will continue to provide multiple products, ecosystem services and other benefits. BC is identifying and addressing research gaps through the Mountain Pine Beetle research strategy, our Future Forest Ecosystems Initiative, and partnerships with academic organizations, other agencies and the private sector.

Climate change is calling us to more fully integrate science, policy, and social issues. BC is adjusting systems to adapt to the changes, and looking at ways to absorb and distribute risk through collaboration and cooperation.

Key words: British Columbia, Mountain pine beetle, Future Forest Ecosystems Initiative.

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ID-377

EFFECTS OF CLIMATE CHANGE ON WOOD PROPERTIES: OVERVIEW OF CURRENT KNOWLEDGE

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Over the last 15-20 years, a great number of publications were issued describing the responses of plants to climate change factors - elevated CO_2, elevated temperature, elevated tropospheric ozone, and their interactions. Amongst these publications, only around 30 papers describe changes in stem wood properties in woody species. For this presentation, we have made a survey of the current knowledge, aiming to draw general conclusions of the anticipated future trends due to climate change in wood properties. In most studies, the trees have been <10 years old (range <1 yr to 40 yrs>) and the duration of the exposure has varied between 0.2 – 6.0 years.

The majority of studies describe effects of elevated CO_2 which, in most cases, causes increased stem wood production. Elevated CO_2 affects wood chemical composition, and particularly an increase in soluble carbohydrates is apparent. Wood structure, in turn, shows only minor changes, and is seen mainly as increased vessel, tracheid diameter and thinner cell walls. Elevated O_3 decreases radial growth and also wood structure, as well as wood chemical composition, are affected. The diameter of vessels and tracheids decreases, and the cell walls become thicker. The few studies with combined treatment of elevated CO_2 and O_3 show that O_3 can counteract the positive growth response of elevated CO_2. Among the climate change factors, the effects of elevated temperature on wood properties are least explored. The few data indicate increasing wood density and tracheid length, and decreasing concentrations of soluble carbohydrates and extractives.

In the presentation, we will discuss the physiological mechanisms behind these changes and their consequences on tree function and end use of wood matter.

Key words: climate change, temperature, carbon dioxide, ozone, wood quality.

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ID-145

MAPPING BIOLOGICALLY IMPORTANT FORESTS – TOWARDS THE RESTORATION OF A TRANS-EUROPEAN FOREST MEGA-CORRIDOR

Diyana Kostovska[1]

Loss of forest cover and increased degradation of the remainder have had a deep impact on biodiversity in Europe's forests: original habitats have been lost and myriad of species dependent on them become endangered, numerous gone extinct. In the face of warming climate and the accelerated nature of climate change, the adaptation and survival of many forest dependent species will rely on the retained ecological connectivity of suitable habitats. Mapping of Europe's Biologically Important Forests (BIFs) is the BirdLife European Forest Task Force's response to this challenge.

The main goal of the European BIF mapping is to determine the precise location of forest areas with high natural values, which will provide the foundation for efficient protection and management of European forest ecosystems. The main data sources for mapping are national forestry databases, supplemented by topographic maps Natura 2000 data and maps, data on forest-dependent bird species from BirdLife Partners, National Red Lists, satellite imagery and field checks. The BIF mapping results in a GIS-based database organised at three levels and an interactive map service available on http://www.birdlife.fi/forestmapping. It is completed in Estonia, Latvia and Lithuania, Poland and Belarus and is being carried out in Bulgaria and Romania.

The BIF programme, exploring all the available data and implementing the state-of-the art forest inventory techniques, can help optimizing both conservation efforts and economic efficiency of forest management. Preservation of all remnants of natural forests and restoration of the ecological connectivity bridging forest biodiversity centres from Fennoscandia to the Balkans is probably the most urgent conservation task in response to climate changes. A trans-European forest mega-corridor, designed, restored and according to the BIF distribution will be of critical importance to forest biodiversity preservation as climate change progresses and pressure increases on remaining forest resources.

Key words: Biologically Important Forests, climate change, forest biodiversity conservation, mapping, restoration.

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ID-045

CLIMATE CHANGE IMPACT ON SOIL SALINITY AND TREE GROWTH OF TIDAL FRESHWATER FORESTED WETLANDS OF THE SOUTH-EASTERN UNITED STATES

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and Jamie A. Duberstein[2]

North American coastal forests along the Gulf of Mexico and Atlantic Ocean are undergoing dieback from increasing tidal inundation and saltwater intrusion attributed to global climate change and variability. These are productive ecosystems due, in part, to the quantity of nutrients received from upstream and marine sources during inundation by the flood effect of local tides. These tidal freshwater swamps are subject to different hydrogeomorphic settings, tidal amplitudes, drought and hurricane frequencies, subsidence rates, and streamflow volumes which, in part, account for varying degrees of salinity exposure and dieback conditions on a local and regional basis.

We have inventoried forest structure of several tidal swamp sites in South Carolina, Georgia, and Louisiana to understand linkages of sea-level rise, hurricanes, and droughts on soil salinity, inundation, and fertility related to species composition and tree growth. All field sites showed that forest complexity and productivity are negatively correlated with residual interstitial soil salinities in these coastal forests dominated by bald cypress, *Taxodium distichum*. Research sites in eastern Louisiana demonstrated spiked and sustained soil salinities from surge over-wash following Hurricane Rita (2005) during the span of a regional drought. Individual trees were banded to monitor monthly basal area increment (BAI) of dominant trees over a 4-year period. Growth data were analyzed to examine the inter-relationships with soil total nitrogen (TN), total phosphorus (TP), pore water salinity, and inundation (flood frequency, flood duration, mean water table depth). As mean annual site salinity increased from 0.1 to 3.4 ppt across all sites, basal area decreased from a high of 87 m^2/ha to a low of 23 m^2/ha. Stand height and growth also differed significantly among sites and with soil fertility. Projected sea-level rise and changing climate is expected to accelerate the extent of saltwater intrusion that will further impact these coastal forests and restoration efforts in the absence of adaptive coastal management.

Key words: climate change, nutrients, soil salinity, tidal swamps, tree growth.

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ID-354

PHENOLOGICAL RESPONSE TO CHANGING ENVIRONMENTAL CONDITIONS OF WESTERN GHATS, SOUTHERN INDIA

Yelugere L. Krishnamurthy[1], A. Nanda and Hiregouja M. Prakasha

The role of temperature, rainfall pattern and phenological response of 277 individuals representing 47 tree species at community level is assessed to understand the vagaries of nature in the areas of mid-Western Ghat regions of Karnataka from June 2004 to May 2006 - a dry deciduous forest (Umbalebylu, 13°.46' to 13° 52' N, 75° 36' to 75°.42' E) at 690 to 750 m ASL. Our paper describes the impact of climate on changed pattern of phenology over the last three years under rapidly changing climatic conditions.

Woody stems above 20 cm DBH with clearly visible canopies were marked with a unique tag on either side of a transect. The trees were observed at regular intervals for various vegetative and reproductive phenology events. The rainfall and temperature varied from 35.5 to 542.1 mm, and 15.1^0 to 36.6^0C respectively during the study period. A regression analysis showed that trees in dry deciduous forests show leaf flushing before the onset of rains in dry season. Flowering also occurred during the dry season. In fact, in most trees, leaf flushing and flowering happened together. Fruit initiation happens with reduction in minimum temperature or with the advent of warm period.

Our understanding of the ecology of tropical trees remains relatively poor. Phenological data helps us to understand the influence of climatic events on the feeding, movement patterns, and sociality of birds and mammals. The phenological pattern of leaves, flowers, and the dispersal mechanism of seeds and fruits, along with a knowledge of the behaviour of herbivors and pollinators, have immense importance to ecologists as these studies help in the assessment of tropical forest diversity under the impact of climate change.

Key words: Southern India, tropical forest biodiversity, climate patterns.

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ID-303

RESILIENCE AND ADAPTATION IN COMMUNITIES IN ALASKA

Linda E. Kruger[1]

Communities across Alaska are encountering a variety of social, economic, and climate related changes, including many influences that are interacting and compounding. In the context of these ongoing changes, this paper explores concepts of sustainability, community resilience, and adaptation and applies these concepts across Alaskan communities. The study draws both on resilience theory from systems analysis research and social capital research in rural sociology and tourism. A key consideration for communities is how prepared they are to adapt to change—whatever form it takes—as it comes their way. For communities wanting to ease the inevitable challenges of transition and plan for an envisioned future, understanding how to engage diverse community members in discussing a desired future is a first step. This is especially true in amenity communities facing a population shift with new residents moving in and possible displacement of older, more established residents.

This paper reviews efforts a number of Alaska communities are taking to design a sustainable future in a time of unprecedented social, cultural and climatic change. Unfortunately, many rural communities are ill equipped to engage in the kinds of planning activities needed to maximize the opportunities that changing times can offer while minimizing the threats that can accompany "rough waters" of change. Rural planning departments are often inadequately funded and staffed, and in some areas non-existent.

The paper reviews the processes each community has undertaken, products and results of their efforts and makes recommendations for other communities. The long-term goal is to better understand communities as adaptive systems, and provide practical guidelines for helping communities adapt to social, economic, and ecological changes.

Key words: adaptive capacity, amenity migration, public participation, resilience.

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ID-067

CAN FOREST MITIGATION STRATEGIES ALSO ADDRESS ADAPTATION OBJECTIVES?

Werner A. Kurz[1]

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change identified that forestry and forest sector activities offer a large potential to mitigate human impacts on atmospheric greenhouse gas concentrations. Mitigation activities can be directed at decreasing greenhouse gas emissions (sources) and increasing the rate of removal (sinks) from the atmosphere. Future climate change impacts on forest carbon dynamics are expected to reduce the mitigation potential, because of regional increases in natural disturbances (wildfire, insects, drought), increased decomposition rates at higher temperatures, and increasing mal-adaptation of tree species to their changing climatic environment. Climate change impacts could cause widespread die-back of trees that are at the margins of their current geographic distribution, or as a result of increased fires, insect impacts and drought. For example, the current outbreak of mountain pine beetle (*Dendroctonus ponderosae* Hopkins) in British Columbia, Canada, is expected to kill about 1 billion m^3 of trees. Large volumes of decaying wood offer opportunities for salvage logging, where ecologically appropriate. Harvested timber can be used (1) for wood products that keep carbon out of the atmosphere and substitute for emissions-intensive materials such as steel, aluminum and concrete, and (2) for bio-fuels to substitute fossil fuels, with a net benefit to the atmosphere. Moreover, forest managers have the opportunity to affect future forest conditions and the rate of carbon uptake from the atmosphere by assisting post-disturbance regeneration, e.g. through planting and species or provenance selection.

Managing the transition of forest ecosystems under climate change, while meeting greenhouse gas mitigation objectives, adds further challenges to forest management. As the burdens of greenhouse gas mitigation efforts and climate change impacts increasingly affect society, it can be anticipated that future societal expectations of the role of forests are changing. Developing forest mitigation strategies that also address adaptation objectives requires a sound understanding of the contribution of forests and forest sector activities to the global climate system (carbon balance, albedo, hydrology) and of the impacts of climate change on future forest dynamics.

Key words: carbon, modelling, climate change, forest management, wood products.

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ID-309

CLIMATE CHANGE, POLLUTANT DEPOSITION AND THE OZONE SITUATION WORLDWIDE: IMPLICATIONS FOR, AND THE ROLE OF, FORESTS

Johan Kuylenstierna[1]

UNEP have recently compiled a Global Environment Outlook (GEO) providing a holistic view of environment and related development issues worldwide. From this analysis, it is clear that many of the global changes will affect and be affected by forest ecosystems. The research and monitoring plans need to take into account these regional, hemispheric and global changes in order to assess risks to ecosystem services and opportunities that forests provide to enhance them. It is also clear that some of the risks which are reducing in Europe and North America, such as acidification, are now increasing in other regions of Asia, Africa and Latin America. Ozone pollution continues to pose a significant threat in Europe and hemispheric background concentrations are increasing. However, massive increases in tropospheric ozone are projected in other regions, particularly Asia.

Global climate change has come to the fore as the most pressing global issue in 2007 and the realisation that unprecedented changes are underway imply significant shifts in biodiversity, ecosystem dynamics and changes in the way the forest ecosystems respond to other stresses, such as attacks by pests and pathogens. The interactions between climate change, ecosystem services, ozone concentrations and sulphur and nitrogen deposition are important emerging areas for research and monitoring. Many air pollutant and greenhouse gas emissions share the same sources and the opportunities for realising co-benefits of reducing one in support of the other is enormous, but only just emerging as an issue at global scale.

Key words: co-benefits, GEO4, interactions, research priorities.

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ID-273

THE CONVENIENT TRUTH

Sylvain Labbé[1]

The environment, especially climate change and global warming, has become the number one concern of the Canadian people, surpassing economy, health and politics.

The first part of this paper presents the results of a survey done in the USA and Canada on public awareness about global warming; public perception of the causes of climate change; and public opinion of the role of forests and the forestry industry in climate change. A total of 3,223 Canadian and 2,333 American online interviews were completed between October 26th and October 31st 2007. The margin of error of the total Canadian results is ± 1.8%, and for the U.S., ± 2.1%. The various IPPC reports have been interpreted by different interest groups and mixed with their own perception. The links between forest harvesting, deforestation, green building systems and carbon footprints generated a lot of confusion with the public and sometimes even government authorities.

The second part of this paper discusses different marketing campaigns by various industries and more specifically those targeted at the biggest cause of CO_2 emission: oil and gas, concrete, steel and plastic. These eco-campaigns have generally no solid ground and sometimes can be classified as ‘‘Green Washing’’. In the meantime, the fragmented wood industry has neither the resources nor the public credibility to promote the most environmentally friendly building material - wood.

The third part of the paper compares the different Green Building systems under development worldwide with their characteristics and specifications, with a special focus on the principles of Life Cycle Analysis (LCA). The wood science community now has the social responsibility to become the leader of promoting strategies for mitigation of anthropogenic carbon emissions related to wood products use.

Key words: climate change, green building, ‘‘Green Washing’’ Campaign, public perception.

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ID-077

FOREST ASSESSMENT FOR IMPROVED MANGROVE FOREST MANAGEMENT IN KENYA

J.K.S. Lang'at[1], B. Kirui, J.G. Kairo and J.O. Bosire

Mangroves world over have been subjected to degradation at alarming rates and are among the ecosystems to be adversely affected by the projected sea-level rise. The situation is aggravated by the fact that landward migration of mangroves would, in most cases, be hampered by human settlement in adjacent areas and topographic factors. In Kenya, lack of management plans, coupled with increasing human population pressure, largely contributes to overexploitation of mangroves. Inadequate quantitative information on structure, composition, natural regeneration and harvesting pressure for mangroves impedes the formulation of policies necessary for their management.

The main objective of this study was to investigate mangrove vegetation structure, composition, natural regeneration and avail data for improved mangrove management. Vegetation survey in a total of 43 plots of 10 m x 10 m each was carried out in the northern part of Vanga Bay, in the Kenyan south coast. Six mangrove species were encountered; *Rhizophora mucronata* (Lam.), *Ceriops tagal* (Perr) C. B. Robinson, *Avicennia marina* (Forsks) Vierh., *Sonneratia alba* (Sm.), *Bruguiera gymnorrhiza* (L) Lam. and *Xylocarpus granatum* (Koenig), in order of dominance. The overall stand density was 1707±761 stems/ha, with mean DBH and height of 10.1±5.8 cm and 6.1±3.1 m respectively. Approximately 80% of the stems ranged from 5 to 13 cm DBH, the most preferred size classes for poles, out of which 88% were *R. mucronata* and *C. tagal*. However, good quality poles represented less than 10% of the total stand density, suggesting the effects of selective harvesting of quality stems. Stumps were observed in 31 out of 43 plots sampled, with 54 being the highest number of stumps in a plot. Natural regeneration consisted of the same species as the adult trees, with *C. tagal* being dominant. Improved management of mangrove ecosystem would contribute immensely in mitigating effects of climate change. For instance maintenance of vegetation cover along the coastlines would ensure protection against coastal erosion and catastrophic events such as the predicted increase in storm intensities. Secondly, sedimentary organic matter input and accretion would ensure increase surface elevation to keep pace with the projected sea-level rise.

Key words: forest structure, Kenya, mangrove management, natural regeneration, south coast.

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ID-277

"FOREST DEVELOPMENT TYPES"
DEVELOPING ADAPTIVE FOREST MANAGEMENT MODELS IN A SCIENCE-STAKEHOLDER DIALOGUE

J. Bo Larsen[1]

In the light of climate change, the development of adaptive forest management strategies is paramount. Addressing societies growing expectations for forest functions and services, it is evident that these strategies must be developed in close collaboration with the beneficiaries.

The Forest Development Type (FDT) is a concept to develop, describe, and communicate long-term goals for forests in stakeholder-driven processes. It describes goals for forest development on a given locality in order to accomplish specific long-term aims of functionality (ecological protection, economic production, and socio-cultural functions). It is based upon an analysis of the silvicultural possibilities, including the uncertainties regarding climate change and future forest functions. It will serve as a guide for prospect silvicultural activities in order to "channel" the actual forest stand in the desired direction, e.g. increasing robustness to buffer future climate and sufficient flexibility to accomplish future functions.

A major object of FDT scenarios is to describe the practical impact of the general policies for adaptive silviculture on the stand level. For each scenario structure, species composition and regeneration dynamics are described both qualitatively and quantitatively, and the goal is specified with respect to conservation, recreation and production. Furthermore, to support the intuitive understanding of FDT scenarios, vegetation structure and composition are illustrated by means of profile diagrams.

The concept enables the collaborative approach by making active participation with the practitioners, creating ownership with the beneficiaries, and generating close links between planning and management. It has been used by the Danish Forest and Nature Agency to develop and implement an action plan for the Danish state forest adopting close-to-nature forest management principles, thereby addressing the uncertainties of climate change and prospect forest functions.

Key words: climate change, forest management, adaptation, stakeholder participation.

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ID-149

PHYTOSANITARY ISSUES RELATED TO CLIMATE CHANGE, INVASIVE ALIEN SPECIES AND TRADE: HOW TO USE THE FRAMEWORK OF THE INTERNATIONAL PLANT PROTECTION CONVENTION FOR THE MANAGEMENT OF FOREST HEALTH

Brent Larson[1]

Climate change, the increasing volume of international trade and invasive alien species all interact to enhance the risk of the establishment of forest pests in new areas. The International Plant Protection Convention, which recognizes the necessity for international cooperation in controlling pests of plants and plant products and in preventing their international spread, and especially their introduction into endangered areas, may help address these issues.

The forestry sector can utilize the framework of the International Plant Protection Convention to help improve the management of forest health. The obligations under the Convention itself, as well as guidelines laid out through international standards, have often enabled nations to set up phytosanitary measures such as pest risk analysis, border controls, eradication plans and surveillance systems. Forest health managers are encouraged to use these existing national systems or, where they do not exist, to engage their national plant protection organization to help implement these international standards in order to internationally harmonize these measures. Regional and international systems also exist to help manage pests that affect forest health. The robustness of this framework will be explained to show how it can adjust as new invasive alien species are encountered and climate and trade patterns change.

The forestry sector's involvement is essential to help in the continued evolution of the framework under the International Plant Protection Convention in order to ensure forestry concerns are addressed. The role and mechanisms on how to get the forestry sector involved will be explained, in particular the need for closer collaboration at a national level between National Plant Protection Organizations and agencies responsible for forestry will be emphasized.

Key words: international trade, IPPC, pathogens.

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ID-366

CONTRIBUTION OF FARMER-MANAGED TREE NATURAL REGENERATION TO ENVIRONMENTAL AND CLIMATIC RISKS MINIMIZATION IN THE SAHELIAN PART OF NIGER (WEST AFRICA)

M. Larwanou[1], M. Illiassou and M.A. Moustapha

The 1973 and 1984 droughts, coupled with overexploitation and unadapted cultural practices, were the precursor of ecological disequilibrium in the agricultural zones of Niger: regression of tree cover, minor performing of production systems and aggressive climatic parameters (wind, temperature and erratic rainfall). This climatic aggression has led to water resource, soil and quantitative and qualitative plant biodiversity degradation. Rural communities, being conscious of this environmental degradation, were engaged during the 1990s in the restoration of tree cover. Since then, there has been a change in the mentality which stimulated an intensification of farmer-managed tree natural regeneration (FMTNR) at all social category levels. Trees have not been considered as a public property, but as privately owned.

The present study aims to qualitatively evaluate the FMTNR contribution in minimizing environmental risks in Niger. Results show that this practice is now widely extended and developed as a component of agrosylvopastoral production systems with disparities in terms of tree density and preserved species within the study areas. In the Aguié District, tree density is more important in the north (113 trees/ha) than in the south (100 trees/ha), whereas in the Magaria district, densities varying between 304 to 360 trees/ha were noted. Identified environmental risks by farmers are related to climate (drought, high temperature, violent wind), biological disturbance (diseases, attacks from crops pests and biological diversity degradation), soil degradation (water runoff, water and wind erosion), and water (rapid drying of wells and water ponds, inundation and water ponds pollution). All these risks lead to the reduction of agricultural productivity, consequently making the rural population more vulnerable. These risks could be considered as the most important factors of rural poverty. In addition to minimizing the above risks, FMTNR also contributes to the improvement of rural community well-being through direct products, such as leaves and fruits, sources of monetary revenues and general contribution to health and cultural equilibrium. Unfortunately, increasing human and climatic pressure on FMTNR is generating a need for a new management approach in order to maintain this proven agroforestry practice.

Keywords: farmer-managed tree natural regeneration, environmental risks, Niger, Sahel.

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ID-346

MAINSTREAMING CLIMATE CHANGE ADAPTATION IN FOREST AND NATURAL RESOURCES MANAGEMENT IN THE PHILIPPINES: THE ROLE OF LOCAL GOVERNMENTS

R. Lasco, P. Jaranilla-Sánchez, R. Delifino[1] and M. Rangasa[2]

Success in implementing climate change adaptation depends to a large extent on the participation of local government officials. In many cases, climate change discussion is confined at the national level to little action in the field. One of the main challenges in promoting climate change adaptation at the local level is the lack of appreciation by local leaders on the need to adapt to climate change. This is because climate change is seen as a long-term problem and thus of less importance than more pressing needs. One exception to this is Albay province in the Philippines. At the initiative of the provincial governor, there is a strong push to adapt to climate change.

In this paper, we document the strong uptake of climate change adaptation options by the local government, explore the reasons that led to this, and their implications to climate change adaptation in forestry and natural resources management. The provincial leadership sponsored the first-ever national climate change adaptation conference with the President herself attending. Subsequently, a climate change center was created in the province. In addition, several bills were filed in the legislative branch to support climate change adaptation. Among the reasons for the elevated interest from the local government of Albay is that the province is buffeted by strong typhoons annually so that policy makers have an high appreciation of climate-related disasters. In addition, the governor and his staff have strong understanding of climate change issues. Here we discuss the implications of the experience in Albay in mainstreaming climate change adaptation into forestry and natural resources management in developing countries. These include finding an appropriate context, the role that meso-scale local government units can play, and its potential limitations.

Key words: adaptation, forestry sector, local governments, small farmers, watersheds.

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ID-101

IMPACTS OF FROST ON BEECH (*FAGUS SYLVATICA* L.) SUSCEPTIBILITY TO SCOLYTINE AMBROSIA BEETLES

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Beech (*Fagus sylvatica* L.) stands in Southern Belgium have suffered in the early 2000s from a steady decline, puzzling by its geographical extent, gravity and suddenness. Bark exudations and necroses broke out on the trunks, along with fungi and the appearance of xylophagous insect galleries (the ambrosia beetles *Trypodendron* spp., *Anisandrus dispar*). These insects are generally considered secondary, normally attacking weakened or dead trees. The hypothesis of a sudden cold wave in November 1998, affecting trees not yet prepared to winter conditions, is highly supported by meteorological (sudden drop of temperature in mid-November 1998), and symptomatological observations (orientation of the necroses, damages correlated with altitude and wind exposition). Frost-related injuries were artificially inflicted to beech trees, by application of different levels of cold shocks on the bark, using dry ice. Beech attractiveness to scolytids was studied by using interception traps established at the base of the trees. Volatile substances produced by necrotic zones were identified, after trapping on adsorbant substrates, by gas chromatography and mass spectrometry (GC-MS). Beech susceptibility to insect attacks was estimated by the colonization success of scolytids caged on the trunk. Ambrosia beetle attacks were observed in spring 2007 inside the treated zones. Results of years 2007 and 2008 show that an artificial early frost event may cause trunk damage and Scolytine attacks. In the context of increased climate variability linked to climate change, these results suggest that secondary insect outbreaks may be used as indicators of tree decline linked to extreme climate events.

Key words: ambrosia beetles, climate events, frost, forest health, tree physiology.

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ID-280

POTENTIAL FOREST PRODUCTIVITY IMPACTS OF CLIMATE CHANGE ON FORESTS OF THE UNITED STATES PACIFIC NORTHWEST

Gregory Latta[1], Hailemariam Temesgen[2], Darius Adams[3] and Tara Barrett[4]

As global climate will change over the next 100 years, forest productivity is expected to change as well. Using PRISM climate and productivity data measured on a grid of 3,356 plots, we developed a simultaneous autoregressive model to estimate the impacts of climate change through the next century on potential productivity of Pacific Northwest (PNW) forests of the United States of America.

Productivity, measured by projected mean annual increment (MAI) at culmination, is explained by the interaction of annual temperature, precipitation, and precipitation in excess of evapotranspiration through the growing season. The model was used to predict the productivity impacts of Scenarios A1B, A2, B1, and COMMIT from the Special Report on Emissions generated for the 4th Assessment Report of the Intergovernmental Panel on Climate Change by the Community Climate System Model. In these scenarios, regional average temperature is expected to increase from 0.5° to 4.5° C, while precipitation increases over time with less trend. In the low population growth, rapid economic development and high energy usage A1B scenario, MAI increases 7% in the moist portion of the PNW west of the Cascade Mountains, and 15% in the dry, high elevation eastern portion of the region. The high population growth, moderate economic development and high energy usage of the A2 scenario raise MAI by 9% on the west side and 18% on the east side. B1 scenario's low growth, high economic development and low energy usage result in west side MAI increases of 5% and east side increases of 15%. The idealistic COMMIT scenario results in no change in west side MAI and 3% change in east side MAI.

While these changes in MAI do not reflect any mitigating effects due to shifts in silvicultural practices or public policy, estimates of potential impacts provide important information to both forest managers and policy makers.

Key words: mapping climate change, mean annual increment, simultaneous autoregressive model, site class.

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ID-291

IMPACTS OF HARVESTING AND THINNING ON CARBON DYNAMICS IN A BALSAM FIR ECOSYSTEM IN NEW BRUNSWICK, CANADA

M.B. Lavigne, R.J. Foster and G.K. Goodine[1]

We assessed the impacts of thinning and clearcutting on carbon sequestration and environmental control of ecosystem processes in *Abies balsamea* (L.) Mill. forests, using the eddy covariance method. Commercial thinning reduced leaf area index (LAI) by 25%; consequently, average gross primary production at midday (GPP_{max}) in July decreased from 2.5 g C ha^{-1} s^{-1} in the year before thinning to 1.8 g C ha^{-1} s^{-1} in the year after thinning. Two years after thinning, GPP_{max} approximately equalled initial values, due to either acclimation of foliage to the changed light environment, or to variation in environmental conditions. Ecosystem respiration (ER) in July changed from 0.6 g C ha^{-1} s^{-1} in the year before thinning to 0.4 g C ha^{-1} s^{-1} in the first year following thinning, and then to 0.6 g C ha^{-1} s^{-1} in the second year. Initial decline in ER may reflect a decrease in autotrophic respiration caused by biomass reduction; the increase in the second year may be due to onset of logging residue decomposition. Clearcutting released a dense layer of *A. balsamea* advanced regeneration. In the growing season following harvest, GPP_{max} in July was approximately 0.1 g C ha^{-1} s^{-1}, increasing to 0.5 g C ha^{-1} s^{-1} in the third growing season. The increase in LAI caused only a modest fraction of the increase in GPP_{max}; acclimation of existing foliage was also important. ER was greatest in the second year after harvesting, suggesting that substantial decomposition of logging residues was delayed for one year after harvesting. We forecast the clearcut site will become a net sink for carbon within the next five years.

Our preliminary conclusion is that balsam fir ecosystems recover photosynthetic uptake relatively quickly after disturbance by a variety of means and that this response offsets additional ecosystem respiration due to decomposition of logging debris. Results such as these are essential for increasing our understanding of ecosystem processes so that models can be developed to predict the impact of altered climate regimes on the carbon dynamics of forests under management.

Key words: adaptation, climate change, net ecosystem exchange.

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ID-252

DOES CLIMATE CHANGE PROMOTE INSECT OUTBREAK SITUATIONS AND ALTERED FOREST ECOSYSTEM FUNCTIONS?

Anne Le Mellec, Holger Vogt-Altena, Annett Reinhardt, Gerhard Gerold
and Beate Michalzik[1]

The assessment report of the IPCC predicts that forest perturbations such as of pathogens and insects will increase dramatically because of climatic changes, including, changes in precipitation and temperature patterns. Limitations of water availability will not only affect metabolism of plants by lowering their photosynthetic activity and thus biomass productivity (NEP, NPP), but will also increase susceptibility of trees to diseases and insects attacks. We assume that outbreaks of phytophagous insects play an important role within forest functioning by their production of organic matter, which enters the soil as herbivore-derived inputs (faeces, green leaf fragments and modified throughfall).

The study was carried out in a German pine forest (*Pinus silvestris*) in weekly sampling intervals from April to October 2005. We analysed the dynamics of organic carbon and nitrogen with throughfall, the inputs of insect faeces by nylon nets and their effects on the soil microbial activity. Our study showed that organic C inputs measured by throughfall under outbreak situation during six month exceeded the annual C entries in temperate forest ecosystems (180 kg C/ha/6 months > 160 kg C/ha/year). Furthermore, impacts by frass via tree net raised up to 520 kg C/ha/6 months.

As yet few investigations were done to study the consequences of forest disturbances and their importance on biogeochemical functioning in forest ecosystems. We assume that these high insect mediated organic matter inputs might enhance the soil decomposition activity resulting in an elevated production of CO_2. From this point of view, insect mass outbreaks might turn forests from carbon sinks into carbon sources due to a limited C storage in timber and an enhanced soil induced respiration. With regard to changing climatic conditions and therefore predicted increasing forest disturbances, further studies are necessary to investigate the altering functions of forest ecosystems.

Key words: climate change, mass outbreaks, phytophagous insects, biomass productivity, forest ecosystems.

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ID-014

INCREASED DECLINE OF KOREAN FIR FOREST CAUSED BY CLIMATE CHANGE IN MOUNTAIN HALLA, KOREA

J.H. Lim[1], J.H. Chun[1], S.Y. Woo[2] and Y.K. Kim[1]

Korean fir (*Abies koreana*), which is a rare and endemic species, is present on high mountains in Korea. To understand the spatial differences and speed of declining, we set permanent plots and air temperature/humidity sensors on three locations in 2003 around the peak of Mt. Halla in Jeju Island. And then, we draw stem-maps and measured mortality, leaf conditions, e.g. leaf length, leaf folding symptoms, and *in-situ* physiological responses to air temperature. Using Landsat TM and IKONOS images, we made the vegetation map and assessed the changes in Normalized Difference Vegetation Index (NDVI), from 1994 to 2003. While populations on north-eastern slope showed vigorous and dense coverage, those on south/west slope were sparse and declining. NDVI on southern and western slope had significantly decreased during the period, while there were no changes on north-eastern slope.

As the result of field measurements, we found tree mortality was increased linearly according to the rise in previous winter temperature in two plots on southern and southwestern parts of the peak. Physiological measurement data, e.g. net photosynthetic rates, showed that temperature higher than 15℃ was stressful to Korean fir populations. Consequently, the recent Korean fir forest decline in Mt. Halla, especially on southern and western slope where solar energy input is higher than north-eastern slope, has been accelerated by water stress due to the imbalance between water requirement and supply from roots in winter and spring which was primarily caused by climatic warming in Jeju Island. It is expected that declining of Korean fir forests in Mt. Halla will proceed faster in the future due to warming, and the speed of declining of the forests on southern/western slope will be faster than on north-eastern slope.

Key words*:* forest decline, global warming, NDVI change detection, water stress.

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ID-187

IMMEDIATE GENETIC CHANGES IN TREE DEPLOYMENT AND BREEDING BECAUSE OF GLOBAL WARMING

D. Lindgren[1]

Man's activities add considerably to the uncertainty about future forest environments compared to experiences of variations in the past. In Sweden, tree breeding materials are routinely tested at several localities which cover a range of environments compared to the geographic main target of the breeding population. The range of testing sites for a breeding population could be widened in a magnitude equivalent to 0.5-1 latitudes as a response to the increased uncertainty. The mean temperature of the Swedish forest land seems to be rising. Current recommendations for environments to use genetic materials are based on field experiments deployed and analyzed several decades ago, thus neither considering the warming which has occurred, nor the predicted warming in the future. A moderate prediction of the speed of temperature rise in Sweden is two degrees 1985-2085. Other factors will also change, but quantitative predictions about these are too uncertain to be the basis for specified changes. Half a degree warming (quarter of a century) is almost equivalent with 50-meter change in elevation. This change has probably already happened or will happen in the near future. It is recommended that genetic materials are deployed at 50 m higher elevation than currently. This deployment recommendation can be considered when dimensioning new seed orchards. For forest tree breeding, the targets of the breeding populations could also be raised 50 meters. These changes seem safe, as they are unlikely to over-compensate for global warming. Even if the climate does not become warmer, the consequences will be marginal. But if no change is made now and it becomes warmer, there is a penalty for waiting with the change, which is likely to be larger than if a change is made and no warming occurs.

Key words: heat sum, tree improvement, transfer recommendation.

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ID-042

IMPACTS OF CLIMATE CHANGE ON FORESTS IN EUROPE – A REVIEW OF THE STATE OF KNOWLEDGE IN DIFFERENT EUROPEAN REGIONS

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Sigrid Netherer[2] and Axel Schopf[2]

Research on the possible impacts of climate change on forests in Europe and the development of adaptation and mitigation strategies started in the early 1990s. Since then, assessments of climate change, its impacts and subsequent consequences for natural resource management have been the focus of continuous research efforts.

In this study the existing knowledge about observed and projected impacts of climate change on forests in Europe is synthesised as a basis to develop adaptation strategies. Moreover, the direct and indirect impacts on the capacity of forests to provide economic, social and ecological services were studied and reported for four different bioclimatic regions: boreal, temperate oceanic, temperate continental, and Mediterranean. The study covered the following goods and services: i) wood production, ii) any non-wood forest products (e.g. berries, mushrooms), iii) carbon sequestration, iv) water retention and provision of clean drinking water, v) biodiversity, vi) recreational use of forests and vii) protective functions (e.g. against soil erosion, avalanches).

For each of the bioclimatic regions, first the projected exposure to climate change was characterized. Then, the sensitivity to most important climate change factors was described and the potential impacts reported. Finally, expert judgements about the main vulnerabilities were given, taking into account the adaptive capacity of the forests and forest management.

In summary, the major direct and indirect impacts of observed and projected climate change on EU forest are reviewed and synthesized based on a thorough literature survey including scientific publications, project reports from relevant national and EU funded research projects.

Key words: climate change impacts, survey, vulnerability, goods and services.

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ID-098

EVALUATING FUTURE WILDFIRE RISK USING THE KEETCH-BYRAM DROUGHT INDEX

Yongqiang Liu, John Stanturf and Scott Goodrick[1]

Climate is an important factor for wildfire ignition and spread. Persistent drought can lead to decreased water availability for vegetation which increases the risk of wildfire disturbance. Various general circulation models (GCMs) have projected a drying trend for many regions of the globe due to the greenhouse effect. Besides significantly changing ecosystem structure and composition, hotter and drier climates will alter wildfire frequency and severity in these regions.

This study evaluates future wildfire risk in response to climate change by calculating and comparing the Keetch-Byram Drought Index (KBDI) under current and projected future climates. KBDI has been extensively used to evaluate wildfire risk. This index is calculated in this study using data prepared by the Intergovernmental Panel on Climate Change (IPCC), including the observed 30-year meteorological data and projected climate in 2080s from the Hadley Centre Coupled Model, version 3 (HadCM3). It is shown that KBDI increases significantly, up to 300, during spring in the southern United States, changing from about 100 (low fire risk) to 400 (moderate fire risk). The area with significant KBDI increase expands to the entire United States in summer and fall. The largest increases occur in the mid-latitudes. KBDI values increase from about 300 to 600 in the southern Pacific coast and to 500 in the southeast, indicating an increase in fire risk from moderate to severe level. The increase in KBDI is caused by the increase in maximum temperature, up to 4°C, as well as a decrease in precipitation. But summer precipitation increases in the United States Gulf coast, which lowers fire risk. Large increases in KBDI also occur in central Eurasia during summer and fall, and northwestern Australia and southeastern Brazil most seasons. The uncertainty in changes of KBDI due to the differences in climate projection with different GCMs and IPCC scenarios is examined.

Key words: global change, vegetation change, wildfire risk, drought index.

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ID-285

A CONCEPTUAL MODEL FOR STUDYING THE EFFECTS OF LANDSCAPE CONNECTIVITY ON ECOSYSTEM ADAPTATION TO CLIMATE CHANGE IN CENTRAL AMERICA

Bruno Locatelli[1] and Pablo Imbach[2]

Climate change is projected to result in shifts in the geographical distribution of ecosystems and species. Biogeography studies that predict the changes in life zone distribution allow evaluating the potential impacts of climate change on ecosystems. However, impact studies must be associated with an estimation of adaptive capacity in order to assess ecosystem vulnerability. Plant migration is a potential response from ecosystems for adapting to climate change. The migration capacity depends on plant types and on the fragmentation of landscape through which species will disperse. However, the development of plant migration models and the collection of data on migration rates remain a challenge.

We developed a conceptual model to represent the impact of climate change on ecosystem distribution considering the capacity of organisms to migrate in a fragmented landscape. This model is implemented with a cellular automata, in which each cell is a landscape unit, characterized by its membership to life zone classes, its richness, and its state (natural *vs.* anthropic). Life zones are used as a proxy for ecosystem types and are assumed to be composed of different groups of plant functional types with different hypothetical migration capacities. The model is applied to the real landscape of the Central American region. Current landscape fragmentation is assessed using land use maps. Landscape scenarios represent either further fragmentation or connectivity enhancement based on the current distribution of the Protected Areas and Biological Corridors. A climate change scenario is applied to the simulated landscape to evaluate ecosystem shifts, under different landscape scenarios. Results show that well-designed conservation plans enhancing connectivity could increase ecosystem resilience to climate change depending on the design of the connectivity network.

Key words: climate change, life zones, adaptation, migration, biodiversity.

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ID-107

THE FUTURE OF FOREST FIRES IN CENTRAL AMERICA UNDER CLIMATE CHANGE AND SOCIO-ECONOMIC SCENARIOS

Bruno Locatelli[1], Pablo Imbach[2], Luis Guillermo Molina[2] and Elena Palacios[2]

Forest fires are of considerable interest because of their social, economic and environmental consequences. Fire occurrence is influenced by climatic factors: for instance, higher temperatures and atmospheric dryness may increase fire risk. In Central America, because of increasing social awareness, measures have been taken to reduce the occurrence of fires. However, climate change might jeopardize these efforts in the future. For the development of prevention plans, it is important to know how climate change will modify forest fire risk in Central America.

Using data mining processes, we investigated the influence of climatic and socio-economic factors on the occurrence of forest fires in Central America. We used climatic monthly data for the 1998-2007 period with a 0.25° spatial resolution and built decision trees to model the occurrence of fires. The decision trees resulted in a good accuracy on the 1998-2007 period.

Using climate change and socio-economic scenarios, we applied the same decision trees to future conditions to create maps of future fire risks. Results show that fire risks are decreasing in some areas and increasing in others. The separate and combined effects of socio-economic changes and climate change on the evolution of fire risk are analyzed. The sources of uncertainties are discussed and the approach is evaluated.

Key words: climate change, forest fire, socio-economic scenario, decision trees

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ID-106

FOREST MONITORING AND CRITICAL LOADS ASSESSMENTS AS A SCIENTIFIC BASIS FOR AIR POLLUTION CONTROL IN EUROPE

M. Lorenz[1], H.D. Nagel[2], O. Granke[1] and P. Kraft[3]

Forest monitoring in Europe has been conducted for 22 years 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). In close cooperation with the European Commission (EC), the spatial and temporal variation of forest condition in relation to natural and anthropogenic factors are assessed on about 6,000 plots spread systematically across Europe. Causal relationships are studied on 860 intensive monitoring plots situated in the most important forest ecosystems. Part of the monitoring data is used for assessments of risks of atmospheric nitrogen and sulphur deposition by means of calculations of critical loads and their exceedances. The results constitute part of the scientific basis of clean air politics under CLRTAP and related EC Regulations.

The present paper emphasises the parameters needed for critical loads assessments and presents first results. Throughfall deposition data on sulphate (S-SO_4), nitrate (N-NO_3), and ammonium (N-NH_4) of the years 2000 to 2005 show marked spatial patterns and temporal trends. Mean sulphate deposition on intensive monitoring plots decreased from 7.9 to 6.1 kg ha^{-1} yr^{-1}. This confirms the success of clean air politics by UNECE and EC in Europe. However, sulphate and especially nitrate and ammonium deposition were found to still exceed critical loads at many forest sites, indicating a continued need for further implementation of air pollution abatement strategies. Studies on relationships between violations of critical limits and observed damage symptoms are necessary in order to improve the knowledge of forest ecosystem response to deposition. Great potential lies in a closer integration of the work of critical loads and cause-effect studies of North American Researchers into ICP Forests.

Key words: Europe, critical loads, forest health, ICP Forests, North America.

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ID-310

RESPONSES TO FLOODING OF POPLAR CLONES PLANTED IN THE PARANÁ RIVER DELTA, ARGENTINA

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The Paraná River Delta is already experiencing the consequences of climate change. Rainfall has been increasing since 1970, and extreme rain events (more than 150 mm of rainfall in two days) are now more frequent, increasing the frequency of flooding. Forestry is the main economic activity in this area, with most of the poplar (*Populus* spp) plantations in Argentina located there. Therefore, genotypes with increased tolerance to flooding will be needed for the area. The aims of this work were: (1) to identify clones tolerant to flooding as suitable parents for breeding programmes to increase flood resistance; and (2) to select extremes of flood tolerance for physiological and molecular studies to gain a better understanding of flooding tolerance mechanisms in poplar.

We analyzed the responses to flooding of 14 poplar clones (*Populus deltoides* and *Populus* x *canadensis*) growing in pots in a greenhouse. Some are commercial clones planted in the area, and others belong to a poplar breeding programme from INTA (Argentina´s National Institute for Agricultural Technology). Plants of approximately 60 cm height were watered (control) or submerged in water covering 10 cm above soil level (flooding treatment) for 35 days. The first symptoms of stress appeared after two weeks. Flooding reduced growth in height and diameter, photosynthesis, stomatal conductance, total leaf area, as well as the number and area of newly formed leaves. In some clones, flooding accelerated leaf senescence and abscission of basal leaves, and induced the development of hypertrophied lenticels and adventitious roots.

A hierarchical cluster analysis was performed to classify the responses of the clones to flooding. Clones with different degrees of tolerance were identified, and will be used for future physiological, molecular and genetic studies of flood tolerance in poplar.

Key words*:* flooding, growth, Paraná River Delta, poplar.

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ID-050

MONITORING INSECT DEFOLIATION OF FORESTS BY MEANS OF LASER SCANNING AND HYPERSPECTRAL IMAGERY

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We present one of the first efforts to analyze and classify insect defoliation with hyperspectral imagery and laser scanning. Remote sensing will provide clear advantages over former methods for monitoring forest damage. Remote sensing methods, such as optical and microwave satellite imaging, digital aerial photography and airborne laser scanning, are promising in various forest monitoring tasks. However, development is needed in order to produce cost efficient and accurate monitoring methods which are able to give an early warning of threatening disturbances in time.

We outline an approach to map a distribution and intensity of defoliation by the Common pine sawfly with airborne laser scanning (ALS), terrestrial laser scanning (TLS) and an EO-1 Hyperion imagery. Interpretation is based on georeferenced field plots on an outbreak area and changes in image features and 3D data caused by defoliation. The spectral features of the Hyperion image and 3D laser point data of ALS and TLS are used to classify the field plots according to defoliation intensity. Climatic drivers and damage agents have a close relationship, and advanced and efficient remote sensing methods are highly needed for risk assessment and monitoring of forest damage. This promising new technology will aid adaptation of forest management to climate change.

Key words: Hyperion, insect outbreak, laser scanning, monitoring, remote sensing.

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ID-323

GENOTYPE X SILVICULTURE INTERACTIONS ON PRODUCTIVITY AND CARBON ALLOCATION IN YOUNG LOBLOLLY PINE PLANTATIONS

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Forest plantations that sequester carbon (C) at a high rate may provide an opportunity for offsetting net atmospheric C emissions. We examined the ecophysiological basis for differences in growth efficiency between two fast growing loblolly pine (*Pinus taeda* L.) clones. Clone A had previously been shown to produce stem wood with approximately half the leaf area as Clone B. Silviculture treatments were a control consisting of shearing and bedding following local commercial operations, and a mulch treatment where chipped logging residue was incorporated into the soil at a rate of 25 Mg ha^{-1} during bedding. We hypothesized that clones would display similar aboveground productivity in the control treatment, but because of lower leaf area and thus lower nitrogen demand, Clone A would display higher productivity than Clone B on mulched treatments. After the third year of treatment, soil nitrogen availability and mineralization rates were lower in the mulch treatment than in the control, which decreased tree growth. There was a significant clone x silviculture interaction on stem volume growth. Both clones had similar rates of growth in control treatments producing 25 m^3 ha^{-1} $year^{-1}$; however, in mulch treatments Clone A produced 21 m^{-3} ha^{-1} $year^{-1}$ compared to 17 m^3 ha^{-1} $year^{-1}$ for Clone B. Because it differentially allocated biomass among plant organs (i.e. foliage, stem, branch, coarse and fine roots), Clone A produced 20% more stem volume per unit leaf area than Clone B.

These clonal differences in C-allocation patterns combined with the impact of the silvicultural treatments on nitrogen availability appear to explain the observed clone x treatment effect on total biomass accumulation.

Key words: allocation, carbon, clone, nitrogen, sequestration.

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ID-068

IMPACT OF CARBON TRADING ON FOREST MANAGEMENT IN NEW ZEALAND

Bruce Manley[1] and Piers Maclaren[2]

The New Zealand Government has introduced legislation for an emission trading scheme (ETS) under which owners of Kyoto-compliant (i.e, post-1989) forests will receive/surrender credits for increases/decreases in the carbon stocks of their plantations. In this paper, we evaluate the potential impact of the ETS on forest management decisions, including whether to establish new forest, choice of species and silviculture, and forest rotation length. Criteria used in the analysis are financial return (Net Present Value -NPV) and carbon price risk (Cost of credits to be surrendered).

Results show that carbon trading has the potential to increase forest profitability and influence the choice of species and silviculture. Forest rotation length increases with expected carbon price. However there is considerable risk arising from carbon prices. Consequently, we evaluate trade-offs between financial return and risk in order to develop strategies that are robust against future carbon prices. We also develop strategies that hedge against carbon price risk at both the stand level and the forest estate level. The former include trading only a portion of credits received. The latter includes managing forest structure via species/age-class composition.

Key words: carbon price risk, carbon trading, forest management.

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ID-112

ROLE OF PROTECTED FOREST AREAS IN ADAPTATION TO CLIMATE CHANGE: WWF'S PERSPECTIVE

Stephanie Mansourian[1] and Alexander Belokurov[2]

The World Wide Fund for Nature (WWF) considers the role of forest protected areas to be critical in adaptation to climate change. As the global conservation organization sets out on its new global conservation programme, it has recognized that many of its core activities are being impacted by climate change. While protected areas have always been at the core of WWF's work as an essential tool to conserve biodiversity, the impact of climate change on biodiversity is now providing protected areas with a renewed role as adaptation tools for a changing climate. The importance of protected areas in this respect is three-fold: in supporting species to adapt to changing climate patterns and sudden climate events, in protecting people from sudden climatic events and, indirectly, in supporting economies to adapt to climate change.

The paper will first explore the importance of forest protected areas for ecological, social and economic purposes, drawing on examples from WWF's network in the context of climate change. It will focus particularly on the broader spatial context, i.e., the landscape, within which protected areas can be found. Finally it will discuss possible management and policy responses to ensure that forest protected areas can continue to fulfil their role in the face of climate change. This will be done in the context of WWF's new global conservation programme and we will draw on examples from WWF's vast field experience.

Key words: climate change, protected areas, WWF.

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ID-320

MAINSTREAMING CLIMATE CHANGE ADAPTATION ISSUES INTO FOREST POLICIES AND MANAGEMENT PRACTICES: A WAY TO BRING CONCEPTS INTO ACTIONS

Nur Masripatin[1]

Forest provides numerous products and services; its roles vary among countries but share common global importance in climate stabilization and biodiversity conservation. Climate change may reduce ecosystem capacity in providing goods and services to society, which could complicate global efforts to reduce poverty and promote more sustainable livelihoods. Negotiations under climate change convention and its protocol resulted in an agreement on emissions reductions; however, the reduction is still insufficient to have significant impact on the global warming trend. More ambitious target in GHGs emissions reductions is critical; at the same time, proportional attention must be given to adaptation.

Forest countries in many parts of the world have taken policy measures to deal with deforestation and forest degradation, rehabilitation of degraded land and improve watershed protection, restoration of secondary forest, and securing their remaining forests. These non-climate policy measures contribute to both climate adaptation and mitigation; however, the extent of the contribution may not be well recorded.

Adaptation is not a single matter of protecting forest health in order to secure its provision of goods and services, but also reducing sensitivity and increasing adaptive capacity of forestry sector and forest dependent people toward climate related events, In this regards, it is important that adaptation to be part of forest policies and practices, as well as national development programmes. Nevertheless, a number of issues need to be addressed to bring the concept into practice, including availability of science to understand forest ecosystem vulnerability and how to improve its resilience to extreme climate-related events, integration of mitigation and adaptation measures to increase their effectiveness, awareness of stakeholders and institutional capacities, consistency between actions at various levels.

Key words: climate change convention, emissions reductions, adaptation.

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ID-376

CLIMATE CHANGE IMPACTS ON GOODS AND SERVICES OF EUROPEAN MOUNTAIN FORESTS – A REVIEW

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and M.J. Lexer[1]

Mountain regions are expected to be affected by climate change at a greater magnitude than other regions. This has already been observed for the second half of the 20th century where temperature increase in the European Alps was two times higher than the European average. Therefore impacts on mountain forest ecosystems and forest goods and services demanded by society are likely to be more intensive compared to forests elsewhere. Furthermore, the importance of forests to sustain densely populated mountain valleys underpins the need for assessments of vulnerability and potential adaptive measures.

To foster focused and efficient research, this contribution reviews the current state of scientific knowledge on mountain forest sensitivities to climate change, likely impacts and vulnerability. The aim of this study is to identify the main climate change related impact factors, mechanisms and impacts on mountain forest services, and to provide information about the vulnerability of European mountain forest types. The analysis is conducted as a literature review. To make efficient use of available information an assessment framework has been designed which considers uncertainties and allows to combine research results with expert judgements in a transparent manner. The investigated goods and services include protective functions, timber production, non-wood forest products, carbon sequestration, water retention and provision of clear drinking water, biodiversity and the recreational use of forests.

The review is part of the “Study on impacts of climate change on European forests and options for adaptation” by the European Union. In synthesising current knowledge and highlighting existing knowledge gaps, it contributes to the objectives of the EU Forest Action Plan.

Key words: climatic change, mountain forests, protective function, uncertainty, vulnerability.

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ID-089

INFLUENCE OF SURFACE FIRES ON VEGETATION DIVERSITY IN HEMIBOREAL *PINUS SYLVESTRIS* FORESTS UNDER CLIMATE CHANGE CONDITIONS

Vitas Marozas, Jonas Racinskas and Edmundas Bartkevicius[1]

Climate change increase frequency of extreme events (drought, wind, fires). Fire is an important ecological factor in hemiboreal forests. The overall effects of fire on ecosystems are complex. The aim of this work was to investigate the changes of ground vegetation and regeneration of tree species in pine forests after surface fires. The study area was located in Southern part of Lithuania in hemiboreal zone of Europe. The field and ground vegetation was recorded in forest stands burned in 1992 and 1994-2002 and compared with the nearby control fire untouched areas. We selected five burned areas for each year (total 50 burned stands). Vegetation sampling was conducted during July and August. For vegetation description in each stand, we systematically placed twenty 1 x 1 m plots. Mann-Whitney non-parametric test was used to identify significant differences in vegetation between burned and untouched areas. It was determined that species richness increased after fire. Early successional species, such as *Agrostis capillaris* L., *Calamagrostis epigejos* (L.) Roth, *Chamerion angustifolium* (L.) Holub, *Festuca ovina* L. and *Melampyrum pratense* L., invaded in burned areas immediately after fire. Abundance of dominant species (*Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L.) recovered after five years. Pioneer moss species (*Polytrichum piliferum* Hedw. and *Polytrichum juniperinum* Hedw.) replaced late successional mosses (*Dicranum polysetum* Sw., *Dicranum scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brit.) Mitt.). Species number in the shrub layer decreased. *Juniperus communis* L. was killed by fire. Amount of undergrowth decreased first four years after fire. Saplings of *Picea abies* (L.) Karst., disappeared at all. Fire stimulated regeneration of *Pinus sylvestris* L., especially during the first four years after fire. Herbaceous and dwarf shrubs recovered 5-6 years after fire, moss cover recovered 9 years after fire. Differences in moss species composition still remained 11 years after fire. Main findings suggest that fire is favourable to biodiversity of pine forest ecosystems. Fires induce regeneration of pine trees and can be used for restoration of pine forest.

Key words: climate change, pine forests, species composition.

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ID-038

STUDYING THE RELATIONSHIP OF FOREST COVER AND RUN OFF VOLUME FROM PRECIPITATION GEOGRAPHIC INFORMATION SYSTEM (GIS)

Hamid Reza Maskani Jifroudi [1], Ali Meraji[2], Maryam Haghyghy Khomami[3], Leila Dazeh[4] and Amir Hossein Firoozan[5]

Water flow patterns divide the landscapes in units of different hydrologic orders, and such a hierarchical division helps understand the complexity of forest ecosystems. However, the streamflow is a complex and time-consuming measurement to make, and is consequently rarely used in the regional forest management planning. Providing a simple means to measure or estimate streamflow would therefore greatly enhance the value and use of such variable.

We have evaluated the variables used in regional forest management programs, such as standing wood volume, with regards to the ease with which they could be measured. Two streamflow series from adjoining watersheds - series 7 and 8 in Baryabon - in the Northern forest region of Iran, were used in this analysis. The two watersheds are very similar in area, shape and soil type but have different canopy properties. Total precipitation, interception, stem flow, through fall, soil type, geology characteristics, type and quality of forest cover and the other needed data were collected and captured in ArcGIS software. The variables were used to adjust the model of the US Soil Conservation Service (SCS) within the GIS framework. The difference in estimated runoff volume between the two series was then related to the difference in wood standing volume to produce a relationship between predicted runoff and standing volume. This approach may open the door to improve coupling of forest cover and streamflow predictions within altered climatic conditions, as predicted from the climate change scenarios.

Key words: runoff, standing volume, interception, GIS.

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ID-211

THE ROLE OF PEST INSECT DAMAGES IN THE DEVELOPMENT OF REGIONAL FOREST RESOURCES UNDER CHANGING CLIMATE

J. Matala[1], P. Niemelä[2] and T. Nuutinen[1]

Climate change has been projected to increase the forest growth in boreal conditions. In Finland, forestry scenario analysis have been made on how these growth enhancements might affect the future forest resources, cutting possibilities, forest bio-energy potentials and carbon sequestration. In these predictions, it has not been possible to take into account increasing risk of forest damages by biotic and abiotic factors. Inclusion of these factors into forestry scenario analysis has been problematic since there has been an obvious gap between the information provided by ecological research of, for example, forest pest insects and simulation systems used in the scenario analysis. The point of view of these research disciplines has been different and forest parameters relevant in their studies have been in different levels of details. Therefore, there is a challenge to join information from ecological studies to improve forestry scenario analysis as regards which role forest damages might have on forest resources at large scales, and how climate change might affect their risks.

In this work, we aim at collecting information from literature on forest pest insect studies in Finnish or corresponding boreal conditions. In data collecting, we have two main emphasis: (i) to recognize the most potential pests that could have impacts on forests of Finland in changing climatic conditions; and (ii) to collect information of such variables that could at the same time describe vulnerability of forests to these most potential pest damages and be applicable in forest management planning system. Based on this literature information and the results on forest parameters from earlier forestry scenario analysis, we finally aim at producing a framework for analysing the role of pest damages in the development of regional forest resources under changing climate.

Key words: climate change, pest insect damage, forestry scenarios.

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ID-235

NEW INSTITUTIONAL ANALYSIS AND THE ADAPTIVE MANAGEMENT OF CLIMATE CHANGE: IMPLICATIONS FOR THE FORESTRY INDUSTRY AND FORESTRY-BASED COMMUNITIES

Ralph Matthews[1]

This paper brings conceptual insights from a sociological perspective known as 'New Institutional Analysis' to the common problem within forestry of trying to identify the 'adaptive capacity' of industry and communities affected by significant climate change impacts. Many social science perspectives on climate change utilize individual level analysis and focus on the cultural models and social resources (social capital) of persons affected. In contrast, 'New Institutional Analysis' focuses on how ways of dealing with both routine and unique situations within industries, communities, and other organizations provide them with social organizational strategies for dealing with future vulnerabilities and unique challenges. Unlike traditional institutional analysis with its focus on norms and rules, 'New Institutional Analysis' examines how established ways of operating within organizations take on 'frames of meaning and action' that serve as *barriers* or *facilitators*. These constitute the overall 'adaptive capacity' of organizations, particularly when responding to new situations. This focus on the adaptive capacity of organizations and communities complements 'active' adaptive management strategies within forestry that require setting objectives, identifying indicators, continuous monitoring, and readjustment of operational strategies.

The proposed paper will provide an overview of the 'New Institutional Analysis' framework and discuss its relevance and implications when included in the context of adaptive management processes in forestry that focus on both ecological and social well-being as desired outcomes of resource harvesting. In addition, and to provide insight into the types of indicators and processes involved in 'New Institutional Analysis', the paper will conclude with a brief examination of the indicators currently being used to examine the adaptive capacity to deal with climate change, of the City of Whitehorse, Yukon Territory, Canada.

Key words: adaptive capacity, ecological and social well-being, City of Whitehorse.

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ID-171

ESTIMATING DEFORESTATION AND FOREST DEGRADATION IN SRI LANKA – A PILOT PROJECT OF A POTENTIAL REDD MECHANISM

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Mitigation and adaptation in the land use and forestry sector within the climate change negotiations is the focus in this paper. The objective is to assess a possible mechanism for reducing emissions from deforestation and degradation (REDD) in developing countries and its feasibility on Sri Lanka focusing on deforestation and change in carbon content in forests since 1990 by using optical remote sensing data. This is done by carrying out a pilot study in Sri Lanka to support the negotiations in the UNFCCC process.

Methods and data used are assessments in GIS and statistical correlation analysis, remote sensing data from e.g. Landsat, ASTER and SPOT, forest inventory data, national statistics regarding land use and forestry and field work with biomass measurements and participatory rural appraisal (PRA) methods to generate data on past forest status. Preliminary results show that northern and southern districts of Sri Lanka show forest cover reduction from 1992 to 2001 whereas districts located in the central mountainous region show an increase in forest cover, hence a likely increase of carbon content. The decrease in forest cover is believed to be a consequence of the ongoing conflict in the country whereas the increase in forest cover is supposed to stem from the National Physical Planning Policy supporting island-wide agriculture and power production. Further, results show the challenge setting up a robust and transparent forest monitoring system on national level due to the ongoing conflict, a fact that other possible REDD nations might face.

Results also show that very few studies on national or international assessments have been undertaken to measure forest resources and forest area change to assess carbon content in Sri Lanka using remote sensing applications or statistic data. Consequently, there is a strong need to elaborate the methods given above to get more accurate result needed for sustainable forest management and for input to the climate change negotiations.

Key words: Sri Lanka, REDD, remote sensing, deforestation, carbon sink.

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ID-276

CLIMATE CHANGE ADAPTATION FOR FORESTRY IN WESTERN CANADA: A SENSITIVITY ANALYSIS OF MODEL PREDICTIONS

Michael Mbogga and Andreas Hamann[1]

In recent years, western Canada has seen plantation failure and die-back of forests due to drought, as well as higher incidence of fire, pests, and diseases that could be linked to directional climate change trends. If future projections of climate modelers are correct, these problems will inevitably become more severe with continued warming, thereby threatening forest ecosystems and impacting forest productivity. Resource managers will be required to respond to climate change through activities such as using non-local seed and introducing species to maintain ecosystem health and services. Further, legislation has to be developed that allows for flexible management without degrading into "anything goes" regulation.

Predictive models of tree species habitat, tree growth, and ecological processes as a function of projected climate conditions can be useful to develop policies and management guidelines for forest resources. These predictions, however, come with many uncertainties related to multiple factors. This study explores how (1) the quality of baseline climate data, (2) the choice of general circulation model (GCM), (3) the type of emission and population growth (SRES) scenario, (4) the choice of predictive model, as well as (5) the selection of predictor variable, influence various dependent variables, e.g. the northward shift in habitat for a forestry species. We show how results from multiple scenarios and models can be used to select management recommendations that will be valid under most future projections.

Key words: bioclimate envelope modeling, sensitivity analysis, western Canada.

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ID-102

USING GFIS AND OTHER NEW TECHNOLOGIES FOR EFFECTIVE COMMUNICATION AND SHARING OF FORESTRY INFORMATION ACROSS DISPARATE NETWORKS IN THE GLOBAL COMMUNITY

R.D. McCracken[1], J.A. Stanturf[2] and E. Mikkola[3]

Scientists, technicians, natural resource specialists, and others working in natural and physical sciences perform extensive research and develop a great deal of knowledge about our local and global environment. However, this information is only useful if it is accessible to its intended audience, including other scientists, policy makers, industry, landowners, non-governmental organizations, or the general public. These audiences obtain information in different ways. By better understanding information-seeking behaviors, we can help scientists use a wide range of information technologies (Web, databases, multimedia, geographic information system mapping, and other applications) to convey their messages to various groups.

Partnerships on global issues that reach across international borders intensify the need for effective and precise communication, since international collaborations also bring language and cultural barriers. To overcome these obstacles, we have an array of tools that can be used to craft messages that are accessible to a wide range of scientists, organizations, and users without altering the essence of the science. One such tool is the Global Forest Information Service (GFIS) which provides a framework to share forest-related data and information through a single gateway at http://www.gfis.net/. GFIS promotes the dissemination and sharing of forest and tree-related information and knowledge among the global forestry community by developing common information exchange standards, building capacity, and enhancing partnerships among forestry information providers and users.

This presentation will discuss the function, features, and use of GFIS along with other current technologies that can further assist individuals and organizations in taking advantage of research and scientific information for policy- and decision-making, scientific processes and applications, and developing new products, materials or services.

Key words: technology transfer, GFIS, Internet, information, forest science.

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ID-278

FOLIAGE BROWSING INSECT OUTBREAKS IN UKRAINE: INCIDENCE, DURATION AND SEVERITY

Valentyna Meshkova[1]

Statistical analyses of outbreaks in Ukraine since 1826 show that foliage browsing insects population dynamics depend on insect seasonal development and relations between the rates of air and soil temperature increase, differing in various regions and forest site conditions. Taking into account current and predicted climate indices and phenological curves of forest pests, their seasonal development in different regions was analyzed. It was found that *Tortrix viridana* L. will always remain a monovoltine species. *Dendrolimus pini* L. may become monovoltine, and *Diprion pini* L. will be bivoltine.

The mean interval between outbreaks in Ukraine is from 7 to 12 years. It is as an average 8 years for *Euproctis chrysorrhoea* L., 9 years for *Lymantria dispar* L. and *Diprion pini* L., 10 years for *Tortrix viridana* L. Mean duration of outbreaks is 3 to 7 years for Ukraine. It is as an average 4.9 years for *T. viridana*, 4.5 years for *Lymatria dispar* and 3.3 years for *Panolis flammea* Schiff.

Outbreak duration of all analyzed insects is the least in the West of Ukraine (3 years), 4 years in the central regions and 5 years in the eastern and southern regions. Increase of outbreaks duration from West to East and from North to South is confirmed for individual pests.

For the last two decades, outbreak incidence increased in the forest zone and its severity increased in the forest-steppe and steppe zones. Edges of stands near clear-cuts after sanitary felling become vulnerable for foliage browsing insects, but new plantations are not susceptible to foliage browsing insects for the first decades.

To predict outbreaks and to develop the strategy of forest protection at climate changes, it is suggested to use databases on outbreaks incidence, severity and duration for different insect species in different geographical regions and at weather conditions of different years.

Key words: foliage browsing insects outbreaks, global climate changes, seasonal development.

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ID-083

THE USE OF INDIGENOUS KNOWLEDGE IN MONITORING AND PREDICTION OF CLIMATE CHANGE AND SEASONAL CYCLES AMONG THE LOCAL COMMUNITIES IN KENYA

Nyangila Jacob Mhando[1]

This paper seeks to outline myriad of issues around Climate Change and to provide an analysis of the use of Indigenous Knowledge (IK) by indigenous people in Kenya in the monitoring and prediction of climate change and seasonal cycles among the local communities in Kenya. The indigenous people have unique ways to interact, learn and understand changes within their surrounding environment and to be able to use various indicators to monitor and predict local climate through seasonal cycles, hence device means and measures to counter the effects brought about by climatic changes. The local communities in Kenya, like the Maasai, are still intricately interwoven with the environment for their pastoral and cultural existence. Ecological indicators earmark change in seasonal cycles as interpreted through indigenous knowledge systems by observing ecological components and their behaviors in pursuit to adapting to conditions triggered by climate change.

Traditionally, the Maasai, for example, observe environmental aspects which enable them monitor changes in local climate and subsequently predict expected conditions and the impacts to their livelihood. These include among others: mammalian/avian behaviors; environmental observation; entomological behavior; changes in plants in terms of flowering; cosmological observation; traditional calendars; wind direction; wildlife and avian migratory system; livestock behavior; outbreak of diseases and epidemics. Naturally the most of the indigenous communities in Kenya have had an intimate relationship with plants, especially on matters related to culture and traditional medicine. Floral behavior plays a significant role in predicting and monitoring seasonal cycles. In certain times of the year, different plant species portray different behavioral characteristics that enable the communities like the Maasai predict climate variations by observing changes and relating with past phenomenons.

Key words: communities, indigenous knowledge, Kenya, monitoring, prediction.

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ID-025

THE FORESTRY SECTOR OF BANGLADESH IN GLOBAL WARMING MITIGATION: THE FUTURE APPROACH TO FORESTRY PRACTICE

Md. Danesh Miah[1] and Man Yong Shin[2]

Anthropogenic emissions of greenhouse gases have been identified as the main cause of global warming and climate change. As one climate change mitigation option, the Clean Development Mechanism (CDM) under the Kyoto Protocol has created the global warming mitigation opportunities that allow Bangladesh to receive investments from developed countries wishing to offset their emissions of greenhouse gases. Bangladesh has a special interest in strategies for combating global warming because its large areas to be planted represent a potentially large carbon sink. The high rate of deforestation contributes a large carbon source. To properly assign carbon credits in the forestry sector of Bangladesh, a number of important issues and uncertainties need to be resolved. Definition of the accounting method and the means of crediting forest reserve establishment are two important issues. Reforestation offers opportunities for carbon credits for the uptake in forest biomass. Current accounting rules, however do not account for carbon stored in forest products. Forest management has been proposed as a global warming response option for the bigger benefits in the short-term while the afforestation/ reforestation can give credits in the long term Reforestation can be the greatest option offered by Bangladesh for mitigating global warming in the first commitment period. Under the current rules, avoided deforestation does not give any credit in the same commitment period. Slowing deforestation also can be an important option in the second commitment period.

The paper discusses the compatibility of the CDM and global response opportunities in Bangladesh; the opportunities of the Bangladesh Forestry Sector to combat the global warming; issues to be settled for carbon credits; the implications of the forestry options for different land uses as well as forest management with carbon benefits. The paper finally discusses the future approach of the forestry sector of Bangladesh to mitigate the global warming and to obtain carbon credits.

Key words: CDM, climate change, forest management, land-use change.

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ID-033

EFFECTS OF FORESTRY ON THE WINTER GRAZING RESOURCES OF SEMI-DOMESTICATED REINDEER (*RANGIFER TARANDUS*) IN SWEDEN

Jon Moen[1], Sonja Kivinen[1] and Anna Berg[2]

Boreal forests in Sweden are arenas for several important land users, including forestry and reindeer husbandry. The boreal forest is mainly used for winter grazing by reindeer feeding on lichens, although some herding districts may also use the forest during summer. Lichens may constitute up to 80% of the winter diet of reindeer and are a key resource to manage in the system. Forestry affects the amount and availability of lichens in many ways.

The aim of this paper is to give an overview of these effects based on a literature study, and discuss how climate change may affect the interaction between forestry and reindeer husbandry. Ground lichens may either be destroyed at clear-cutting (for instance, through soil scarification to increase tree regeneration), or become inaccessible due to logging residues and snow compaction. Further, young forest stands may have a high canopy cover which restricts the light reaching the ground and reduce lichen growth. Arboreal lichens are key resources during late winter when snow conditions make it difficult for the reindeer to dig for ground lichens. Due to slow growth rates and limited dispersal, arboreal lichens are strongly dependent on an old forest and continuity in canopy cover. Harvesting of trees and short rotation times will thus have strong effects on the amount of arboreal lichens. Climate change will further exacerbate these effects. For instance, increased forest productivity will result in denser forests with shorter rotation times with subsequent negative effects on both ground and arboreal lichens. Indirect climate effects through changes in markets, such as an increased demand for biofuels will also have negative effects on the winter grazing resources of reindeer as more focus is placed on forest production measures, such as increased fertilization and the introduction of new fast-growing tree species.

Key words: conflicting goals, lichens, *Rangifer tarandus*, reindeer.

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ID-092

CLIMATE CHANGE IMPACTS ON FOREST HEALTH: INSECT PESTS, DISEASES AND INVASIVE ALIEN SPECIES

Beverly A. Moore[1] and Gillian B. Allard[2]

The world's climate is changing. Increased temperatures and levels of atmospheric carbon dioxide as well as changes in precipitation and in the frequency and severity of extreme climatic events are just some of the changes occurring. These changes are having notable impacts on the world's forests and the forest sector through longer growing seasons, expansion of insect species ranges, and increased frequency of forest fires for example.

Climate change can affect forest pests and the damage they cause by: directly impacting their development, survival, reproduction and spread; altering host defences and susceptibility; and indirectly impacting ecological relationships such as changing the abundance of competitors, parasites and predators. A deeper understanding of the complex relationships between a changing climate, forests and forest pests is vital to enable those in forest health protection and management to expect and prepare for changes in pest behaviours, outbreaks and invasions.

This paper investigates these relationships and the implications for forest health protection and management. Specific examples where insect and pathogen lifecycles or habits have been altered by local, national or regional climatic changes are discussed. For example, the mountain pine beetle (*Dendroctonus ponderosae*) has shown decreases in generation time, and winter mortality resulting in exponential population growth and major range extension in western North America. Warmer temperatures have resulted in range expansions of pests such as the pine processionary caterpillar (*Thaumetopoea pityocampa*) and the oak processionary caterpillar (*T. processionea*) in Europe, and the southern pine beetle (*D. frontalis*) and red band needle blight (*Mycosphaerella pini*) in the United States. Similar patterns are expected for other pathogens such as *Armillaria mellea*, *Cronartium ribicola* in western North America, and *Phytophthora cinnamomi* in Europe. They may also have altered the life cycle of the spruce webspinning sawfly (*Cephalcia arvensis*) in the Southern Alps resulting in rapid population growth.

Key words: climate change, diseases, forest insect pests, invasive alien species.

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ID-307

FINDING THE DEFORESTATION, ENERGY AND FOOD SECURITY NEXUS: IS A PCD APPROACH TO ADAPTATION THE LINK?

J. Muller and D. Sparks[1]

Climate variability is challenging past and future development interventions aimed at rural communities who depend on forests to meet their basic energy needs for cooking and heating. Yet this aspect of the forestry-energy nexus has received very little attention in dialogues on climate variability, despite the fact that the majority of households in rural areas are primarily dependent on fuelwood for cooking and space heating. There is a multiplicity of risks associated with fuelwood use – for example the fact that women are increasingly walking further distances to collect wood, indicating that fuelwood is becoming scarce and risks depletion. This places pressure on natural resources around rural settlements and leads to localised degradation and deforestation. It is apparent that energy, food security and forest management are closely linked and require robust adaptive capacity strategies as poverty levels rise and dependence on fuelwood increases. An effective and appropriate response is critical to ensure the sustainable production and efficient use of fuelwood.

This innovative multi-disciplinary and multi-country case study research, currently being developed, aims to highlight the interface of forest management and fuelwood dependency in the context of the adaptive capacity of rural communities in the face of climate variability. What sets this project apart from others is the proposed methodological approach, presented in the poster. Driven by a people-centred development approach and using appreciative methods of inquiry, the aim is to use a gendered lens to produce innovative options and locally-based strategies to increase resilience. This will take cognisance of indigenous knowledge and reflect on current adaptive practices through a participatory process which facilitates the co-generation of knowledge. The use of a range of participatory techniques and tools will build the bridge between indigenous and scientific knowledge in order to enhance local adaptive capacity and improve rural livelihoods, particularly those of women.

Key words: fuelwood dependencies, indigenous adaptive capacity, participatory research, people-centred development.

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ID-074

CAN LONG DISTANCE GENE FLOW CONTRIBUTE TO ADAPTATION OF FUNGAL PATHOGEN POPULATIONS TO CHANGING CLIMATE?

Michael M. Müller and Jarkko Hantula[1]

Many important forest pathogens like *Heterobasidion* sp., *Gremmeniella abietina*, *Sphaeropsis sapinea* etc. have a wide distribution in Europe. When climatic conditions change, fungal subpopulations may change through selection among traits present in the subpopulation as well as selection among new traits arriving via gene flow from other subpopulations. Some pathogens are distributed to just a part of the area occupied by their host tree(s). They may spread to new areas becoming favourable and escape from areas becoming unfavourable. Changes in the genetic structure of pathogen populations and changes of their distribution area may cause a challenge to forest health.

The natural way for most fungi to exchange genes between subpopulations and to invade new areas is to produce spores able to drift with air flow. However, there are limits for spore dissemination set by geographic distance, meteorological factors, longevity of spores, etc. Most of the economically important fungal forest pathogens are disseminated by wind carried spores. There is little knowledge on limits of gene flow between remote subpopulations of forest pathogens.

We investigated gene flow between subpopulations of two fungal species infecting Norway spruce (*Picea abies*) in several European countries. The fungal species investigated were *Heterobasidion parviporum* causing root and but rot and *Lophodermium piceae* infecting needles as endophytes. Gene flow was determined by comparing allele frequencies of three neutral DNA markers in target populations. Preliminary results show that considerable gene flow exists between remote subpopulations of, for instance, Italy and Finland. According to the analysis of molecular variance, only less than 5% of total variation was attributed to variation between subpopulations. This result shows that distances of thousands of kilometers will not hinder gene exchange between subpopulations of these fungi.

Key words: allele frequency, climate change, DNA sequence, gene flow, *Heterobasidion parviporum*, *Lophodermium piceae*, Norway spruce, *Picea abies.*

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ID-090

TROPICAL FORESTS, WATER AND CARBON SEQUESTRATION: EXPLORING THE OPPORTUNITIES TO LINK MITIGATION AND ADAPTATION TO CLIMATE CHANGE

Daniel Murdiyarso[1], Anders Malmer[2] and Ulrik Ilstedt[3]

Mitigation of climate change through land use, land-use change and forestry (LULUCF) activities has dominated the debate over the relationship between tropical forests and global climate change. Afforestation and reforestation projects were formally mandated to enhance carbon sequestration and sinks in lands with low carbon stocks through market mechanisms. Less discussion has focussed on how sustainable forest management may be used for adaptation to climate change. As a result, it is hard to identify the roles and potentials of tropical forests to reduce the vulnerability of ecosystems and society to climate change impacts. It is well documented, however, how forest ecosystems provide goods and services for communities and society.

By taking the scarcity of water resources in the tropics as an example, we argue that, in addition to carbon benefits from sink project activities, one should consider the expected improvement of the adaptive capacity of the forest ecosystem and the resilience of the forest-dependent community. We used a systematic review and meta-analysis to clarify the effect of planted trees on water infiltration which indicates ground water recharge. The effect is clearly positive and relevant although limited data are available in the tropics.

The implementation of project activities should identify the synergies and trade-offs between mitigation and adaptation and consider the type of activities, the scale of project in particular ecosystems, and the level of stakeholder participation. Mitigation pathways may be used as entry point, while narrowing the knowledge gaps of forest-water relationship to better inform decision-making processes. Nevertheless, synergies between mitigation and adaptation measures should be developed whenever ecosystems and societies are considered to be vulnerable to climate change.

Key words: carbon sequestration, water yield, vulnerability, tradeoffs, synergies.

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ID-087

THE CHALLENGES OF ASSESSING CLIMATE CHANGE VULNERABILITY USING AN ECOSYSTEM APPROACH

Daniel Murdiyarso[1], Heru Santoso[2] and Monica Idinoba[3]

As it stands, the Compendium on Methods and Tools to evaluate impacts of, and vulnerability and adaptation to, climate change published by the UNFCCC are largely applicable for impact and adaptation assessments. Only a few of them are designed to assess vulnerability of natural and social system, and they are mainly for the sector-specific, notably human health sector. The impacts of climate change on terrestrial vegetation including forest ecosystems and *vice versa* are relatively well-documented; however, very little is known regarding their sensitivity and the indirect impacts on the sectors associated with them.

This paper attempts to assess vulnerability of ecosystems to understand their structures and functions and their provision of goods and services which are relevant to local and global concerns. The exercise is carried out, firstly in major carbon pools of tropical peatland ecosystem, which is increasingly vulnerable due to both human-induced fire risks and climate variability; secondly, in dry forest ecosystem, where the sustainability of water yields is facing tremendous pressures from both climate variability and competing land-use.

The challenges are documented and analyzed to develop vulnerability criteria and indicators encompassing natural and social systems. It is suggested that a toolbox should be devised and tested to examine its usability and applicability.

Key words: vulnerability assessment, forested peatland, dry forest, criteria and indicators.

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ID-088

FOREST POLICIES: VULNERABILITY AND ADAPTATION IN FOREST SECTOR IN INDIA

I.K. Murthy and N.H. Ravindranath[1]

India is one of the mega diversity countries. It has a large extent of diverse tropical forests and also a large percentage of its rural population depending on forests for their livelihoods. Among all the tropical countries, India has implemented effective forest conservation policies, as well as a large afforestation programme at an annual rate of about 1.38 Mha. The rates of deforestation in India have declined since 1980, despite having one of the lowest *per capita* forest area of 0.06 ha, compared to world average of 0.62 ha/capita and 0.15 ha/capita in Asia. Preliminary studies on assessment of impact of climate change on forest ecosystems have shown that over 75% of the forested grids in India are likely to experience shifts in forest types and species dominance. Forest policies and programmes determine the status of forests and biodiversity.

India has implemented many forest conservation and development policies and programmes, some of which enhance the vulnerability of forest ecosystems to climate change and others contribute to reduction in vulnerability. India provides an excellent example of policies driving forest status and forest area and is also playing a very critical role in the global negotiations in reducing emissions from deforestation and forest degradation. India insisted and succeeded in incorporating forest conservation and sustainable forest management under the *Bali Action Plan*. Thus, it is important to identify the policies that reduce the vulnerability of forest ecosystems. Formulation and implementation of dedicated forest policies and programmes aimed at adaptation to climate change are likely to be unacceptable to the forest policy makers in developing countries.

In the paper, it is proposed to firstly, analyse the evolution of forest policies in India and implications for forest area and its status; secondly, to assess the implications of current policies and programmes on the vulnerability of forest ecosystems; thirdly, to present the potential policies and programmes that would reduce the vulnerability of forest ecosystems to climate change. Finally, the feasibility and acceptability of *'win-win'* as well as dedicated policies aimed at promoting adaptation to climate change will be addressed in the paper.

Key words: adaptation to climate change, forest policies, implications for forest vulnerability, India.

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ID-257

EUROPEAN SCALE FOREST RESOURCE MODELLING AT HIGH RESOLUTION BASED ON INVENTORY DATA

V. Nabuurs, V. van den Wyngaert, G. Hengeveld and M.J. Schelhaas[1]

European forests are highly diverse, serve a wide variety of societal needs, and are owned by a wide range of forest owners in 36 countries. In the past projections of the approximately 175 million ha with the European Forest Information SCENario (EFISCEN) model were based on slightly aggregated inventory data. These data were gathered from the national inventory institutes, and projections addressed availability of wood, carbon issues and biodiversity aspects, as well as biomass for bioenergy. Within EFISCEN, aging of the forest is simulated by moving area to a higher age class, while growth is simulated by moving the area to a higher volume class. Transition chances are derived from increment figures from the input data, or from growth and yield tables. These transitions can be changed over time to simulate changes in growing conditions, like climate change.

In order to improve the projections, we have been gathering plot level NFI data from each national NFI institute. We now have 330,000 plots from 18 countries. This is sufficient to make projections of the European forests at 1 x 1 km resolution. A new high resolution simulation model (EFISCEN-SPACE) is presented as an improved tool to analyse European forest resource development under climate change. The new tool allows overlays with various sorts of GIS material and improved assessments in relation to management changes. The improved model is a diameter class cohort model running for pseudo-stands at the 1 x 1 km resolution. Issues to be addressed are related to wood availability, future assortments, biomass for bioenergy, biodiversity, accessibility and distances to industry, impacts for climate change and carbon issues.

Key words: GIS, climate change, forest inventory, bioenergy.

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ID-155

FRUIT DORMANCY IN *CERIOPS DECANDRA*: AN ADAPTATION TO OVERCOME CLIMATE ADVERSARY?

B. Nagarajan[1], M. Krishnamoorthy and C. Pandiarajan

Seed dormancy is commonly observed in the tropics, but dormancy in fruits is relatively uncommon. Throughout the plant kingdom, maternal investment usually terminates with seed production. However, in Rhizophoraceae, the viviparous mangrove family (all the taxa) are endangered: after fertilization, zygotes continue to grow into seedlings on the mother plants. Zygotes gain 500% fresh weight as they mature into seedlings. The taxon *Ceriops decandra* is an exception to the process. In this threatened species, fruits remain dormant for a few months after fertilization. Since flowering in mangrove is highly adapted to latitudinal variations, an insight into physiological responses and climate change seems to be very important. Transfer of genetic material for coastal afforestation across locations tuned to different climatic rhythms may not give the desired results.

A three-year study was conducted in Pitchavaram (11º25'52"N, 79º46'47"E) in East Coast of India. Forty individuals sampled across three different islets were observed for phenological patterns and floral adaptations in relation to the influence of climate. In *C. decandra*, populations flowering and fruiting happen during late March–early June. During this period, precipitation is very rare and salinity steeply increases with rising day temperatures (up to 40 ºC). The study site is adapted to the North East Monsoon where precipitation starts in late September. With the onset of monsoon conditions, dormancy is broken and propagules grow and are dispersed by mid-December when the salinity levels are low. The population structure of *C. decandra* could have been very different without this adaptation.

During the period 2006 and 2007 unusual rains in June and July led to breaking of dormancy in about 14 out of 40 individuals. The propagules failed to establish in the ensuing months owing to higher salinity. We infer that changing precipitation patterns and precocious development of propagules are detrimental to C. *decandra* populations in the Pitchavaram mangroves. The implication of phenology and reproduction in *C. decandra* and its deployment and management of coastal afforestation are discussed in detail.

Key words: *Ceriops*, dormancy, endangered, mangroves, phenology.

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ID-244

MANAGING TRUE MANGROVES: ARE BIRD POLLINATED TAXA THE MOST VULNERABLE TO CLIMATE CHANGES?

B. Nagarajan, C. Pandiarajan and M. Krishnamoorthy[1]

Changing composition in vegetation is an obvious indicator of physio-climatic changes. Among tropical forests, mangroves are dynamic ecosystems; despite their low taxonomic diversity levels, they are unique. Mangroves are the first to be lost to the increasing sea levels. Species with robust adaptation survive while those based on delicate interactions fail. Our studies on reproductive fitness in Rhizophoraceae indicate the bird-pollinated taxa in spite of having the longest duration of flowering exhibit the lowest rate of reproductive success. We quantified plant-pollinator interaction in *B. gymnorrhiza* populations in Ernakulam (09° 52’26” N; 76° 17’ 16” E) in West Coast regions and in South Andaman Islands (11° 47’ 51” N; 92°42’20”E) in India. Studies on flowering patterns were conducted during October–December in the West Coast and in May-June at Andamans. In Indian main land, *B. gymnorrhiza* is visited by *Nectarinia zeylonica* while in Andamans, *N. jugularis ssp. andamanica* is the pollinator. Birds start visiting (usually in pairs) from 6.00-18.00 hrs in a random intermittent fashion about 4-5 times in an hour. Foraging time varies 4–6 seconds per flower and about 4-10 perches per tree. Since visiting males were in bright plumule, we infered that the breeding season of birds overlapped with the flowering phenology. Each flowering branch consists of two flowers arranged opposite in axils. Opened flowers live 15–20 days during which each flower secretes about 1 ml of nectar. We observed that flower abortion is nearly 95% and about 60% of fruits abort. Nearly 70% of aborted flowers did not contain any pollen load. We found that, in bird-pollinated species, visits are lower and the pollination failure is higher than in insect pollinated species.

In future, documentation of life history traits in sunbirds could be obligatory for the species recovery of *B. gymnorrhiza*. It is understandable that climatic changes not only influence phenological patterns but subsequently the reproduction of the pollinators as well. With increasing sea levels, mangroves like *B. gymnorrhiza* must grow to colonize landward to deserve our focus.

Key words: abortion, *Bruguiera gymnorrhiza*, bird pollination, climate, reproductive success.

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ID-245

GENETIC STRUCTURE OF ALBIZIA GUMMIFERA: IMPLICATIONS FOR RESTORATION IN EAST AFRICA AND MADAGASCAR

J.S. Nantongo[1], J.B.L. Okullo[1], G. Eilu[1] and S. Cavers[2]

Restoration is viewed as a solution to wide spread genetic and ecological degradation. *Albizia gummifera* is an indigenous tree native to both East Africa and Madagascar with potential for restoration. It grows rapidly in forest gaps and forms mycorrhizal and rhizobial associations. For successful restoration, assessment of genetic structure and genetic diversity or uniformity is vital as they influence adaptive potential of a species.

The aim of this study was to assess the extent to which genetic structure of *A. gummifera* is an important factor in selecting germplasm for restoration in East Africa and Madagascar. In the study sites, leaves were collected from *A. gummifera* trees, separated by at least 100 m and preserved in silica before DNA extraction, which was done using DNeasy kit. For amplification of chloroplast RFLP regions, initial screening of 25 RFLP primers was done, of which three showing variation were considered for analysis. Estimates of genetic diversity, gene flow and differentiation were obtained. Results showed that the species is genetically diverse with 14 cpDNA haplotypes. Ugandan samples were most diverse, followed by Madagascan and Kenyan. Although the majority of variation was distributed within populations, significant population differentiation was observed and each population contained distinct haplotypes. Greatest genetic distance was observed between Kenyan and Madagascan populations and lowest between Ugandan and Kenyan populations. These observations are attributed to degradation histories, migration differences, selection and barriers.

This study has shown that *A. gummifera* tree populations in East Africa and Madagascar are highly diverse with chloroplast markers with more intra- than inter-population variation. However, populations are significantly differentiated and transferring propagules to sites outside their own for restoration purposes may pose a genetic threat. More research is needed to ascertain adaptive differences among *A. gummifera* populations at quantitative loci with respect to abiotic and biotic factors that may affect the success of introductions.

Key words: *Albizia gummifera,* conservation, genetic diversity, indigenous species population variations.

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ID-008

ANALYSES OF ADAPTATION STRATEGIES OF FOREST-FORMING TREE SPECIES AND FOREST STANDS BASED ON RECONSTRUCTION OF THEIR POST-FIRE SUCCESSIONS

D.I. Nazimova[1], O.V. Drobushevskaya[2], G.B. Kofman[3] and M.E. Konovalova[4]

Predicting the effect of climate change on the composition of the Siberian boreal forests requires an understanding of successional trajectories following natural disturbances. Mixed forests consisting of Scotch pine (*Pinus sylvestris*), Siberian larch (*Larix sibirica*), birch (*Betula pendula*), aspen (*Populus tremula*), with a mixture of Siberian fir (*Abies sibirica*) and spruce (*Picea obovata*) with well developed herbaceous layer are typical of low mountains with humid climate in the South Siberia. They are classified as subtaiga class, forming well-recognized belt (subzone) between south taiga and forest-steppe.

Using detailed forest inventory materials, data of 120 temporary plots and GIS technologies, a number of postfire successions with 250-350 years duration are reconstructed. A great diversity of long-term dynamics (250-350 years) has been revealed: 12 successional tracks for light-coniferous mixed forest (humid herbaceous subtaiga) and 6 tracks for perhumid chern taiga, with final stage of fir forest with moss-herbaceous understorey. On the border of humid subtaiga and perhumid fir taiga, the replacement of larch and scotch pine by Siberian fir is observed. However, this process does not reach final stage due to repeated fires, and Scotch pine mature stands form sustainable subclimax in the humid low-mountain subtaiga. The results show that successional trends in subtaiga have specific features. The most fire-tolerant tree species under these conditions are Scotch pine and Siberian larch dominating at characteristic times of 250-350 years. But larch gives place to Scotch pine and birch, which can produce much more seeds. It is evident that either the first or the second generation of Scotch pine prevails in all the final stages in subtaiga subzone. Among the small-leaved forest stands, it is worth to mention also aspen stands which are sustainable on fertile and moist soils. Rich biodiversity of herbs in the understorey (*Carex macroura, Calamagrostis arundinacea, Vicia unijuga et al.*) proves their adaptation to fire regime. The predicted increase in fire regime, that will accompany climate change in the South Siberia, will likely result in reducing larch and dark coniferous in favour of Scotch pine, birch, aspen stands and non-forest communities with bushes, herbs and grass.

Key words: Siberian tree species, successional tracks, sustainability, climate, fire regime.

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ID-337

A NEW ZEALAND SUPPLY CHAIN RESEARCH STRATEGY FOR GREEN BUILDINGS AND THE POTENTIAL IMPACT ON CLIMATE CHANGE

Barbara Nebel[1] and Simon Love

Although 90% of homes in New Zealand are currently built from wood, very few commercial buildings are built in timber. The Government announced in 2007 that "Within a year, new government-funded building projects for buildings up to four floors (including the ground floor) will have to commission designs and at least consider options for using wood or wood-based products as the main structural materials." Initial research has shown that savings in GHG emissions and embodied energy can be realized by building in timber while other studies indicate that there are no technical or financial reasons why wood should not be used.

New Zealand's Ministry for Agriculture and Forestry has put a research strategy in place to provide further results to underpin the existing research. This paper provides insight into three key initiatives currently underway. A key part of the research strategy is the development of a full supply chain model representing the material flows, as well as the carbon flows for the forest industry in New Zealand. This project covers log production, sawmilling, panel and board production as well as the use phase and end of life scenarios for timber buildings. Emphasis will be on representing the uptake and storage of carbon during the useful lifetime of the product. The predominant tree species grown in New Zealand is *Pinus radiata* and the results for GHG emissions and energy use for log production are presented in this paper.

The second project compares four designs of an office building, including concrete, steel, timber and 'timber plus'. The same performance with regard to operational energy is assumed for all four designs. Reliable and locally relevant Life Cycle Inventory data for different building materials is a key requirement for studies, such as the above building comparison. New Zealand specific data will therefore be developed in a third project, on the basis of New Zealand data and a Life Cycle Inventory model from Germany.

The three projects demonstrate an integrated research strategy that covers the whole supply chain for forestry and links to research in other primary sectors in New Zealand.

Key words: forestry, supply chain, LCA, timber, climate change.

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ID-181

POTENTIAL EFFECTS OF CLIMATE CHANGE ON HERBIVORES AND PATHOGENS – A REVIEW AND AN EXAMPLE

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Herbivores and pathogens are affected by climate change, either directly or indirectly, through plant nutritional quality and host tree resistance as well as through community interactions (e.g. effects on natural enemies). Depending on the pest species and the bioclimatic region, alterations in environmental conditions (such as temperature increase, changes in amount and patterns of precipitation, increased frequency and intensity of storm events, or increase of atmospheric CO_2) may have positive, indifferent or negative consequences for the health status of European forests. As part of the "Study on impacts of climate change on European forests and options for adaptation" (Tender No. AGRI-2007-G4-06) by the European Union, current knowledge on the impact factors of a changing climate, their mechanisms and potential effects on target species, as well as remaining uncertainties and existing knowledge gaps were synthesised by means of a thorough literature review. Alterations in frequency, size and geographical range of pest outbreaks have already been observed recently and are increasingly to be expected in future. While certain species will be able to expand their ranges of distribution or increase incidence and/or intensities of outbreaks, other species might suffer from range contractions or even population crashes and local extinctions.

The potential effects of climate change on herbivores will be demonstrated by the example of the pine processionary moth, *Thaumetopoea pityocampa*. This Mediterranean pest insect that frequently occurs at outbreak density not only throughout its main distribution area of the Mediterranean basin, but also at the margins of its natural range (e.g. Venosta/Vinschgau valley in Northern Italy) exhibits the potential of latitudinal and altitudinal range expansion. The results presented in our contribution refer to the project PROMOTH – Global change and pine processionary moth: a new challenge for integrated pest management funded by the European Union.

Key words: climate change, herbivores, pathogens, *Thaumetopoea pityocampa.*

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ID-123

REDUCED EMISSIONS FROM DEFORESTATION AND DEGRADATION (REDD): A REVENUE SOURCE FOR NATURAL FOREST MANAGEMENT BY COMMUNITIES IN VIETNAM

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Deforestation in the tropics accounts for approximately 18-20% of total greenhouse gas (GHG) emissions including carbon dioxide (CO_2), a major greenhouse gas responsible for global warming. Strategies and incentives for reduced emissions from deforestation and degradation (REDD), which are not included in clean development mechanism (CDM) of the Kyoto Protocol, have emerged as the most promising areas in the international climate change negotiations. Vietnam is a country with high rates of natural forest destruction and degradation. The concern of REDD in Vietnam is increasing as the Government of this country has already submitted its readiness plan idea note (R-PIN) to the forest carbon partnership facility (FCPF) of the World Bank. REDD strategy development has started in Vietnam. The Forest Protection and Development Strategy 2006-2020 (FPDS) adopted 'forest protection, conservation and environmental services program' as one of its operational programs to address natural forest loss and degradation.

The study aims at identifying potentials and constraints to enter international carbon markets through the REDD mechanism. The REDD strategy has the potential to significantly improve the overall quality of forest management when measured against economic, biodiversity and social parameters. REDD will directly contribute to Vietnam's obligations under the United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD) and to the economic development of remote and ethnic minority areas. Effective enforcement of forest law is the main constraints to introducing effective REDD strategies in Vietnam. Other challenges include the lack of awareness capacity and investment in forest protection, reducing the economic marginalization of forest boundary communities, centralized planning target and weakness of physical planning. The outcomes from the study are expected to be useful for the implementation of REDD and forest governance, not only in Vietnam, but also in other developing countries.

Key words: carbon dioxide, community forestry, deforestation, REDD, Vietnam.

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ID-069

A STRATEGIC APPROACH TO ENSURE SUSTAINABLE MANAGEMENT OF FOREST RESOURCES OF CAMEROON TO CLIMATE CHANGE

Grégoire Ngono[1]

There is widespread political and scientific concern about the alarming increase in the release to the atmosphere of carbon-dioxide (CO_2). Climate change (including climate variability), together with major processes as high deforestation rates, can affect the provision of goods and services from forests and, hence, hinder sustainable development. In order to reduce greenhouse gas emissions and to assure the well-being of forest-dwelling people, a strategic approach to ensure sustainable management of degraded areas surrounding the Dja Biosphere Reserve (DBR) in the South province of Cameroon was carried out by the Specialized Research Centre on Forest and Environment through intensive planting of a large number of tree species.

The nature of the study was a field trial and the species selected included fast-growing, light-demanding and poorly dispersed Non-Timber Forest Products (NTFPs) tree species. They were selected by stakeholders of the study area due to their livelihood importance, development relevance and vulnerability to climate change. The methodology was implemented through a two-year period, using coupled human-ecosystem approach, to assess the vulnerability and to facilitate the formulation of relevant adaptation strategies by decision makers at the different levels. The connection between the ecology of forest and vulnerability to climate change was assessed through an analysis on how changes in climate, climate variability in particular (temperature, rainfall, and extreme events) will affect the ecological parameters that control ecosystems functions underlying goods and services. In particular, vulnerability was assessed by selecting forest ecosystems that are relevant to the study area and that provide the goods and services for this area. The outputs were a methodology framework to assess vulnerability and policy briefs. The field trial revealed an advantage of quickly establishing a large number of species. The fast-growing species excluded weeds and the short-lived species created canopy gaps. However, its application was expensive due to the need to collect the seeds and nursery-raise a large number of species.

Keys words: adaptation, afforestation, agroforestry, carbon dioxide, deforestation, vulnerability.

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ID-333

TROPICAL FOREST VALUES AND VULNERABILITY TO CLIMATE CHANGE

J.N. Nkem and B. Locatelli[1]

The value of a product or service is determined by the relationship of its worth vis-à-vis the cost to the stakeholder that desires it, and the resource-base responsible for its provision at a given situation. Value is commonly characterized by function rather than structure. Capturing the full value of tropical forests along side economic importance, is crucial in understanding climate change risks and the extent of vulnerability of shared resource pools and the implications on multiple stakeholders and the national development goals. Approaching vulnerability of tropical forest through its values could be attractive in engaging stakeholders for adaptation. This paper highlights the expanded benefits in assessing vulnerability of tropical forest ecosystems through the value of the goods and services they provide for livelihood adaptation and national development.

Consolidating the desirable ecosystem services as defined by stakeholders that are likely to be affected by current or future climate change impacts on the forest under particular management regimes, seems strategic for adaptation. This approach also recognizes place, system, and non-static dimensions besides the preferred ecosystem service or bundle of services in the assessment of vulnerability and adaptation.

Case studies from the Tropical Forests and Climate Change Adaptation (TroFCCA) project implemented by the Center for International Forestry Research will be used to demonstrate perceived value judgments of tropical forests regions in their prioritization of adaptation needs from tropical forest ecosystem services. Silvicultural examples will be used to demonstrate how forest management practices can safeguard the value-base of tropical forest ecosystems to different stakeholders.

Key words: tropical forest, values, vulnerability, climate change.

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ID-150

FORESTS AND CLIMATE CHANGE - LESSONS FROM INSECTS

Frederick Nubed Nomi[1]

Climate change may indirectly affect the forest ecosystems through the activity of phytophagous insects. Climate change has been claimed to be responsible for the range expansion northward and upward of several insect species of tropical forests, as well as of changes in the seasonal phenology. Several papers have dealt with the prediction of the most likely consequences of the climate change on the phytophagous insects, including some of the most important forest pests. Increased levels of CO_2 in the atmosphere involve an increase of the C/N balance of the plant tissues, which in turn results in a lower food quality for many defoliating insects. Some insects respond by increasing the level of leaf consumption and consequently the damage to the tree, whereas others show higher mortality and lower performance. The level of plant chemical defences may also be affected by a change of CO_2. The temperature is affecting either the survival of the insects which are active during the cold period, such as the pine processionary moth, or the synchronization mechanism between the host and the herbivores, as in the case of the larch bud moth. An increase of temperature may alter the mechanism by which the insects adjust their cycles to the local climate (diapause), resulting in faster development and higher feeding rate, as in the case of the spruce web-spinning sawfly outbreaks in the tropics. Currently, it is difficult to make reliable predictions about the effects of climate change on the relationships between the forest trees and phytophagous insects. However, good conceptual frameworks, such as the carbon/nutrient balance and the growth/differentiation balance theories are available to interpret experimental results and to formulate new hypotheses as to how climate change will affect specific forest pests.

Key words: temperature, phenology, range, host-insect relationships.

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ID-275

POSITIVE EFFECT OF THINNING ON THROUGHFALL AS POSSIBLE WAY FOR ADAPTATION OF YOUNG SCOTS PINE MONOCULTURES TO CHANGING CLIMATE

Jiří Novák, Marian Slodičák and David Dušek[1]

Scots pine (*Pinus sylvestris* L.) monocultures usually grow in lowlands of central Europe and they are often located on poor desiccated sandy soils. Additionally, climate change towards a warmer and dryer vegetation period may worsen these environmental conditions. Therefore, forest owners need applicable measures, which react to this new situation, especially in the young stands. Thinning, i.e. reduction of stand density, can be a possible way for support of adaptation of young Scots pine monocultures to changing climate.

Effect of thinning on throughfall in young Scots pine stands has been investigated on the experimental series Tyniste (Eastern Czechia) on sandy-gravel terrace with sandy soil at elevation of 260 m (*Pineto-Quercetum*). Series of thinned and unthinned (control) plots were established in 6-year-old pine stand of planting origin with initial density 10,000 trees/ha^{-1}. Thinning started at the stand age of 7 years (combined selection = schematically + negative selection from below). The second thinning (positive selection from above) was done nine years later (at the age of 16 years). Both precipitation outside of the canopy (open space), and precipitation under the canopy of thinned and unthinned stands was measured weekly (age of 7 – 22 years).

The results of experiment confirmed the positive effects of thinning on the water regime of young Scots pine stand. On the thinned plots, throughfall increased by 2 to 6% compared to precipitation under the canopy of control plots. This positive effect was significant during four years and persisted six years after the first thinning. Later (following four years), we found significantly higher values of throughfall (about 2 to 4%) on control plots, probably due to dynamic growth of green crowns in the thinned stands. However, two years after the second thinning, the throughfall in thinned stands was higher again.

This study was supported by the long-term Research Project of the Czech Ministry of Agriculture MZE-0002070201.

Key words: *Pinus sylvestris* L., thinning, throughfall.

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ID-124

ADAPTATION TO CLIMATE CHANGE IN CERTIFIED FORESTS – THE INTERNATIONAL TRADE IN TIMBER AND ADAPTIVE FOREST MANAGEMENT

Walters Nsoh[1]

Illegal logging and the associated unsustainable trade in illegally-harvested timber threatens to offset any real efforts that seek to ensure sustainable adaptive forest management to climate change. While this has been recognised internationally and a number of measures are being put in place, there is evidence that the problem is still widespread. In addition to the various initiatives being pursued, several Governments have, as a way of verifying that public procurement requirements for legal and sustainable timber are met, adopted forest certification. A number of forest certification schemes exist and are currently being widely used by various Governments as part of their timber procurement policy. Among the various limitations to the use of this tool are domestic legislation in some timber-producing countries, destruction of endangered species, indigenous peoples' rights and international trade law. Overcoming these limitations to improve on the potential of forest certification is most likely to have climate change considerations on the adaptive capacity of certified forest communities. This therefore puts to question the extent to which the international trade in timber affects the adaptive capacity in forest managed for commercial purposes. While it is argued that illegal logging could be stopped if global trade restrictions are implemented, through which all countries restrict the import of non-verified and non-certified forest products, verification and certification itself is likely to be seen by free traders as a potential trade barrier.

This paper brings to focus some of the ways to achieve a balance between the use of forest certification and adaptive management of forest for climate change in forest managed for commercial purposes and highlights the importance of popular schemes, such as the Forest Stewardship Council (FSC), in verifying that public procurement requirements for legal and sustainable timber are met.

Key words: forest certification, legality, sustainability, adaptive capacity, climate change.

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ID-046

TOWARDS DEVELOPING OPTIONS AND INDICATORS ON COMMUNITY- BASED SUSTAINABLE MANAGEMENT OF FOREST RESOURCES IN THE ERA OF CLIMATE CHANGE – CASE STUDY FROM ORISSA, INDIA

Nabaghan Ojha[1]

Orissa state is situated in the east coastal region of India accounting for 7.38% of the total forest cover of the country with actual forest cover having 48,336 km^2 as per Forest Survey of India Report 2003. There are 29,302 forest fringe villages in Orissa, with a population of about 15 million directly or indirectly dependent on forest. They have been managing and using the resources since long back with their indigenous management practices. Most of them benefit economically from the resources through collection and selling of Non-Timber Forest Products (NTFP) like mahua flower (*Madhuca indica*), Sal seed (*Shorea robusta*), Tendu leaf (*Diospyros melanoxysis*), among others. But unfortunately the continuously fluctuating weather conditions like unprecedented rise in temperatures, flood, drought and cyclone over the last couple of years, probably due to climate change, gradually disturb the resources in terms of its availability, production and use. Since 2000, Mango and Mahua trees have been reported to flower unusually early, which leads to low yield of produces. Mahua flower, an important source for rural livelihood, with a business of around 500 million per annum in the state, has been severely affected in the last eight crop seasons. Similarly, 200,000 trees in about 25,000 hectare reserve forests have been uprooted and in some places the regeneration capacity of species has declined. Change in climate following the super cyclone in 1999 possibly caused these changes.

Climate change is likely to impact forest biodiversity severely through changing biome types and shifting forest boundaries in the coming days. This will in turn impact the supply of forest products, as well as the livelihoods of forest-dependent communities. In this paper, an effective community-based forest management module has been proposed with simple options and indicators through blending indigenous management practices with the modern techniques.

Key words: climate change, forest-dependent poor, non-timber forest products and community-based sustainable forest management plan.

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ID-199

POSSIBILITY OF ADOPTING REDD PRINCIPLE IN THE CONTEXT OF NEPAL

Bishwa Nath Oli[1]

Deforestation is the second leading cause of greenhouse gas (GHG) emissions behind energy production, and is responsible for about one quarter of anthropogenic GHG emissions. The 13th Conference of Parties of the UNFCCC held in December 2007 had put forward a concept of REDD (Reduced Emissions from Deforestation and Degradation) in which developing countries would be provided financial incentives for reducing emissions from deforestation. This step has opened an opportunity for Nepal to work on a carbon credit mechanism for the forestry sector. With a view to exploring the possibilities of adopting REDD principle in Nepal, international policy and dialogues on REDD related to policy implementation, and management aspects for the forest sector of Nepal are analyzed. Deforestation and forest degradation are central environmental issues, both globally and also in Nepal. In the 1960s, the forest cover of Nepal was about 60% but this has declined to 42.7% in 1978 and 39.6% in the 1990s. A number of policies and both legal and institutional measures are available for the effective management of forests in Nepal. However, there are no single policy instruments that deal with climate change issues. Community forests are well recognized models of participatory forestry. Recognizing the greater involvement and costs of local people in managing the community forests, the REDD principle can be applied in these community forests. However, some issues still prevent the full acceptance of the REDD mechanism. There is a weak trend of data on forest cover, growing stock, biomass stock in Nepal and data on carbon stock is not available. National capacity to estimate and monitor deforestation and implement approaches to reduce emissions need to be developed, at least at a pilot scale.

Key words: deforestation, forests, Nepal, possibility, REDD.

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ID-243

UPTAKE OF CARBON IN SWEDISH FOREST ECOSYSTEMS

Mats Olsson[1]

This presentation deals with fluxes of CO_2 and N_2O from productive forest ecosystems. Most of these occur on mineral soils; however, a substantial part occurs on drained peatlands. Based on growth data from forest statistics and biomass expansion factors, the annual net accumulation in forest biomass was estimated to be 38 M ton C, or 1.7 ton C ha^{-1}. This value does not include biomass with annual turnover, i.e. litter. The main part, 17.7 M ton C, of the uptake is harvested as stemwood for pulp and lumber production, and a small part of the harvest residues are removed as bioenergy. The annual carbon uptake exceeds the harvest and there is an annual increase in living tree biomass corresponding to 4.8 M ton C annually. The forest growth data are consistent with measurement of net ecosystem exchange using the eddy covariance method. The annual net ecosystem exchange was an uptake of 2.9 ton C ha yr^{-1} in southern Sweden and 0.8 ton C in northern Sweden. Modelling approaches indicate that mineral soils sequester 0.09 – 0.42 ton C ha^{-1} yr^{-1} in southern Sweden and -0.05 - 0.14 ton C in northern Sweden. The occurrence of a small soil C sink is also supported by unpublished data from the National Soil Inventory. An assumed average of 0.05 ton C ha^{-1} yr^{-1} for 17 M ha forest land on mineral soils (peatland excluded) gives an annual national soil sink of 0.9 M ton C yr^{-1}. The emissions from 1M ha drained organic forest soils are estimated to be 3.3 M ton C equivalents yr^{-1}, making all soils under productive forests a net source of greenhouse gases (3.3 M ton C yr^{-1}). Due to the accumulation of C in tree biomass the forest ecosystem is a sink of about 1.5 M ton C annually.

Key words: organic carbon, greenhouse gases, carbon sequestration, biomass carbon.

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ID-370

DYNAMIC HEIGHT-AGE FUNCTIONS USED TO ACCOUNT FOR VARYING EFFECTS OF CLIMATE CHANGE ON TREE HEIGHT GROWTH

G.A. O'Neill[1] and G. Nigh[2]

Height-age (site index) models have a wide application in forestry because of their ability to predict height at a given age. Conversely, they are also used to predict site index from height and age. In a rapidly changing climate, however, height growth as a function of time can be expected to change because of changing site conditions. An approach is therefore needed to adjust height-age models so that they reflect the expected impacts of climate change over the course of a forest rotation and beyond.

Analyses of provenance field test data have shown that the further seed is transferred from its climatic origin, the poorer its growth. Transfer functions relate the height of populations in provenance tests to the climatic distance that seed is transferred, and are therefore good predictors of the impacts of climate change on tree height. We extend this concept by using a bi-variate transfer function to estimate annual impacts of climate change on height growth. We then incorporate the estimated annual impacts into a conventional height-age model to create a dynamic height-age model that captures the effect of a changing climate on site productivity and height growth.

We demonstrate our approach using data from a 32-year-old wide-ranging *Pinus contorta* provenance test to develop dynamic height-age models for three future climate scenarios in British Columbia, Canada. Our results suggest that for all three climate change scenarios, height growth will slow slightly over the course of a rotation, resulting in an average volume loss of 12% by the end of the rotation.

Key words: growth response function, height-age model, *Pinus contorta* var. *latifolia*, provenance test, site index, transfer function.

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ID-055

THE POTENTIAL FOR GLOBAL CARBON UPTAKE BY USING SWEDISH FORESTRY PRACTICE

Göran Örlander[1]

Swedish forests (and many of the European forests) have had a constant increase in standing volume, growth and cutting by *ca* 1% annually since the 1920s. The accumulation of carbon in the forests has been substantial, and the use of wood as bioenergy, timber, etc., has substituted fossil fuels, avoiding thereby CO_2 emissions.

The main possibilities to affect the carbon uptake in the world's forests are to reduce deforestation, forest damage (e.g., fires, insect, fungus attacks, flooding, wind throw) and increase growth. Forests cover *ca* 4 billion ha of the earth's surface. About 40 % of that area is regarded as production forests. The growing stock per hectare has been relatively constant during the last decades, deforestation has been substantial (7 million hectares per year), and around 100 million hectares damaged each year. The amount of carbon in the forests is about the same as that in the atmosphere. The annual net supply of CO_2 to the atmosphere equals to around 4 Gt C, or about 0.5% per year.

The potential of the world's forests to accumulate carbon was made assuming that the production forests were managed and had the same development as the Swedish. The calculations indicate a possible increased of CO_2 uptake of in total 4,0 Gt C/ year in total, divided into increased growth 2,3 Gt C/year, reduced deforestation 0,6 Gt C/year, and reduced damage 1,1 Gt C/year.

In summary, the calculations indicate that the potential for global carbon uptake by using Swedish forestry practice is about the same as today's net emissions of CO_2.

Key words: forest growth, deforestation, forest damage, CO_2,

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ID-373

ASSESSMENT OF IMPACTS AND ADAPTATION TO CLIMATE CHANGE AND THE LINKS TO SUSTAINABLE DEVELOPMENT IN AFRICA

Elasha Balgis Osman[1]

The Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC-TAR & IPCC-AR4) pointed up that developing regions like Africa who emit the least GHGs will shoulder the greatest burden from the climate change impacts. Poor countries in Africa, and poor people within countries, will suffer the most because of limited access to capital, chronic conflicts and failure of governments to respond effectively. Moreover, Africa is likely to witness a decline of agricultural productivity, especially in sub-Saharan countries. Climate change therefore presents a real risk to poverty reduction strategies, threatens to reverse decades of development efforts and poses an additional challenge to meeting the Millennium Development Goals.

Integration of climate change in development policies and initiatives can be done by making development “climate-proof”, as well as by making sure that all measures and plans addressing climate change mitigation or adaptation also account for the different dimensions of sustainable development. An example could be extracted from a case study in Sudan, which evaluated the impacts of sustainable livelihood strategies that have been adopted in response to 1980s African Sahelian drought. The interventions aim at increasing the coping capacity and improving the livelihood conditions of Sudan's rural population in one of the most drought-prone areas. Assessments have indicated that these strategies have contributed to the rural development through: (a) improving the natural resource base and the local capacities to manage and control them; (b) diversifying sources of income and improving the overall economic situation; and (c) strengthening social networks and social stability, i.e. addressing - even within a very small scale - the three pillars of sustainable development (environmental, social, and economic) and hence, demonstrating what could notionally be called the developmental spill over of adaptation in the rural community. Sustainability, productivity and equity that have not only economic, but also social and environmental dimensions are key issues, and were also assessed using a comprehensive set of indicators.

Key words: sustainable development, mainstreaming climate change, livelihoods.

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ID-383

BIOMASS ENERGY AND CARBON SEQUESTRATION POTENTIAL OF WASTELANDS IN INDIA

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In India, 16 to 20% of the geographic area (55 to 64 million ha) are considered as degraded or wasteland, which is not under crops or forests. Wasteland includes for example waterlogged, gullied land and steep sloping areas, hence its capacity of producing biomass is limited. These lands are today supporting grazing animals and provide fuelwood, hence they are utilized, and alternative uses have opportunity costs, though the biomass productivity is likely to be very low. Estimates state that India's wasteland is producing only 20% of its capability; leaving room for development potential. India has been implementing a large afforestation programme, in part on these wastelands. Further, the Government of India has initiated an ambitious program of raising Jatropha plantation (*Jatropha curcus* L.) to produce biodiesel for the energy sector. This study will assess the biophysical potential of producing biomass for energy, carbon sequestration and timber production to meet the growing needs of India. The options would include Jatropha, woodfuel plantations for biomass power, multi-species plantation for meeting the biomass needs of local communities. The potential will be assessed using wasteland information at the district level (Wasteland Atlas of India), topography (CGIAR/SRTM), temperature and precipitation data (CRU), soil data (IGBP), and agro-ecological zones over India. There is a need to assess the multiple options for reclaiming the wastelands in India.

The result will indicate regions and total area with high and low biomass growth potential, based on biophysical parameters, which will be used for further hotspot analysis. This result will further enhance the understanding of wasteland and biomass production for energy and adaptation, as well as carbon sink enhancement for climate mitigation options.

Key words: wasteland, biomass production, energy, C sink, India.

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ID-259

THE EFFECT OF ENVIRONMENTAL CHANGES ON FOREST DISTURBANCES IN SOUTH KOREA

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Forest disturbances, including forest fire, insect pests and diseases, and landslides from 1976 to 2005, were investigated to trace major forest disturbance patterns and their characteristics over time in accordance with forest growth development and environmental changes in South Korea. While the damaged area by insect pests and diseases continuously decreased for the past 30 years, damaged areas by forest fire and landslide were fluctuating through years. However, the interval between large forest fires has become shorter as larger fires occurred in the past 10 years than in the 1970s and 1980s. The low precipitation between January and April were significantly correlated with large fire occurrences (p-value=0.029) and an increase in precipitation was negatively correlated with fire occurrences in this period. The composition of major insect pests and diseases damaging Korean forests has been changed continuously, and become more diversified. While damages by pine caterpillar (*Dendrolimus spectabilis*) and pine gall midge (*Thecodiplosis japonensis*) decreased, damages by introduced pests have been more serious recently. The change of precipitation pattern that brought more localized heavy rain or powerful typhoon resulted in the recent increase in landslide areas. The fact that forest disturbances of fire, insect pests and diseases, and landslides are closely linked to local climate characteristics indicates that changes in climate characteristics, such as precipitation pattern by global warming, may alter disturbance regimes in the region.

Key words: South Korea, insect pests, diseases, climate change.

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ID-113

ON THE RISE - PLANT INVASIONS INTO MOUNTAIN FORESTS

C.G. Parks[1] and MIREN[2]

Currently, high mountain forests are less affected by invasive plant species than are mid- or low-elevation forests - but worldwide, mountains face increasing pressure from invasive species due to climate change and intensified human use. The Mountain Invasion Research Network (MIREN) addresses the problem of plant invasions in mountain regions using mountains as model study systems for research into the mechanisms of plant invasions, particularly under the conditions of global warming.

MIREN has defined a comprehensive research agenda for understanding plant invasions into mountains, involving three main approaches: (1) detection and analysis of invasion patterns at multiple scales, (2) experimental studies of invasion drivers, and (3) assessment of the impacts caused by non-native species and their conservation implications. MIREN aims to respond to management needs to conserve the unique ecosystems of high mountains, as well as to general research needs to understand the mechanisms behind plant invasions. Six core mountain regions of the globe are currently participating in standardized baseline screening and monitoring and in standardized comparative experiments. These core mountain regions cover the major climatic zones and include island and continental systems.

Key words: alien plant species, biodiversity conservation, global change, high altitude environments.

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ID-290

NEW ZEALAND'S POTENTIAL FOREST RESPONSES AND THREATS UNDER CLIMATE CHANGE - AN OVERVIEW OF RELATED RESEARCH

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New Zealand forestry is based predominantly on radiata pine (*Pinus radiata* D. Don.) growing in a plantation forestry regime. This simplistic forest management approach allows and simplifies the study of projected climate change effects on New Zealand's forests on a national scale. We are currently in the initial stage of a research project focusing on the response of our production forests to climate change. Preliminary results regarding the modelling of productivity and the influences of weeds and pests will be presented, as well as the development of a proposed integrative modelling framework, dealing with multiple effects of climate change on our production forests. With an increase of CO_2 concentration and the expected increase of temperature, positive changes in productivity of New Zealand's forests are expected; however, risk factors such as the potential new arrival or improved growth of plantation weeds may counterbalance such an increase.

We will highlight such potential feedbacks based on current examples. The intended linkage of direct effects of climate change on our forest production trees and the indirect risks of pests and weeds in form of an integrative model framework will be discussed. An outlook will be given on the intended handling of uncertainty and a broader view on the potential implications of climate change on New Zealand's forests and forestry in the future.

Key words: Radiata pine, New Zealand, climate change, productivity, weeds.

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ID-293

STAND LEVEL VARIATION IN LEAF AREA TO SAPWOOD AREA RATIO ALONG AN ARIDITY GRADIENT IN THE JARRAH FOREST OF SOUTH-WESTERN AUSTRALIA

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The proportion of canopy leaf area (A_l) to cross-sectional stem sapwood area (A_s) is directly related to the water conducting capacity of trees and can be used as a way of assessing the adaptability of forest stands to increased aridity or drought severity. A strong positive correlation between leaf area to sapwood area ratio (A_l: A_s) and water availability has been observed for several different tree species around the globe. In the jarrah (*Eucalyptus marginata*) forest of south-western Australia, a decrease in (A_l: A_s) may be an important adaptation to increased drought stress which occurs annually in this ecosystem. We obtained the (A_l: A_s) of sixteen stands dominated by two tree species, jarrah and marri (*Corymbia calophylla*), across a gradient of aridity in the southern jarrah forest to test the adaptability of whole forest stands rather than individual trees or species to water stress. We estimated stand level sapwood and leaf area in sixteen 30m x 30m plots. An aridity index (potential evapo-transpiration divided by precipitation) was obtained from interpolated climatic data for each stand. We obtained allometric equations relating tree diameter at breast height (*DBH*) to sapwood area by coring and measuring sapwood depth of 18 marri and 46 jarrah trees of different sizes. Stand level sapwood area was estimated from these equations. Canopy leaf area was estimated using a leaf area index (*LAI*) obtained through digital cover photography. Although the aridity gradient across the sites was not large (1.28 to 1.51), a significant decrease in (A_l: A_s) was observed with aridity. Thus tree stands in the jarrah forest ecosystem adapt to water stress by decreasing their leaf area relative to their sapwood area.

Key words: aridity, drought adaptation, leaf area index, leaf area to sapwood area ratio.

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ID-030

BIODIVERSITY CONSERVATION, FOREST MANAGEMENT AND CLIMATE CHANGE ADAPTATION IN BOLIVIA UNDER THE CURRENT POLITICAL CONTEXT: IMPLICATIONS FOR POLICIES AND CONSERVATION

Bernardo Peredo-Videa[1]

Nature and biodiversity conservation are an economic, environmental and social process. It is also a political and cultural process in developing nations, characterized by being the richest regions in biodiversity but also the poorest economically. Paradoxically, whilst biodiversity and forest management provide substantial socio-economic and environmental benefits, local people have not often received benefits resulting from these processes. Thus ecosystem degradation has increased. This would be the case of Bolivia, considered amongst the richest countries in forest biodiversity, especially within the Tropical Andes Hotspot, recognized as the global epicentre of biodiversity. However, the country is one of the poorest nations in Latin America with indigenous communities amongst the most vulnerable groups.

Despite some progress and advances during the last decade in forest management, these efforts have been mainly promoted due to the international cooperation. Therefore, many political arguments and economic policies are asking new questions on the effectiveness of these initiatives for conservation, including climate change adaptation and the discussion of emerging trade-offs as part of new development approaches to reduce high levels of poverty. The research identifies the role and dynamics of climate change and forest management in Bolivia, both coming from local and national agendas. Hence, it reviews the policies and practices proposed and implemented in the current policy framework and evidences that new threats arise to forest and biodiversity conservation due to increasing deforestation rates.

Therefore, the presentation provides evidence from the field to analyze the opportunities to integrate climate change adaptation policies and forest conservation into national and local agendas. It identifies the challenges and implications of policy-making in the existing climate change and forest processes under the administration of President Evo Morales by providing up-to-date empirical evidence and conclusive analysis of the policy responses by the Bolivian government to climate change adaptation, forest management and biodiversity conservation.

Key words: biodiversity conservation, climate change, deforestation, forest management, policy-making.

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ID-131

CHANGES IN LIANA AND TREE COMMUNITY STRUCTURES AS CONSEQUENCE OF INCREASED HURRICANE FREQUENCY IN TROPICAL FORESTS IN COZUMEL, MEXICO

D. R. Pérez-Salicrup and P. Patiño-Conde[1]

Hurricanes are major disturbances which, historically, are affecting Caribbean islands every 10-15 years. One documented effect of climate change is the increase in hurricane frequency. Tropical forests in the Caribbean island of Cozumel are managed to provide ecosystem goods and services to this important tourism center, particularly water.

In this study we use data originally collected to evaluate the relative resilience of trees and lianas to hurricane damage to project what would happen to density, basal area and biomass of plants of these two growth forms as a consequence of reducing the frequency of hurricanes to 4 and 8 years. Seventeen years of recovery after the last hurricane, Cozumel had a density of 3,110 trees $\geq$ 5 cm DBH, and 4,164 lianas $\geq$ 0.5 cm DBH, which accounted for a tree basal area of 35.5 m^2/ha, a liana basal area of 0.68 m^2/ha, and a tree biomass of 196.52 tons/ha, and liana biomass of 10.61 tons/ha. After the combined effect of hurricanes Emily and Wilma in 2005, 9% of trees died, and surviving trees had negative growth rates for one year. Liana density and basal area were reduced to half of their original values. After two years, trees showed vigorous growth, and lianas increased in density, but most stems were very slender. Opposite to our original predictions, a hurricane frequency of 4 years resulted in reduced tree and liana densities and basal areas. With a hurricane frequency of 8 years, lianas increased in abundance relative to trees. Under both scenarios, the hydrological cycle of this Island might be modified, resulting in a modified provision of water as consequence of changes in forest structure.

Key words: climate change, hurricanes, lianas, trees, tropical forests,

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ID-172

PREDICTING THE IMPACTS OF PEST ATTACK ON FOREST PRODUCTIVITY UNDER CHANGING CLIMATE

Libby Pinkard and Michael Battaglia[1]

While use of models to explore carbon cycles in forest ecosystems is well advanced, the medium- and long-term impacts of pests on forest carbon pools have received scant attention. There is considerable evidence that damage caused by forest pests can decrease forest productivity and hence carbon stocks, and should be considered when exploring the role of forests in carbon sequestration.

How much productivity is affected by pest attack is related to the compensatory mechanisms implemented by the tree - changes in patterns of biomass allocation between above and below ground components, allocation to leaves influencing crown recovery rates, changes in photosynthetic processes that may increase CO_2 uptake, competing sinks for carbon and nitrogen. All of these responses are influenced by site factors - water and nutrient availability. There is a requirement for models predicting effects of pest attack to be dynamic with respect to biomass allocation, leaf area development and carbon and nitrogen pools, in order to predict effectively the consequences of multiple pest attacks of varying severity, and the interaction of pest attack and management interventions or environmental perturbations like drought.

We used a case study to explore the potential impacts of pest attack on tree productivity. CABALA, a linked carbon, water and nitrogen model of forest growth, was modified to account for foliar pest attack. The model was tested for two widely-distributed temperate plantation species, *Eucalyptus globulus* and *Pinus radiata*, against detailed experimental data of resource pools and biomass allocation under a range of abiotic stresses and varying severities, frequencies and patterns of defoliation or pathogen attack. It was validated using plot data from field sites with a know history of pest damage. The model was run for current and 2030 and 2070 projected climates, allowing for both photosynthetic acclimation to elevated CO_2 and no acclimation. Defoliation scenarios for two widely-distributed pest species (Mycosphaerella leaf disease and *Essigella californica*) were developed for each climate scenario using the Ecoclimatic Index and Growth Index from CLIMEX, a bioclimatic species distribution model.

The results will be discussed in terms of implications of climate change to *E. globulus* and *P. radiata* plantations in Australia and other parts of the world, and of application of the approach to other host and pest species.

Key words: climate change, abiotic stress, defoliation, forest productivity.

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ID-036

REDUCING EMISSIONS FROM DEFORESTATION AND FOREST DEGRADATION: NEGOTIATIONS AND METHODOLOGICAL ISSUES

Catherine Potvin[1]

The Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) met last December in Bali in a context of great expectations. Several factors influenced the climate of the negotiations. Amongst these, the fourth Assessment Report of the IPCC, extremely pessimistic, and the need to conclude the negotiation on the future of the Kyoto Protocol within 12 months contributed to give a sense of urgency to the Conference. One of the important decisions reached at COP-13 concerned the possibility of taking into account reducing emissions from deforestation and degradation (REDD) in developing countries as acceptable mitigation strategies to combat climate change.

This talk will present the key players during the two years of negotiations that led to the Bali REDD decision and discuss their positions. A characteristics of the REDD negotiations has been the very strong participation of developing countries. Therefore the differences and communality in positioning within the G77 and China will be examined in detail. International organizations, such as the World Bank, the United Nations Development Programme, etc, certainly influence the negotiations indirectly. A brief assessment of their activities will therefore be presented. The talk will then discuss the two main points of tension in the negotiation to date, namely scale (national or sub-national) and scope (deforestation, degradation and conservation) of implementation of REDD activities, as well as the solutions agreed upon in Bali. The future of a REDD mechanism will clearly depend on resolving these issues and future ones that have not been discussed so far. Two of these pending issues - permanence of the emissions reduction and financial flows - will be considered. To conclude, the presentation will focus on some methodological challenges showing how the lack of appropriate scientific methodologies could affect the implementation of REDD activities.

Key words: Kyoto Protocol, REDD mechanism, reduction of emissions, financial flows.

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ID-375

COUNTERACTING DESERTIFICATION AND BUSHFIRES THROUGH REFORESTATION: THE CASE OF ZION HILL, SAINT-VINCENT AND THE GRENADINES

Joel Poyer[1] and Candice R. Ramessar[2]

Some of the anticipated impacts of climate change in the tropical and sub-tropical zones are an increase in temperature, prolonged dry seasons and decrease in water availability. These factors threaten tropical forests leading to its replacement by savannas and desert-like conditions. This paper will present the results of a pilot project implemented by the Ministry of Agriculture and Fisheries of Saint-Vincent and the Grenadines, in direct partnership with villages, to reforest an area on its Leeward Coast to combat desertification as a result of increasing temperature. Using a needs assessment survey of the village and scientific analyses of the soil and vegetation, the project combined introducing cultivation of plant species that provided ecological benefits and economic value to villagers as adaptation measures to the changing climatic conditions.

The results of the project are an ecology that is markedly different from before the reforestation project commenced. The annual fires have ceased, erosion has been significantly reduced, and the savanna-like conditions have been altered. Precipitation and fauna have increased, whilst the micro-climate is much cooler. The communities have taken ownership of the project and are realizing several livelihoods from the area.

This project illustrates the importance of community participation in adaptation and mitigation actions to combat the effects of climate change and effectively manage forest resources at the local/village level in the Caribbean.

Key words: adaptation, climate change, desertification, Saint-Vincent and the Grenadines, community participation reforestation.

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ID-175

IMPACTS OF AND ADAPTATION TO CLIMATE CHANGE OF FOREST BIODIVERSITY IN THE PHILIPPINES

Florencia B. Pulhin[1] and Rodel D. Lasco[2]

The Philippines is a Southeast Asian country which has very diverse species of flora and fauna. As such, Conservation International (CI) designated the Philippines as one of the world's 17 mega-diversity countries. However, its current state is alarming as many of the species are already threatened or extinct. Many stressors (i.e. overpopulation, deforestation, unsustainable livelihood, development) greatly contribute to the erosion of biodiversity in the country. With climate change, biodiversity is expected to be further threatened. To determine the potential impacts of climate change in biodiversity of the Philippines, we examined the impact of changes in temperature and precipitation on distribution of forests using the Holdridge Life Zone, an ecological classification system based on the three climatic factors, *i.e.* precipitation, heat (bio-temperature) and humidity (potential evapo-transpiration ratio). Using GIS, distribution of forests in the Philippines was determined at current climate conditions, at 1^0C, 1.5^0C, and 2^0C increases from current values of temperature and 25%, 50% and 100% increases from current values of precipitation. Results of the study show that at current climate conditions, Philippine forests are composed of the dry tropical, moist tropical and wet tropical forests. However, with increase in rainfall and temperature, there will be total loss of the dry forests.

Currently, there are adaptation options undertaken by stakeholders to cope with the impacts of climate related events in forestlands in the Philippines. To assess such, a participatory approach was used. Results showed that for each land use, specific adaptation strategies were undertaken by the stakeholders. With climate change, these options may not be enough. Thus, the following adaptation options need to be undertaken in managing the forests of the country: risk and vulnerability assessment, protection of remaining forests, rehabilitation of degraded lands, improve harvesting technology, mainstream climate change adaptation in policies, plans and programs and secure sustainable financing.

Key words: biodiversity, climate change, management.

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ID-132

FACTORS AFFECTING THE ROLE OF URBAN AND PERI-URBAN FORESTS IN ADAPTATION TO CHANGING CLIMATIC CONDITIONS IN KHARTOUM STATE, SUDAN

Hamad Ibrahim Rahamtalla[1]

Khartoum is the national Capital of Sudan, situated in the semi-desert zone. Rainfall ranges from 75–300mm. Natural vegetation is mainly *Acacia spp*. In addition to the direct benefits of trees in Khartoum, they play a vital environmental role and contribute to improvement of microclimate and air quality, reduction of carbon dioxide, cooling and cleaning the air and reducing air pollution. Though it is the smallest state in area, Khartoum is considered as the most densely populated, embracing almost one third of the country's population (about 9 milllion). This is mainly due to migration and displacement of people from rural areas, particularly those affected by conflicts and war, which resulted in pressures on available resources.

The consequences of these pressures were: increased rates of deforestation, overgrazing of fragile soils, expansion of residential areas on forest lands, desertification and land degradation that remarkably influenced the adaptation capability of the area to changing climatic conditions. During the last 20 years the area experienced more frequent drought periods, dust storms, unprecedented damaging floods and torrential rains.

Khartoum State forestry Authorities, in partnership with related stakeholders, implemented afforestation and reforestation programmes. Activities included: private and community nurseries and woodlots; institutional forests like Khartoum Refinery Company Shelterbelts; farmers' shelterbelts; schools tree planting; public roads afforestation; Arbor Day Campaigns; extension and awareness campaigns.

Despite these efforts and activities, there is still much to be done. The rate of reforestation is far behind the targets. A number of factors and problems negatively affect forest health and vitality. This remarkably interferes with the adaptation capability of the forests to changing climatic conditions.

Recommendations mainly focus on: involvement of all stakeholders and decision makers; raising their awareness about the magnitude of the problem and proposed plans; strengthening their capacities in all aspects of resource degradation and the linkage to changing climatic conditions. Addressing environmental degradation through afforestation and reforestation programmes and investing in environmental management.

Key words: afforestation, adaptation, climate change, degradation, Khartoum.

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ID-007

COMBINING SPECIES SUITABILITY MODELS AND EXPERT KNOWLEDGE TO UNDERPIN POLICY DEVELOPMENT FOR SCOTTISH FORESTS IN A CHANGING CLIMATE

D. Ray[1] and C.P. Quine[2]

Climate change is now one of the greatest global challenges, and research is underway to establish the likely impacts on many aspects of the environment. In Scotland, we have implemented a hybrid approach to developing strategic plans for the adaptive management of forests in an uncertain climate change future. The approach combines biophysical models of climate and soil quality, knowledge-based tree species suitability models, and an expert assessment of the likely biotic and abiotic impacts. The tree species suitability model based on Ecological Site Classification was developed within a GIS framework to assess changes resulting from future climate scenario projections published by the UK Climate Impacts Programme (2002), which are based on Hadley RCM outputs. An expert group of forest scientists assessed the factors considered very likely to limit the suitability of specific tree species in future climates and discussed forest adaptation options to reduce impacts. Knowledge accumulated through the discussion was used to prepare a scientific summary of the likely impacts of different climate change scenarios, and this was disseminated to the forest industry. The main scientific report was used by policy makers to develop a climate change action plan to implement the Scottish Forestry Strategy over the next five-year period.

The approach of using spatial decision support tools and expert opinion is an effective means of engaging with policy makers. The implementation of adaptation strategies for the management of forestry in Scotland will be underpinned by web-based applications to provide detailed advice to practitioners. The applications are modular and can be updated easily to facilitate adaptive management principles. Adaptive management policy in Scotland favours 'no-regrets' solutions. These include effective climate and site matching support tools, introducing more southerly provenance material, mixing species in stands and within forest blocks, and developing contingency plans to cope with widespread damage.

Key words: ecological site classification, knowledge-based modeling, Delphi analysis, policy development, climate change action planning.

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ID-284

PREDICTING INSECT CONTINENTAL DISTRIBUTIONS FROM THE PHYSIOLOGY OF INDIVIDUALS

J. Régnière[1]

Much evidence is accumulating that insect distributions are changing. The changing earth's climate is providing mobile species with an evolving "hospitability" template, and increasing global commerce expands opportunities for mobile species to colonize new habitats. Predicting the distribution of insects in the face of accelerating global commerce and climate change is quite a challenge. Many fruitful approaches are available and are being improved. Some are correlative; some are based on process-level knowledge. We have focused on an eco-physiological approach based on the known responses of species to specific weather factors at the physiological level. Of particular importance are developmental responses, of course, as they determine climates under which an insect can achieve a stable, adaptive seasonality. With this underlying minimal requirement, models can also take into account other weather influences such as cold tolerance.

We have used this approach to predict the change of distribution and impacts expected of three important species in North America: the native spruce budworm (*Choristoneura fumiferana* (Clem.)), the invasive gypsy moth (*Lymantria dispar* L.) and the geographical-barrier hopper mountain pine beetle (*Dendroctonus ponderosae* Hopkins). These studies point to the following conclusions: (1) the distribution of most insect species will shift towards the poles (and to higher elevations); (2) temperate regions will bear the brunt of these shifts; (3) distribution shifts may be good or bad, depending on the species and the point of view; and (4) a warmer world is not necessarily a more pestilent world.

Key words: distribution shift, invasion, forest insect, *Choristoneura, Lymantria, Dendroctonus.*

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ID-363

PROTECTION FOREST AND THEIR VULNERABILITY IN EUROPE: A FIRST APPROACH FOR HARMONIZED LARGE AREA MAPPING IN ALPINE AREA

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Protective functions of forests are becoming increasingly important, in particular considering climate change. These forests protect people and assets against natural hazards, such as snow avalanches or rockfall, particularly in mountainous areas, but have to be properly identified and managed in order to perform their protective functions. For that reason, some Alpine countries have developed national guidelines for the delineation of protective forests and their management. However, these national or regional mapping efforts vary in their underlying concepts, in their level of detail, and the data used. At the European scale, information for decision-makers is only provided through the indicators on protection forests provided by the Ministerial Conference on the Protection of Forest in Europe, which are only available on a national scale and have a low level of comparability. The intent of this work was therefore to develop an approach that would yield harmonized information on the European-wide spatial distribution of protective forests, including their vulnerability to climate change.

This approach uses a simplified GIS analysis based on available digital terrain data and forest maps, to identify forests within an area susceptible to natural hazards. In order to estimate the present and future potential protective effect of the forests, stability properties, i.e. resistance and resilience, are generally reported to be relevant, particularly for the Alpine region. For the large area approach, we propose to assess the stability by a mapped vulnerability index. This newly developed index links the modeled distribution of European dominant trees with their current and future suitability which is modeled applying the IPCC SRES A1B future scenario. The index represents the degree to which the current distribution matches the optimum ecosystem characteristics where the resistance to, and the recovery from disturbance is assumed to be enhanced. This approach enables us to map current and future distribution of protection forest in Alpine areas and highlight areas where the protection forest is highly susceptible to climate change.

Key words: GIS, natural hazards, protective functions, suitability maps, vulnerability.

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ID-097

MEANS OF COMBATING FOREST DIEBACK – EU SUPPORT FOR MAINTAINING FOREST HEALTH AND VITALITY

Aljoscha Requardt[1], Michael Köhl[1] and Andreas Schuck[2]

A feasibility study on *'Means of combating forest dieback in the European Union'* was initiated by the European Parliament, asking the European Commission to investigate the development of concrete proposals for preventing, mitigating and control forest dieback in the EU. The study was carried out by the Institute for World Forestry and the European Forest Institute in 2007. The main objectives of the study were to: (i) review the different factors affecting forest dieback in the EU and their related causes, (ii) analyse and evaluate the effectiveness of available EU legislations and instruments to combat forest dieback in the EU and (iii) examine the possibilities for establishing a specialised entity for forest protection.

For the scope of the study, a survey was conducted in the EU Member States on the importance of damaging agents in EU27 forests. The results of the survey clearly show that the significance of individual threats to forest ecosystem health and vitality varies within European regions. Highly ranked were in particular those threats which are linked to the effects of climate change. Differences in relation to damage types and intensity reflect the importance for particular instruments.

The feasibility study showed that at the EU level several efficient and well established measures have been implemented which contribute to the prevention, mitigation and control of forest dieback. The study also revealed that as a consequence of the current state and the predicted development of environmental pressures, particularly that of climate change, swift actions are necessary at EU level to combat forest dieback and its repercussions effectively. Existing measures need to be further developed in order to (a) increase synergy effects between individual instruments (b) make the instruments more transparent to the entire range of potential stakeholders and beneficiaries, and (c) improve the communication between the different actors involved.

Key words: forest health and vitality, EU policy, prevention, mitigation, control.

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ID-151

MODELLING CARBON ASSIMILATION FOR AN ONTARIO BOREAL SPRUCE PLANTATION – CANADIAN CARBON PROGRAM (CCP)

Phillip E. Reynolds and Gordon Brand[1]

The ability of forests to sequester carbon varies. Young vigorously growing plantations may have greater sequestration potential than mature stands, a sequestration potential that is linked to the rate of carbon assimilation of net photosynthesis. Annual carbon assimilation was estimated for a mixed 20-year-old black and white spruce plantation near Timmins, Ontario. Carbon assimilation was measured for each species (black and white spruce, balsam fir, white birch and trembling aspen) using a LiCor 6400 Photosynthesis System to develop light saturation curves for nine Photosynthetically Active Radiation (PAR) values each at six air temperatures. 3-D surface models relating net assimilation to temperature and PAR were developed for each species. These models were coupled with daily and seasonal air temperature and PAR to generate daily, monthly, and seasonal rates of carbon assimilation. Data were then combined with leaf area index measurements to estimate daily, monthly, or seasonal carbon assimilation per hectare. Maximum assimilation rates were highest for the hardwoods, approaching three times that of conifers. Rates were higher for aspen than birch. For conifers, rates were highest for black spruce, followed by white spruce, and fir. Species differences were also evident for optimal temperatures of carbon assimilation. Maximal assimilation occurred between 10 and 15^{o}C for fir, between 15 and 20^{o}C for black spruce, and between 20 and 25^{o}C for white spruce. Assimilation peaked at 30^{o}C and 35^{o}C for birch and aspen respectively. Net assimilation at the lowest temperature (10^{o}C) was seasonally dependent: higher in the fall when soils were warmer than in spring following snowmelt.

These data suggest greater potential for conifer assimilation in the off seasons (spring/ early summer and autumn). By contrast, greater hardwood assimilation occurs during the summer months. Increased assimilation is expected as annual growing seasons lengthen due to global warming. By occupying different niches for carbon assimilation, species are able to reduce competition and coexist in the same stand.

Key words: carbon assimilation, sequestration, white spruce, black spruce, balsam fir, white birch, trembling aspen.

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ID-314

MODELLING CARBON ASSIMILATION FOR BOREAL JACK PINE PLANTATIONS – ONTARIO LONG-TERM SOIL PRODUCTIVITY (LTSP) STUDY

Phillip E. Reynolds and Gordon Brand[1]

The LTSP study was established in Ontario in 1993 to examine the effects of harvesting and other site preparation techniques on long-term productivity (i.e., yield, biomass, carbon sequestration) of pine or spruce plantations. Annual carbon assimilation was estimated for a 10-year-old jack pine plantation near Thessalon, Ontario. Small plot treatments consisted of tree-length (TL) harvested with standard disc-trenching, full-tree (FT) harvested with disc-trenching, FT harvested with blading, and FT harvested with blading and soil compaction. Half of each plot was herbicide released annually. Carbon assimilation through net photosynthesis was measured for each treatment using a LiCor 6400 Photosynthesis System to develop light saturation curves for nine Photosynthetically Active Radiation (PAR) values each at six air temperatures. 3-D surface models relating net assimilation to temperature and PAR were developed for each treatment. These models were coupled with daily and seasonal air temperature and PAR to generate daily, monthly, and seasonal rates of carbon assimilation. Data were then combined with leaf area index measurements to estimate daily, monthly, or seasonal carbon assimilation per hectare. Maximum carbon assimilation occurred between 20 and 25^{o} C. Net assimilation at the lowest temperature (10^{o} C) was seasonally dependent: higher in the fall when soils were warmer than in spring following snowmelt. These data suggest greater potential for assimilation in the off seasons (spring/early summer and autumn). Site preparation, rather than harvest nutrient removals or herbicides, appears to have had the greatest impact on carbon assimilation. Assimilation rates were highest for plots site prepared with disc-trenching, and lowest for bladed and/or compacted plots. Increased assimilation is expected as annual growing seasons lengthen due to global warming. Additionally, assimilation can be increased by disc-trenching and avoidance of blading or heavy compaction. Without optimization of site preparation methods, carbon assimilation rates can be expected to differ widely on either a stand or landscape scale. Proper management of site preparation can therefore affect the rate of carbon sequestration through its effect on net photosynthesis.

Key words: carbon assimilation/sequestration, long-term productivity, soil productivity, soil compaction, soil nutrient removals.

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ID-316

EXPLORING FOREST MANAGEMENT SOLUTIONS IN TRADITIONAL KNOWLEDGE SYSTEM TO ADDRESS CLIMATE CHANGE ISSUES

Arun Rijal[1]

Though the share of Nepal in the global emission of greenhouse gases is negligible (with 0.13 t *per capita* CO_2 emissions), it has to face the consequences of global warming. Such warming is raising temperatures by 0.06^{o}C per year. Due to this over the past few years, Nepal is experiencing severe droughts and other adverse weather conditions which have affected agriculture, water bodies, forest and created several other environmental problems. Shortages of water and food availability in Asia are likely to be exacerbated by climate change in coming decades, as stressed by the IPCC (2007). In Nepal there has been considerable expansion in the exploitation of natural resources which has resulted in increasing environmental degradation

This study found that rural communities of Nepal are rich in traditional knowledge which they have practiced since unknown past, which have protected and conserved plants, animals, water resources and other components of their life support systems while exploitation of natural resources took place in the areas where such knowledge and community management are ignored. Traditional knowledge is also found to be scientifically based and has helped to address climate change-related issues like soil degradation, soil fertility, genetic erosion, soil respiration, loss of soil moisture, land erosion, landslides, carbon assimilation, watershed degradation, drying of water bodies, decrease in water level and land productivity. Traditional forest management practice has also helped in protecting and restoring forests and sequestering million of tons of carbon each year which helps to address greenhouse gas problems. Conflict related to benefit distribution is one of the serious threats to forests in Nepal which could be addressed by using knowledge from traditional practices which is efficient in equity distribution. Recognition of traditional knowledge in policy and expansion of its practices in areas experiencing climate change induced problems could help to address both ecological and economic challenges.

Key words: traditional knowledge, forest management, climate change, adaptation, community forestry, Nepal.

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ID-035

MEDITERRANEAN FOREST UNDER CLIMATE CHANGE SCENARIOS: THE RESPONSE TO INCREASE OF DROUGHT

F. Ripullone[1], M. Borghetti[1], S. Raddi[2] and F. Magnani[3]

In Mediterranean-type climates, forest ecosystems are typically subjected to high temperature and scarce soil water availability during most of the summer. Moreover, due to the impact of climate change, more extreme drought periods are expected for the next decades as a consequence of reduced precipitation up to 15-20%. A better understanding of functional and structural changes in response to increased drought is crucial to provide information about the capacity of Mediterranean forests to acclimation to reduce the vulnerability under the new climatic scenarios.

In this study, the precipitation regime was altered in replicate plots of an Arbutus unedo L. forest (Rome, Italy) over two consecutive years in order to simulate two scenarios: (i) a partial rain exclusion (-20%), i.e. water depletion (D), was induced in D plots by a system of rain gutters suspended above forest floor; and (ii) a sprinkler net was designed to supply water, i.e. watered (W), in W plots in order to keep the soil water content (SWC) during the summer above 10% threshold that represented well-watered conditions.

Significant acclimation was observed as a result of the increase in hydraulic resistance in the soil-plant continuum, which persisted even after the return to full water availability during fall and winter. The down-regulation of photosynthesis and the summer accumulation of photo-protective pigments prevented the onset of any run-away damage and reduced the forest vulnerability. Further, the imposed drought-induced slight or no changes in water-use efficiency, as a result of the parallel increase in stomatal and non-stomatal limitations. This behaviour prevented the forest maintaining a positive carbon balance under dry conditions - a negative feature under climate change scenarios which may further reduce the growth and productivity.

Key words: acclimation, drought, Mediterranean forests, growth, stomatal conductance, water-use efficiency.

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ID-237

ADAPTATION TO CLIMATE CHANGE IN FOREST ECOSYSTEMS AFFECTED BY THE POOR

Carmenza Robledo[1], Jürgen Blaser[2], Nicole Clot[3] and Anne Hammill[4]

In developing countries, forests play an important role in supplying goods and services to the poor. These forests are under many stresses due to unsustainable management practices, lack of clarity on tenure and access rights, and permanent pressure for land-use change. Climate change increases the stress of both forest ecosystems and forest-dependent people. What is the response under extreme climate events? What is the role of forest ecosystems in increasing the resilience of poor communities? What coping strategies are sustainable and how can they be promoted? Over a two-year period, an interdisciplinary team addressed these questions in a systematic manner using the Community-based Risk Screening Tool for Adaptation and Livelihoods (CRiSTAL) in Mali, Tanzania, Bangladesh, Sri Lanka and Nicaragua.

The research shows strong linkages between forests and other livelihood assets with special regard to governance of natural resources. Different types of communities were included in the research as pastoralists, agriculturalists or forest users. In all cases, forest ecosystems delivered food and shelter during extreme events (droughts and floods) becoming key assets for reducing vulnerability. Additionally in some of the villages covered by the research, the local community used forest products (e.g. charcoal) for getting complementary income during these periods. However, lack of clarity of land tenure as well as legislation forbidding forest use strengthened underlying conflicts and therefore increased the overall vulnerability of poor people.

This presentation analyzes the corresponding challenges for policy makers when designing adaptation policies in the forest sector under the main goal of addressing sustainable development.

Key words: sustainable forest management, livelihood, poor, coping strategies, land tenure, use rights, vulnerability, extreme events.

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ID-327

A BATTLEFIELD FOR FORESTS: AN ACTOR-ORIENTED ANALYSIS FOR STUDYING LOCAL INSTITUTIONS AND THE DEPLOYMENT OF ECOSYSTEM SERVICES IN CENTRAL ARGENTINA

P. Rodríguez-Bilella[1]

This paper introduces an investigation carried out with rural communities in Córdoba (central Argentina), which historically had their livelihoods closely linked with forestry activities. Nowadays, the dry forests of the area are disappearing, both because of the extractive activities of the local population as well as for the expansion of the agriculture frontier. The national government has set a very restrictive legislation in order to protect dry forests, and this has led to a plurality of conflicts within different categories of actors.

The interdisciplinary research made use of an actor-oriented approach in order to explore how different social actors define, in a framework of persisting inequities and poverty, the environmental problems at stake, as well as the solutions for them. The research understood that climate change and processes, such as high deforestation rates, can affect the provision of ecosystem services from forests and, hence, hinder sustainable development. Attention was paid to the multiple and conflictive perceptions and social representations different social actors have of the ecosystem services offered by the dry forests. The investigation highlights the key role of a proper understanding of different kinds of information, values, and perspectives into decision–making in the framework of climate change. The significant role of local institutions in the management and use of the forest's ecosystem services as commons has been changed by migration and excessive state intervention. Both collective action and secure property rights are needed to sustainably manage natural resource systems such as forests. The incorporation of an actor-oriented approach was a theoretical and practical alternative in order to strengthen the study of the relationship between ecosystem services, climate change, local institutions and poverty reduction at the community and regional levels.

Key words: ecosystem services, institutions, livelihoods, policies, poverty.

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ID-300

ITALIAN FORESTRY MEASURES INTRODUCED THROUGH THE NEW CHALLENGES OF THE EUROPEAN SILVICULTURE

Raoul Romano and Stefano Cilli[1]

The European Regulation for Rural Development (CE n.1698/05) gives a new role to the forest sector concerning the implementation of rural development policies. Forestry becomes an important instrument for integration with other components of development. The European Forest Strategy and Forest Action Plan Principles have been introduced to the EU Strategic Guidelines. The multifunctional value of the forests and its fundamental role in fighting the climate change are definitely considered as a concrete opportunity to reinvigorate the sector, especially in rural and mountain areas.

The purpose of this study is to verify the impact resulting from the forest measures provided for the Rural Development Policy (2007-2013) on territory, on the specific productive sector and on the commitments Italy made according the Kyoto Protocol.

Key words: Italy rural development, forestry measures, forest management, indicators, global change.

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ID-330

COMMUNITY-BASED ACTIVITIES IN DISASTER-PRONE UPLAND AREAS AS A MEANS OF ADAPTING TO A CHANGING CLIMATE IN THE PHILIPPINE COUNTRYSIDE

P.A.J.Sanchez[1], R.D. Lasco[2] and M.V.O.Espaldon[3]

This is a case study of the community-based activities that serve as adaptation strategies for disaster-prone areas in the country. There are frequent natural disasters in the Philippines such as floods, droughts, and typhoons all year round. Recently, these disasters have either increased in number or in intensity. For the most part, the poorest of the poor in the Philippines are those who live in upland areas (both forested and non-forested areas) in the country. They are most vulnerable to changes in climate despite the fact that they are the least responsible to these changes.

This paper is a collection of local activities (however simple) that are being conducted by the different institutions, local government, national government, non-governmental organizations, international organizations, and concerned groups that have proven quite useful to local communities through multi-stakeholder participation in activities such as innovative early warning systems, structural modifications, livelihood changes, implementation of century old practices, modifications in crop schedules and the like. It is interesting to see how the poor people in our countryside are able to successfully adapt to a changing climate given very limited financial resources.

Key words: community-based adaptation strategies, ecosystem management, multi-stakeholder participation.

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ID-148

FLOWERING CALENDAR OF A PROTECTED FOREST:
A CASE STUDY OF ARABUKO SOKOKE FOREST, KENYA

Susan Sande[1,2], Sue Nicolson[2] and Ian Gordon[1]

Bees, with their specific requirements for nutrition and nesting, are good indicators of landscape structure and overall biodiversity of a forest, provided the ecological and seasonal patterns they show are taken into consideration. They are also a sensitive group to climate change. Meaningful ecological studies on the foraging behaviour of honeybees require sampling protocols that take into consideration temporal fluctuations in abundance and flowering composition which are, in turn, determined by climate. Arabuko Sokoke Forest is the largest remaining protected fragment of a forest mosaic that once stretched from southern Somalia to northern Mozambique. It is the second most important forest for threatened bird conservation on mainland Africa, home to six globally threatened bird species and an additional five bird species that are coastal endemics, three rare near-endemic mammals, unique amphibians and several other plant and animal species that need to be conserved.

We aim to introduce beekeeping to halt tree felling for economic gains. A flowering calendar, which is a record of periods of flowering by bee-foraged species, is an initial step in this process. Indeed this is the first flowering calendar for a protected forest. A record of blossoming plants (observed, reported or suspected to be foraged) was made every two weeks from May 2006 to December 2007. Over 70 plant species belonging to 16 orders flowered during this period. Seventy percent of these flowered for 1-2 months and 28% for over two months. Six plant species flowered throughout the sampling period. A plant with a flowering period of more than one month is considered important for apiculture. All except one the foraged by bees were flowering for >1 month thus important for apiculture. This calendar has yielded knowledge of honey flow and dearth periods, an aid to proper management and encouragement to the locals to conserve this forest.

Key words: beekeeping, forest conservation, flowering calendar, climate change.

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ID-312

ESTIMATE OF FOREST DAMAGE USING THE "POTENTIAL LEVEL OF FOREST DESTRUCTION BY FIRE" METHODOLOGY

C.M. Sant'Anna[1] and D.O. Pedroso[2]

One of the potential consequences of climate change over many parts of the world, including Brazil, is an increase in forest fires, with consequences both in terms of forest dynamics, but also in terms of carbon storage and feedback to the atmospheric system. The development of tools for the quantification of forest damage by fire is therefore quite important. This study had as main objective to estimate the forest damage using the Potential Level of Forest Destruction by Fire (L_d) methodology in a mixed forest area composed by *Eucalyptus*, *Pinus* and native broadleaves in Minas Gerais, Southeast of Brazil.

The methodology to estimate forest damage caused by fire uses five factors: a) forest age, b) forest type, c) slope and aspect, d) people and vehicles access and e) available fire fighting resources. Each item determines part of the risk of damage. The risk values are attributed by the following criteria: a) 0.10 (low risk), b) 0.50 (medium risk) and c) 0.90 (high risk). The five values are multiplied by 100,000 and the values can vary in a range from 1 (minimum risk) to 59,049 (maximum risk). We have applied this methodology to a study area where we estimated the potential level of forest destruction by fire to be of 2,025, that means that the forest should have medium damages caused by fire. After the first wild fire event in the studied area, the following damages were measured: the carbonized height in Eucalyptus and Pinus was 8.0 meters and in the native forest was 2.0 m. Although the shrub mortality had been of almost 100%, the tree mortality was very low. These data are an indication that the Potential Level of Forest Destruction by Fire methodology could be a reliable tool to get an estimate of forest damages caused by fire. Further work may permit to link such estimates with climate scenarios and adaptation of forest management to minimize loss both in wood volume and carbon.

Key words: destruction level, forest damage, forest fire.

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ID-177

IMPACTS OF CLIMATE CHANGE ON LANDSLIDES AND USING VEGETATION AS AN ADAPTATION OPTION TO REDUCE THE LANDSLIDE RISK

Heru Santoso[1], Kurniatun Hairiah[2], Adrin Tohari[3], Gatot M.Soedradjat[4] and Hety Herawati[1]

Every year, landslides occur in Indonesia and cause damage to infrastructures, economic lost, and even lost of lives. Despite many efforts to stop the occurrences of landslides and to reduce the lost, landslides continuously threaten the steep hill-sides. The severity of disasters from landslides is expected to increase due to climate change, in particular the increase of climate variability.

The first national dialogue on landslides and climate change held in Bogor, Indonesia December 2006, identified the links between rainfall patterns and the occurrence of landslides and the role that vegetation plays in this interaction. However, there are still many gaps of knowledge that need to be adequately addressed before adaptation options can be identified. These include: to what extent climate change will further increase the susceptibility and severity of landslides; will climate change cause an expansion or shifting of the area in risk to landslides; and can vegetation be used as an adaptation option? This paper is an attempt to answer these questions based on findings from recent investigations on the link between climate change an landslides, and the role of trees in anchoring soils and reducing landslide risk in Bukit Sentul Area, District of Bogor, Indonesia. It shows that climate change may alter the susceptibility of landslide occurrence up to a certain limit, but with little change on their spatial distribution. Trees that have high Index of Root Anchoring (IRA) and high Index of Root Binding (IRB) tend to increase the stability, but weight aboveground tree biomass could increase susceptibility to landslides. It appears that a mix of tree species with deep roots and ground cover species with intense and strong fine roots will provide the highest slope stability in the area. This suggests that tree species selection could be an option of adaptation that reduces the landslide risk potentially exacerbated by climate change. We also argue that disaster prevention and hazard mitigation options should be developed from within the community.

Key words: climate change, landslides, vegetation role

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ID-109

MITIGATION AND ADAPTATION POTENTIAL OF AGROFORESTRY: ADAPTATION IMPLICATIONS AND POLICY OPTIONS FOR MEETING CHALLENGES OF SUSTAINABLE LIVELIHOODS AND ENVIRONMENTAL SUSTAINABILITY

Vivek Saxena[1]

Climate Change and Global warming continue to be among the most pressing public concerns around the world. Adaptation by rural people to the effects of climate change, and the importance of linking carbon credits more aggressively with smallholder agroforestry are the issues to be addressed in all policy options. Small-scale forestry has emerged as potential adaptation as well as mitigation strategy to meet the challenges of climate change. Adoption of small-scale forestry also offers protection to natural forests as the fast growing demand for wood products is met from on farm wood production. Such land-use systems help sequester carbon as well as in conservation of naturally rich carbon sinks. The CDM, A&R projects also promote community involvement and small–scale forestry is seen as a means of encouraging small landholders and cultivators in developing countries to adopt small-scale forestry. Small-scale forestry is also a potential effective option for adaptation for sustaining and improving livelihoods of farmers due to decreasing agricultural output as a consequence of climate change. Policy makers have to recognize the huge potential of small-scale forestry in carbon markets and improving rural livelihoods by incorporating useful tress in their farms.

The paper analyses the role of small-scale forestry models for mitigation and adaptation options and identification of key barriers in adoption of various models. Successful models from Yamunanagar district of Haryana State of India have been highlighted. The success of small-scale forestry has led to evolution of markets of more than US$210 million in Yamunanagar district of Haryana, India. The Kyoto Protocol, CDM, Carbon trading, etc. offer new challenges and opportunities for recognition and reward for environmental services. Policy options for promotion of small-scale forestry as mitigation cum adaptation strategy have been suggested.

Key words: small-scale forestry, climate change, agroforestry.

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ID-135

FOREST HEALTH AND ADAPTATION OF FOREST MANAGEMENT: PERSPECTIVES FROM THE IPCC'S FOURTH ASSESSMENT REPORT (AR4)

Dieter Schoene[1]

"Warming of the climate system is unequivocal". With high agreement "global GHG emissions will continue to grow over the next few decades", and will "cause further warming and induce many changes in the global climate system". Among the "systems likely to be especially affected are such ecosystems as the tundra, boreal forests, Mediterranean type ecosystems, tropical rainforests and coastal mangroves." Many of today's forests and most newly established stands will experience climatic conditions that may deviate drastically from those of today.

Forest ecosystems have evolved over millennia under certain site conditions. As manifest in practical site mapping, they react quite sensitively to even minute changes in their environment. Therefore, forests cannot be expected to remain as they are, and many will be at risk. Currently, they provide vital services for the existence of many human societies and for the functioning of the biosphere. Regarding climate change, "forests can make a very significant contribution to a low-cost global mitigation portfolio that provides synergies with adaptation and sustainable development". However, this contribution will be voided if forests succumb to fire, insects, disease, wind, snow, ice, floods, tropical storms or drought. Therefore, forests themselves need adaptation. And, as many forestry decisions remain essentially irreversible for decades or even centuries, adaptation should begin soon.

AR4 validates increasingly comprehensive climate models not only by observation of climate parameters, but also by observed impacts of climate changes on ecosystems, such as effects on health and vitality of forests. It describes a plethora of continuous changes affecting forests, e.g. the altered productivity of many tree species, and also spectacular impacts, such as the mountain pine beetle outbreak in North America. Overall, an image of forestry entering a new era emerges. However, AR4 does not offer a holistic, state-of-the-art approach for adapting managed and unmanaged forests to climate change. In spite of their vital roles, forests remain the step-children of current adaptation efforts. The presentation seeks to complement AR4 in this respect, by pointing out traditional and novel forest management tools for decisions under uncertainty and adaptive forest management under climate change.

Key words: Kyoto Protocol, mitigation, sustainable development, adaptive forest management.

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ID-374

SUSTAINABLE FOREST MANAGEMENT UNDER CLIMATE CHANGE: ADAPTATION STRATEGIES BASED ON A COMPREHENSIVE VULNERABILITY ASSESSMENT

R. Seidl, W. Rammer and M.J. Lexer[1]

Climate change is rapidly modifying the environment of forest ecosystems and confronts forest management with considerable challenges. A particular hotspot is the European Alps, where warming has been proceeding with twofold magnitude of the global trend over the last decades. Moreover, increasing pressures from multiple societal demands add to complexity in forest management decision making. Thus the development of adaptive Sustainable Forest Management (SFM) strategies is strongly needed considering the lead times of silvicultural measures.

The aim of the study was to assess the vulnerability of approx. 440,000 ha mountain forests under the stewardship of the Austrian Federal Forests and to propose feasible adaptive management strategies for highly vulnerable forest types. To that end, we integrated state-of-the-art climate impact assessment tools and methodologies, addressed multiple forest goods and services and engaged in a stakeholder process to develop robust SFM strategies.

The principal tool in studying climate and management effects on forest dynamics was the ecosystem model PICUS v1.4. The hybrid model combines elements of a 3D gap model with a generalised process model and employs detailed sub-modules of forest soil dynamics, bark beetle disturbance and management interventions in an integrated model environment. Besides a de-trended climate baseline (1961-1990), three climate change scenarios were investigated to account for uncertainties in climate development until 2100. Model simulations provided data to a framework of vulnerability indicators covering both ecological and socio-economic aspects of SFM. The preferences of involved stakeholders were an essential component in assessing vulnerability as well as in the development of adaptive management measures. Selected adaptation strategies were virtually implemented in the simulation framework. Residual vulnerability under each of the analysed alternatives served as selection and evaluation criterion, i.e. to prioritise adaptation needs and assess potentials of alternative strategies. Based on this comprehensive assessment and decision making framework promising adaptation strategies are proposed and residual climate change impacts are quantified.

Key words*:* adaptive management, climatic change, mountain forests, vulnerability assessment.

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ID-062

EXAMINATION OF TREE MORTALITY IN SEMI-ARID CENTRAL ANATOLIAN REGION OF TURKEY DURING THE LAST SIX-YEAR PERIOD (2002-2007)

A. Semerci, B.N. Sanlı, O. Sahin, O. Çelik, B. Balkız, S. Ceylan and N. Argun[1]

In this study, 33 different tree mortality cases in Central Anatolian region were examined during a six-year period (2002-2007) to determine reasons behind the mortality: (1) meteorological data of the areas, (2) soil conditions, (3) laboratory incubation of diseased samples in PDA environment, (4) description of pests causing the damage were evaluated. After classifying 33 different tree mortality cases, 46% were dead due to drought, 15% due to frost, 15% due to inappropriate soil conditions, 15% due to pests, 6% due to diseases, and 3% due to other reasons. Also, there were pests in 47% on the drought damaged areas. The most common pest species in this semi-arid region were: Bark Beatles (*Pityokteines curvidens, Cryphalus picea*), Aphid, Scale insects (*Leucaspis sp.*), *Pissodes pini, Diprion pini, Euproctis chrysorrhoea, Lymantria dispar, Kermes sp. Pissopodes notatus, Evetria buoliana, Dioryctria splendidella*.

The main reason of the tree mortalities in Konya and Yozgat was drought. Drought triggered mortalities have been observed every dry year in pine (*Pinus nigra* Arn. subsp. *pallasiana*) in Konya and fir (*Abies cilicica*) stands in Konya. Drought-induced tree mortality in Scots pine (*Pinus sylvestris*) stands in Yozgat (near the furthest southern distribution) was considered as the sign of a reduction of its natural southern distribution. In conclusion, it can be said that in Central Anatolian Region the main reason for tree mortality was drought, and drought stress reduces tree resistance against pathogens and diseases. It would be better for the Forest Service to have a good forest monitoring system to help in interpreting future tree mortality cases.

Key words: drought, pine, Anatolia, pests.

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ID-053

INCREASING KNOWLEDGE ABOUT ADAPTATION OF FORESTS TO CLIMATE CHANGE: AN EXPERT PANEL APPROACH

Risto Seppälä[1]

The world's forests and climate are closely interlinked. Climate change is already having profound effects on forests, and land-use change through deforestation is a major source of carbon emissions. So far, the discussion has mainly focused on mitigation measures; adaptation of forest to climate change has been secondary. Although available information is certainly not always sufficient to fully support proper adaptation policies and management activities, the real problem is in the inefficient use of information.

In order to fill the gap between the existing information and the use of it to help forests and forest-dependent people to adapt to climate change, an Expert Panel on Adaptation of Forests to Climate Change was established in October 2007. It is a first thematic panel in the framework of the Joint CPF (Collaborative Partnership on Forests) Initiative on Forest Science and Technology as a mechanism to provide independent scientific assessments of existing information.

It is the task of the Expert Panel to prepare a state-of-knowledge report on the impacts of climate change on forests and their goods and services, vulnerabilities of forest ecosystems and forest dependent people to these impacts, as well as adaptation to climate change in terms of management and policy measures. A special summary for policy makers will form part of the assessment report. Although the report will mainly be addressed to the forest sector, and especially the UNFF (United Nations Forum on Forests), it aims also at contributing to other forest-related processes.

All six Coordinating Lead Authors and several other members of the Panel consisting of 23 scientists and experts will attend the Umeå Forest Adaptation 2008 Conference. Therefore, the Conference and its documents can provide excellent inputs to the assessment report which is due to be completed in December 2008.

Key words: adaptation, climate change, expert panel.

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ID-381

PLANT WATER RELATION AND GROWTH RESPONSE OF *CORDIA AFRICANA* LAM. SEEDLINGS OF THREE SEED SOURCES EXPOSED TO DIFFERENT WATER REGIMES

Yigremachew Seyoum[1] and Masresha Fetene[2]

A greenhouse experiment was conducted to investigate intraspecific variation in drought tolerance of *Cordia africana* Lam. seedlings obtained from three seed sources. These seed sources were Arjo, Dembi and Melka Oda located in the southern and western parts of Ethiopia. The seedlings were well-watered, moderately stressed and severely stressed by applying 100%, 60% and 25% of field capacity, respectively. Seedling growth (biomass, leaf area, height, diameter) and water relation (leaf water potential, relative water content, stomatal conductance) parameters were recorded. Seedlings from Arjo showed the least response in leaf area under increasing water stress. Seeds from Dembi showed significantly ($P \leq 0.05$) lower stomatal conductance in severely stressed seedlings while seedlings from Melka Oda had higher leaf area in moderately stressed seedlings indicating distinct response of seed sources to moisture stress. Moreover, Melka Oda showed the highest root-to-shoot ratio and dry weight to turgid weight ratio, indicating differences in biomass allocation pattern and cell wall thickness. Leaf area, stomatal conductance dry weight to turgid weight and root-to-shoot ratios can be used for selection of drought-tolerant seed sources in *C. africana*. It is concluded that the responses of the seedlings reflect the relative dryness of their seed sources. Moreover; the result provides an indication for a possibility of choosing among *C. africana* populations to design plantations in drought prevalent and marginal sites and to enhance future plantation efforts for timber production using this valuable indigenous species.

Key words: *Cordia africana,* drought tolerance, seed sources, stress.

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ID-017

NURTURING WATER AND PROTECTING SOIL THROUGH FOREST COVER – A CASE STUDY FROM INDIA

S.K. Sharma[1]

The total forest cover of India, as per State of Forest Report, constitutes 20.64% of the geographic area of the country and plays a significant role, especially in soil and landside protection, headwater conservation and biodiversity preservation. In India, forests meet annually nearly 40% of the energy needs in the form of fuel wood. This has led to massive deforestation in the country causing soil erosion, landslides and diminishing water resources. The *Gangotri glacier,* which is one the largest in the *Himalaya,* provides around 8.6 million m^3 of water annually and supports one of India's largest river basin, the *Indo-Gangetic Basin* in downstream, has been receding rapidly after 1971 due to climate change to which deforestation is also contributing. The recent rises in the price of fossil fuels and their adverse affects on the environment have led to a renewed interest in forests, partly as an alternative source of lower cost bio-energy and partly as carbon sequestration. The latest viable solution in India is to substitute the use of greenhouse gas-emitting fossil fuels with the biofuels - fuel processed from *Jatropha* plants which can be grown in poor soil conditions, with great environmental benefits of preventing soil erosion and also revitalizing the soil. The crop is proving an excellent source for the production of bio-energy as well as afforesting the deforested regions of the country. The study on watershed preservation indicates that the forest soils with *Jatropha* cultivation have excellent ability to infiltrate rainwater (infiltration capacity – 260 mm/hr), twice as great as that of grassland (125 mm/hr) and three times that of bare land (76 mm/hr). More than a million hectares of land is under *Jatropha* cultivation in nearly a dozen states in India, otherwise severely deforested. *Jatropha* thus, assures Sustainable Water Resources, Forest Management, Agricultural Growth, Rural Development, Energy Security with overall environmental protection.

Key words: biodiversity, glacier, *Jatropha,* soil cover, water infiltration.

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ID-001

ASSESSMENT AND MANAGEMENT OF HIGH CONSERVATION VALUE FORESTS IN THE CONTEXT OF MASS FOREST MORTALITY

A.A. Shchegolev[1]

The Northern Dvina and Pinega Rivers watershed area (the Dvinsky forest) covers over 1 million hectares and is considered as the biggest intact forest in Europe. The Dvinsky forest can be classified as a high conservation value forest. Large-scale mortality of spruce forests in the area was first detected in the 1990s but according to representatives of logging companies and authorities, the process has now turned into an "ecocatastrophe."

The evaluation by the World Wide Fund for Nature (WWF) carried out in the course of research expeditions in 2006-2007 showed that percentage of dead standing wood did not exceed 30% (15-20% on average). The mortality process results in formation of varied forest structures and modified habitats of animal populations. Elk population is a very indicative example. Lately, plots have been developed in dead spruce area, providing elk with both summer and winter forage. As a result, the animals have stopped mass migrations and are staying within the forest massif all the year round.

Although more experimental work would be needed to test how to reduce spruce mortality, the measures to lower the risk of seeing an intensification of spruce mortality, especially in the forests adjacent to areas of clear cuttings, might include: (a) No forestry operations resulting in extensive forest fragmentation should take place; planning and cutting areas allotment should be carried out taking into account natural landscape borders; (b) Stable elements of forest stands should be preserved while clear cuttings, as they prevent transformation of forest environment (key biotopes and key biological elements); (c) A specially protected area in the central part of the Dvinsky forest should be established.

The status of a model forest in the Dvinsky forest could help realize the above measures. The agreement regarding the establishment of a model forest in the Dvina and Pinega watershed area has been signed in April 2008 by the Federal Forestry Agency and Administration of Arkhangelsk region.

Key words: high conservation value forests, spruce mortality, biodiversity.

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ID-283

ALTERNATIVES FOR DEFORESTATION REDUCTION IN THE LEGAL AMAZONIAN

Montandon Erika Shiota[1] and André Felipe Simões[2]

The most relevant Brazilian contribution to the climate change, global warming being the main aspect, comes from the high levels of deforestation and burning in the Amazonian area. In the last decades, it has been one of the specialists' largest concerns in environment. The relationship of deforestation with global warming starts from the liberation of carbon gas to the atmosphere, at the moment of the cut or burning of the forest. In function of uncontrollable increases of deforestation taxes and burning in the Amazonian area during last years, mainly man-made action, the emission of green house gases increased considerably.

In such a context, the reflections appear returned for the actions in the sense of analyzing the main focuses of the deforestation, the reasons for which it happened and still continues to be practiced, what is being made so that it is contained, and the main alternatives for the reduction of the taxes to acceptable levels.

To present the concepts of sustained development, ecological-economical zoning, plan of sustainable forest handling in order to highlight the practices that defend the preservation of the environment without its destruction, compose the objectives of the present work. Bio-regionalism, *permaculture*, eco-villages and agri-forests will be approached as "experimental ways" that has been offering interesting results, in the context of the fundamental search of the harmony between development and preservation of the environment. To analyze the structural and the conjectural aspects related to the deforestation of the Legal Amazonian, some case studies (focused in the states of the North region of Brazil, and based on interviews realized with local population) are presented and discussed.

Key words: deforestation, preservation of the environment, Brazil.

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ID-216

OCCURRENCE AND EFFECTS OF TWO MICROMYCETES IN A RELICT EUROPEAN BEECH FOREST IN SOUTHERN ITALY

G. Sicoli, G. Bruno, E. Boncaldo and N. Luisi[1]

In southern Italy, on a slope in proximity of the ridge of the Bradano river, at 850-900 m asl, lies a forest (about 5 ha) where European beech (*Fagus sylvatica* L.), mixed with European hornbeam (*Carpinus betulus* L.), seems to be a relict species. This association represents a singular peculiarity in the landscape of beech forests in the southern Apennines. Some of the beech trees manifest symptoms of dieback: crown transparency and branch withering on old trees, and cankers and brown wood-streaking on the stem of dead and declining saplings. To detect and characterize the most frequent fungi inhabiting these plant tissues, approximately 100 isolations were carried out from stems of five beech saplings randomly selected in a 20 x 20 m-sized plot. The thermo-pluviometric data recorded between 1921 and 2001 in Forenza, the closest station to the forest, were collected and processed for climatic analysis according to well-known indices, such as De Martonne's and Emberger's. More than 50% of isolations yielded *Biscogniauxia nummularia* (Bull.: Fr.) O. Kuntze and a *Phaeoacremonium*-like fungus, as possible weak agents of bark necrosis in beech trees living in unfavourable conditions. Their fastest growth was obtained *in vitro* at temperature ranges between 20-30°C and 20-25°C, respectively. Climatic analysis recorded 13.1°C and 693 mm as mean annual values of temperature and rainfall, respectively, and 30.0 and 62.2 as the two above-mentioned indices, respectively.

These results suggest that, in this forest that is climatically close to the tolerance limit for beech survival, beech tissues are colonized by largely thermophilic micromycetes. The risk of this species for becoming extirpated from this area is therefore substantial. Although apparently negligible in terms of surface area covered, this perspective could be deleterious in the panorama of southern Italian forests.

Key words: *Fagus sylvatica,* forest dieback, pathogenic fungi, thermo-pluviometric analysis.

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ID-239

CLIMATE CHANGE AND *ARAUCARIA ANGUSTIFOLIA* BERT O. KTZE CONSERVATION STRATEGY

Marcos Silveira Wrege[1], Rosana Clara Victoria Higa [1], Ricardo Miranda Britez[2], Valderês Aparecida de Sousa [1], Paulo Henrique Caramori[3], Hugo José Braga[4] and Bernadete Radin[5]

Araucaria angustifolia, known as Parana pine, sets the boundary of the Ombrophylous Mixed Forest. Natural occurrence is above 500 m on the Brazilian Southern tableland and it has been related to climatic fluctuation during the Quaternary. The species was intensively exploited for timber use and due to the expansion of the area for agricultural use. The bioma conservation status is considered critical and only a restricted area is left on an advanced successional stage. The majority of the remaining area is under considerable pressure because it is located on the most populated areas. Besides human pressure, the species is also threatened by recent global climate change. It is a threat to some protected sites that can be decimated in a nearby future. The aim of this work is to point out areas threatened by climate change to support araucaria conservation programs.

Using 30 years climatic series with multiple linear regression maps were drawn with 1°C, 2°C and 3°C temperature increased over the natural distribution map. Latitude, longitude and elevation were use as independent variables to establish temperature suitable zones. These are preliminary results and show a significant decrease on what is nowadays favorable for the species development. With an increase of 3°C in temperature, the favourable area will be confined to a small part of the highest part of Southern Tableland. More climate variables will be used to improve maps future limits and to give priority for germplasm collection and conservation.

Key words: Atlantic rain forest, climate change, conservation.

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ID-061

MONITORING THE MASTING BEHAVIOUR OF BEECH (*FAGUS SYLVATICA*) IN FLANDERS (BELGIUM)

G. Sioen, P. Roskams, P. Verschelde, B. Van der Aa and A. Verstraeten[1]

In the Northern part of Belgium, the crown condition survey is carried out on 72 plots in a 4 x 4 km grid (Level I) and in eleven Level II plots. Beech is present in 17 plots of the Level I grid and five of the Level II plots. The 196 trees in Level I are older than 60 years. In some plots, like the Forest of Zoniën (Soignes) near Brussels, trees are older than 150 years.

Since 2004, seed production is assessed in these plots using four classes: no seed production, light (only visible with binoculars), moderate (visible without binoculars) and high seed production (whole crown with seeds). Seed production in beech was extremely high in 2004. Moderate to high production was noticed on 44.6% of the trees in Level I; this was only 5.1%, 11.7% and 12.7% in 2005, 2006 and 2007, respectively.

In some of the Level II plots, fruits and seeds are collected in litter traps. In 2004 the seed production in the Forest of Zoniën was the highest since the beginning of the monitoring (in 1999): 4,362 kg/ha.

Climatic factors, like high summer temperature, could influence the masting behaviour in beech. Probably the warm and dry summer of 2003 played an important role in the high seed production. During the period 1989-2004, mean July temperature was most of the time higher than normal the year before a mast year. In this period, a clear correlation between precipitation and the occurrence of masting could not be found.

In the past mast years were observed less frequently compared to the last decade. Climate change may have been responsible for the higher frequency of high seed production in beech.

Key words: *Fagus sylvatica*, masting, summer temperature.

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ID-031

CHLOROPLAST DNA (cpDNA) VARIATION OF *SHOREA LEPROSULA* IN INDONESIA ASSESSED BY PCR-RFLP

I.Z. Siregar, R.S. Resmisari and U.J. Siregar[1]

Due to its fast growing ability, *Shorea leprosula* (Dipterocarpaceae) is highly recommended for rehabilitation of degraded dipterocarp forests in Indonesia. In degraded forests, the environmental condition has changed substantially affecting genetic variation stored in the plantation population and its dynamic. In addition, future adaptive abilities, i.e. genetic responses of selected seed sources for plantation, are also challenged in the era of global climate change. Initial attempts to reveal spatial patterns of genetic variation in *S.leprosula,* based on different genetic marker types are important to be carried out for sound utilization and management of existing genetic resources. A preliminary investigation was carried out using PCR-RFLP method with aim to determine cpDNA variation in *S. leprosula* sampled from nine populations in Indonesia. Leaf samples from five individuals per population were collected and then subjected to standard procedure of cpDNA analysis. In this study, cpDNA polymorphisms were tested using combination of 4 primers and 10 enzyme restrictions.

Results showed that low variation among cpDNA haplotypes in *S. leprosula* has been detected in the *rbcL* gene digested with *Alu*I where two haplotypes were identified and distributed within and among populations. Only three out of 13 populations of *S. leprosula*, namely Population Asialog and Bukit Tiga Puluh in Sumatra and Population ITCI in Borneo, showed cpDNA variation, although the values are low (H_T=4.8%; H_S=2.5%). The lack of or low haplotype variation among populations rules out the use of the developed marker as a tool to prove the geographical origin of *S. leprosula* which is important in the management of planting stocks for future plantation adaptation. The results also suggests that the geographical delineation of seed sources for conservation purposes still requires further genetic information as revealed by other more variable marker types.

Key words: cpDNA, genetic variation, enzyme restriction, populations, dipterocarpaceae.

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ID-298

HOW TO PROTECT FORESTS AGAINST AGGRESSIVE BIOTIC FACTORS UNDER CHANGING CLIMATE SCENARIOS?

M. Skorupski[1] and W. Magowski[2]

The first results of the changes in widespread of *Ips typographus* caused by climate change can be observed already in the example of Norway spruce (*Picea abies*) forests in southern range of the species in lowlands and in several mountain regions in Europe. Due to a little higher average temperature, this insect can have up to two life cycles during one year. So the dynamics of possible outbreak is much more dangerous, and thousands hectares of already dead spruce forest are enough warning to find a solution for the problem.

The first observations of interactions bark beetles – mites were made at the beginning of the 20th century. The research on organisms associated with forest insect pests started in the second part of the century. There were many ideas of potential role of different group of organisms like insects, predatory mites and entomopathogenic fungi. For example, in balanced forest ecosystem, most of bark beetles bring with them predatory mites which help to keep population of the insect on a balanced level. Higher average temperature creates better conditions for the pest and when separate specimens set free from the predator, it makes possible an outbreak. The biological and chemical methods of fighting the insect are not yet enough to protect spruce forests and year by year the problem is increasing. Research undertaken during last years has shown a lot of new directions with testing different biotic factors against this forest pest. Very interesting investigations of parasitoid mites and predatory mites (i.e. *Aetiophenax* spp., *Dendrolaelaps* spp., *Ellatoma* spp., *Iponemus* spp., *Pyemotes* spp., *Tarsonemus* spp.) of bark beetles could be a very important component of increasing this sector of forest protection. The need to develop research on complex biological enemies (fungi, nematodes, mites and other insects) of forest insect pests to create more sustainable forests is very important.

Key words: aggressive biotic factors, climate change, forest protection.

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ID-311

IMPACT OF LAND-USE AND CLIMATIC CHANGES ON PULPWOOD PRODUCTION AND CARBON SEQUESTRATION SUSTAINABILITY AT THE LANDSCAPE LEVEL

P. Soares, M. Tomé, P. Borges, S. Marques and J.G. Borges[1]

The expansion of *Eucalyptus globulus* Labill. in Portugal occurred in the second half of the 20th century, as a consequence of the implementation and development of the pulpwood industry in the country. Nowadays, *E. globulus* plantations cover 672,149 ha of continental Portugal, representing 21% of the forest area. The Decision Support System (DSS) GlobLand was developed to analyze the impact of land-use and climatic changes on pulpwood production and carbon sequestration in the living tree sustainability at the landscape level. Forest growth is simulated with the GLOB-3PG model, a model that links the 3PG model - a simple process-based model parameterized for Portuguese eucalyptus plantations - and the GLOBULUS model - an empirical growth and yield stand model. The DSS encompasses the simulation of stand-specific management alternatives as well as the evaluation of total wood production and the correspondent net present value (NPV) for each combination of prescriptions. An optimized solution is proposed where the goal function is the maximum NPV of pulpwood production given some constraints.

The developed software is used to show results obtained in one area dominantly occupied by eucalyptus plantations in the centre of Portugal. The system allows for the simulation of different management options as well as different climate change scenarios.

Key words: *Eucalyptus globulus* plantations, GlobLand, GLOBULUS, Portugal.

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ID-334

ADAPTATION OF FOREST MANAGEMENT IN BRANDENBURG: CHALLENGES IN A CLIMATE CHANGE 'HOTSPOT' OF GERMANY

P. Spathelf[1] and A. Bolte[2]

Rich in water bodies but arid, the Federal State of Brandenburg is considered one of the most vulnerable regions related to climate change in Germany. Mean annual precipitation varies between 540 and 610 mm. Climate change scenarios, with a forecast increase in mean temperatures and drought periods in summer, underline the special need for adaptation strategies to secure future multiple-use forestry in north-eastern Germany.

We will present an adaptation strategy for the forests of Brandenburg which are mainly dominated by pure, even-aged pine forests. The strategy was recently presented to the state forest authorities and consists of a variety of measures that will be evaluated for adapting land use management to climate change. Adaptation measures involve complex decision processes among stakeholders and have a regional reference with regional networks for knowledge transfer. Ideally, they incorporate planning and action options to cope pro-actively with current and new risks for forest management.

The core of the adaptation concept is to develop resilient mixed forest stands taking into account: (i) forest transformation from pure even-aged pine stands to highly structured uneven-aged stands with high stability; (ii) measures in tree species selection and forest tending to improve the hydrological situation of forest sites; (iii) the enhancement of forest development types by integration of more robust, drought-tolerant tree species and provenances; (iv) the application of a variety of felling and regeneration systems for risk minimization and maintaining silvicultural options; (v) long-term natural regeneration with many seed trees in order to increase genetic variability and thus adaptability.

The proposed adaptive measures in forestry will contribute to an integrative land-use concept that includes risk analyses and priority planning, following concepts either of stabilizing actual forest structures or of transforming such forests by using active adaptation measures.

Key words: adaptation measures, Brandenburg, climate change, forest management, resilience.

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ID-265

LOCAL COMMUNITY'S PERCEPTION ABOUT *LANTANA CAMARA* WIDE SPREAD IN UGANDA WOODLAND FORESTS

Peter Ssetenda[1]

In Uganda, *Lantana camara* continues to spread in woodlands, especially grazing and farming areas. *Lantana camara* is regarded as an invasive species and no one seems to know its actual origin. There is hardly any vegetation where it grows and the soil under the canopy is bare and often dry. With this knowledge the researcher carried out a study of local people's perceptions about the wide spread distribution of the species compared with native species. A Pest Risk Analysis (PRA) carried out by the Centre for Integrated Development on local communities identified *Lantana camara* as the most serious problem affecting forest vegetation. The researcher tackled people's attitudes about the species, its behavior in relation to other native vegetation and its persistence in the dry season. Data collection methods included a questionnaire with open and close ended questions capturing qualitative and quantitative, observations on growth habits in relation to vegetation and physical soil features under the canopy. Random sampling was used to choose 100 households for the study. The Statistical Package for the Social Sciences (SPSS) was used to analyze data. It was found that 96% of the households surveyed have negative attitudes about the species as they do not know its origin. *Lantana camera* also changes soils so that only cereals are able to grow, and it dominates native fodder vegetation. It is also never affected by dry season and it is hard to avoid its spread. It was concluded that *Lantana camara* is an invasive species since it survives the dry season, dominates other vegetation and it creates dry and bare soils under the canopy.

One major recommendation to overcome this plant locally was planting trees that could overtop it. The spread of invasives like *Lantana camara* is part of global changes that incorporate climate changes and other impacts that we have on our environment. The spread of invasives complicates the adaptation of management practices to climate change.

Key words: invasive species, *Lantana camara,* perception.

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ID-058

SWEDISH FORESTS – HISTORICAL DEVELOPMENT AND PLAUSIBLE SCENARIOS FOR THE NEXT CENTURY

Göran Ståhl[1]

In Sweden, detailed information about forests at a national scale is available from the 1920s onwards. At this time, national forest inventories were initiated and they have been conducted repeatedly since then. In terms of growing stock, the development of Swedish forests has been positive. With the exception of only a few single years, the growth has always been higher than the harvests, and thus the growing stock has increased steadily over time. This has mainly been due to more intensive management practices. Studying the composition of forests, there has been a shift towards younger forests and shorter rotation periods. Overall, this development has implied a major build-up of carbon in forest biomass.

Forest scenario analyses are frequently conducted in order to assess plausible future development given different forest policy. Currently the scenario analysis system Hugin, which is closely linked to national forest inventory data, is applied for this purpose. The latest scenarios indicate that both the growing stock and the harvesting levels may continue to increase from the current levels, provided that current forest management practices are maintained. It is also foreseen that increased temperatures due to climate change will lead to increased growth. In addition, forest policy adaptations towards increased-growth management are currently being discussed in Sweden. Thus, it is likely that the trend with increasing levels of growing stock, and thus carbon stock, will continue for several decades.

Key words: national forest inventory, growing stock, carbon stock.

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ID-371

RESTORATION FOR THE FUTURE: THE CHALLENGE FROM GLOBAL CHANGE

J. A. Stanturf[1], Palle Madsen[2], Magnus Löf[3] and Yongqiang Liu[1]

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 (or reality) of global change, however, suggests that backwards is the wrong way to look and silviculturists should look forward to future climate conditions and construct resilient ecosystems. Anticipating future conditions, however, is more complex than simulating increases in temperatures and decreases in precipitation. Managers need strategic but adaptive approaches. Global ecosystems have been altered by anthropogenic activity to an extent unprecedented in the historic record. Land cover changes, such as deforestation and wetland conversion, river channelization and damming, soil erosion, are just some of the overt drivers of change leading to loss or diminishment of species, ecosystem function, and quality of life. Land cover change and associated activity such as biomass burning, along with industrial emissions, are thought to impact the global climate perhaps irreversibly. Global change is comprised of the effects of past human 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 habitat or change competitive relations. Changed conditions will cause effects at variable rates and over a range of scales, complicating strategies for responding. Restoration strategies may focus on resistance, resilience, or to facilitate adaptation for further change. Emphasizing function, rather than past composition or structure, restoration for future conditions will result in novel ecosystems as well as translocating high-value current plant communities in novel locations.

Key words: assisted migration, facilitated adaptation, novel ecosystems.

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ID-288

EXPANDED SILVICULTURAL APPROACHES TO SUSTAINABLE BIOENERGY PLANTATIONS TO MITIGATE CLIMATE CHANGE

J.A. Stanturf[1], B.J. Stokes[2], M.A. Buford[2] and J.H. Perdue[3]

Energy produced from biomass sources is a way to mitigate greenhouse gas emissions; they are carbon neutral. Recently, biofuels produced from crops as ethanol have been criticized as "deforestation diesel." Whether the source is maize and soybeans from the American Midwest, sugar cane and soybeans from the Brazilian Amazon, or oil palm from Southeast Asia, the "greenness" of biofuels is questioned as to their energy efficiency and carbon neutrality, or their effects on food security and biodiversity. Worldwide, almost 50% of the timber harvested is used for fuel, accounting for over 11% of yearly fuel consumption. The future demand for bioenergy may be ten times as large as current use.

Our thesis is that bioenergy produced from wood energy plantations could add substantially to the energy security and be produced sustainably, with minimal adverse environmental effects. A recent USDA/DOE 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 crops, a combination of grasses, trees, and other crops. This would add an additional 2.4 to 5.8 quadrillion British Thermal Units (BTU) of renewable energy (compared to the 2.9 quads from biomass in 2003, which accounted for almost 3% of total energy consumption in the United States). Much of this production could come from the South and be in the form of pine, hardwood, or mixed species. The potential of growing wood for energy in the southern United States is large and can be expanded by considering new approaches, including growing dense stands and thinning heavily, interplanting hardwoods with nitrogen-fixing legumes, fast-growing *Populus*, *Pinus*, *Salix*, or *Eucalyptus*, coppice, genetic modification, and alternative weed control. Sustainability criteria, including protecting the resource base, maintaining biodiversity, achieving carbon and climate neutrality, and attaining a neutral or positive energy balance will be evaluated.

Key words: *Eucalyptus,* lignocellulosic, *Pinus, Populus*, *Salix.*

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ID-286

HOW TO INTEGRATE NATURAL RISKS INTO A SIMPLE DECISION MODEL FOR FOREST PRODUCTION

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Against the background of climate change, the influence of natural disturbances (storm, insects, etc.) on the silvicultural production needs more than ever to be considered in forest management, since it is through the alteration of disturbance regimes that climate change impacts on forests will be most strongly felt. As a contribution to this topic, this presentation shows a simple calculation model, implemented in Excel frames, which tries to support decisions in forest production under these conditions.

The forest production model used in these calculations was developed on the basis of the growth model TreeGrOSS, an Open Source project of the Northwest German Forest Research Station. Instead of the classical yield tables used in the German forest practice increment and yield tables, derived from growth simulations using TreeGrOSS, were implemented, since they superiorly reflect the current growth conditions and silvicultural practice (thinning with release of crop trees and subsequent girth limit felling). Risk is integrated into this model by an age-dependent survival function, which describes the probability that a forest stand of a given age survive a time interval of certain length. Furthermore, price reductions and cost additions caused by calamities are considered.

Using this forest production model, we demonstrate as an example the influence of different survival rates on relevant decision criteria for a spruce management class. In order to consider the uncertainty of survival prediction, the distributions of these criteria are generated using Monte Carlo techniques. In terms of portfolio theory, this allows decision making under different risk preferences. Modification of the survival probability as a function of future disturbance scenarios will allow forest managers to incorporate climate change in their management planning.

Key words: natural risks, survival function, production model, decision support.

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ID-100

APPROACHES TO DETERMINING APPROPRIATE PROVENANCES FOR FUTURE CLIMATES

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Forest trees have large amounts of genetic variation in adaptive traits such as bud phenology, drought hardiness, cold hardiness and growth, and much of this variation is related to geographic patterns in temperature and moisture. Generally, local populations are optimally adapted to their local climates, or nearly so. As a result, seed and breeding zones and seed transfer guidelines have been developed to use local seed sources. These zones and guidelines assume, however, that climates are stable over the long term, an assumption that we now know is unlikely.

A study of Douglas-fir (*Pseudotsuga menziesii*) in western Oregon and Washington, USA, indicates that current practices of using local sources from within current seed zones will result in a high risk of mal-adaptated stands by the end of the century. Populations expected to be adapted to future climates are located 500 to 1,000 m lower in elevation and 2-5 degrees latitude further south. A study based on an extensive set of provenance tests of lodgepole pine (*Pinus contorta*) in British Columbia, Canada, indicates that productivity would increase up to 7% given warming of about 1.5ºC, but would substantially decline given greater warming, particularly for southern British Columbia, with some populations being extirpated. Productivity could be increased by as much as 14-36%, however, by moving populations to their optimal climates. Approaches to determining appropriate provenances for future climates include: (1) simply move populations the environmental distances equal to projected changes in temperature and, possibly, precipitation; (2) use seedling common garden studies to characterize variation in adaptive traits and select populations with adaptive traits that match future environments; (3) use population response functions for adaptive traits derived from short-term controlled environment tests; and (4) use population response functions derived from long-term provenance tests. Advantages and disadvantages of each approach are discussed.

Key words: genetic variation, provenances, seed zones, genecology, response functions.

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ID-292

SENSITIVITY OF TROPICAL DRY FORESTS TO CLIMATE VARIABILITY: RESULTS OF AN 18-YEAR STUDY FROM MUDUMALAI, SOUTHERN INDIA

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A 50 ha Forest Dynamics Plot was established in the tropical dry forests at Mudumalai, southern India, during 1988-89. All woody stems above 1.0 cm DBH (diameter at breast height) are being enumerated annually for recruitment and mortality, and every four years for stem size. This forest is subject to dry season ground fires, significant herbivory by large mammals such as elephants, and high inter-annual variability in rainfall (mean annual rainfall = 1245 ± 291 mm - range = 764 – 1840, N = 18 years). This dry forest thus provides an opportunity to examine woody plant responses, in particular stem growth and mortality, to climate variability.

We report variability in tree mortality rates observed during 1989-2006, a period that also witnessed one of the most severe droughts (during 2001-2003) in recent decades. Overall annual mortality rates (stems >1 cm DBH) showed considerable variation with a mean of 7.0 ±.4.7 (range = 1.5% - 17.5%, N = 18). Mortality rates of the larger stems (> 30 cm DBH) were low, averaging 1.2% (± 0.5 SD), only about a third of mortality rates in similar-sized stems in tropical moist forest. Mortality in stems >15 cm DBH was negatively correlated with rainfall with a 2-time lag period. Following the severe drought of 2001-2003, the mortality rates in the larger stems were enhanced 3-4 times (with a lag of 2 years), but even these rates were not much higher than the average long-term mortality rates of trees in tropical moist forest. These results are valuable in understanding the potential response of tropical dry forest species to future climate change and variability.

Key words: Tropical dry forests, India, climate variability, mortality rates.

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ID-079

PROJECT MIKADO – DOCUMENTING THE ENVIRONMENTAL PROPERTIES OF WOOD PRODUCTS IN NORWAY

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MIKADO is a three-year (2007-2009) collaborative research and technology development project run by 20 Norwegian partners, including research institutes, manufacturers and trade associations. The main objective of the project is to establish a scientifically founded documentation of the environmental properties for wood and wood-based products, and thereby a basis for promoting environmental qualities as a competitive edge for the wood and timber industry. One of the main results from the project will be Environmental Product Declarations (EPDs) for a relatively wide range of timber and other wood-based products. Results from the first part of MIKADO will be used to implement systems of Ecodesign, giving an approach of sustainable production and consumption.

A literature survey has been prepared as the first delivery from MIKADO, showing results from recent worldwide research. Studies from Sweden show that the major part of energy use from the forestry relates to timber transport (50%) and logging and hauling (30-40%). Recent studies identify a net reduction of CO_2 emissions to the atmosphere with intensive forestry, which on the other hand can conflict with other parameters of a sustainable forestry.

Timber products have low emissions in the production phase compared to other materials such as concrete. The study, however, highlights the importance of establishing consensus on methods for LCAs of buildings. It has also been a challenge to find acceptable lifetime data for timber products. The MIKADO project will work on scenarios for lifetime expectancy of timber products. Finally, several studies show that material recycling is the most environmentally sound method to utilize recovered wood; however different assumptions may lean towards energy recovery as the best method.

The paper will also present the work leading to the Product Category Rules (PCR) for "Solid Wood Products", including the experiences and challenges of producing rules for timber products. Also being presented are the results from a survey amongst the project partners, identifying the timber industry's awareness on environmental issues.

Key words*:* RTD project, environmental properties, EPD, PCR.

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ID-336

SUSTAINABLE DEVELOPMENT THROUGH BUILDING ADAPTIVE CAPACITY: THE MODEL FOREST CIRCUMBOREAL INITIATIVE

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As climate change becomes apparent, the need for adaptive capacity becomes a critical issue. Sustainability, as is has been approached traditionally, is challenged. The society demands a more diverse range of forest and landscape products and services that ever before, and as the demand becomes more and more diverging, the adaptive capacity becomes increasingly critical. This is particularly true for rural societies relying on natural resources. To be able to manage natural resources and landscapes in a sustainable way, there is a need for a deeper understanding of current and future challenges. The research community needs to provide accurate and timely knowledge, decision makers need to understand and apply this knowledge, and the land users, as well as the public society, need to be equipped with appropriate guidelines. To be able to adapt efficiently and in practice, there is a strong need for innovative and appropriate mechanisms and tools.

One approach towards a more sustainable land management situation is to employ landscape-sized case studies (Model Forests) located in different geographical regions that represent different chronological and developmental phases of use of forests and other natural resources. They should also reflect different premises concerning land use priorities, and different political, economic, social and cultural situations. A suite of Model Forests allows us to describe, analyze and assess state and trends on landscape level, to identify issues and driving forces at various levels that are relevant for different types of users today and in the future, and to increase the capacity of land-use partnerships with respect to power, attitudes, knowledge, and ability to act and communicate. Managed and studied in a wise way, a vibrant network of Model Forests will provide adaptive capacity based on sustainable landscape management on larger scale and under various premises.

Key words: sustainability, Model Forest, landscape, network.

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ID-201

MAJOR CONIFERS DISTRIBUTION IN RUSSIA IN A WARMING CLIMATE

N.M. Tchebakova and E.I. Parfenova[1]

A mounting body of scientific evidence is relating transformations in the forests to climate change. The objective of this study was to design bioclimatic models of the major conifers distribution and model the potential effect of two climate change scenarios on their distribution across European Russia and Siberia during the current century.

Our bioclimatic models determine unique climatic limits for major conifers from three bioclimatic indices: growing degree days, base 5^0C, negative degree days, base 0^0C, and annual moisture index. Major conifers in European Russia and Siberia are: *Abies sibirica*, *Larix sukaczewi*, *L. sibirica, L. gmelinii, L. cajanderi*, *Picea abies*, *P. obovata*, *Pinus sylvestris,* and *P. sibirica*. The conifer distribution predicted only from climatic variables was then corrected for permafrost which is the primary factor controlling distribution of forest trees. Each conifer distribution was mapped for 1960, 2020, 2050, and 2080 by coupling our bioclimatic models to bioclimatic indices and permafrost distributions. These in turn were calculated using climatic anomalies derived from two climate change scenarios, the HadCM3 A1FI and B1, reflecting the largest and the smallest temperature increase respectively.

During the current century, the warming and drying climate should become increasingly more suitable for drought-resistant, light-demanding conifers, *Pinus sylvestris* and the *Larix* genera as a whole, with the exception of *L. gmelinii* + *cajanderi* which will follow the permafrost retreat in Siberia. However, permafrost will not thaw deep enough to support conifers requiring 1-2 m of the active layer depth (ALD). Over East Siberia, *Larix gmelinii* + *cajanderi* withstanding the shallow ALD would still dominate the taiga. Habitats for water-loving, shade- tolerant conifers, *Picea abies, P. obovata*, *Pinus sibirica* and *Abies sibric*a, would shrink and shift north- and northeastward as far as 600 km by 2080. Their distribution will be limited by the permafrost border in the north and the dry climate in the south.

Key words: climate warming, conifers, European Russia and Siberia

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ID-220

IMPACT ASSESSMENT OF CLIMATE CHANGE ON FUELWOOD PRODUCTION AND UTILIZATION IN GHANA: AN ESSENTIAL TOOL FOR ADAPTATION

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Charcoal and firewood production and utilization have survived many criticisms over the past decades in developing countries, including Ghana. Recent research revealed that about 80% of communities depend solely on charcoal production as domestic energy source in Ghana because it is a relatively cheap and clean energy source. In the wake of soaring crude oil prices, demand for fuelwood is expected to increase. In recent times, however, concerns over the sustainability of the forests resources as impacted by the charcoal demand and over the health of users have intensified, especially in the wake of global climatic risk.

In this present study, the impacts of climate change on the method and extent of production of fuelwood were assessed in the major fuelwood producing communities of Ghana, using different woodfuel supply demand models. The implications on supply and demand of this domestic energy source were projected, with increased difficulties for collectors and susceptibility to diseases ranking high. The study concluded with a recommendation for timely adaptation strategies to be developed, based on empirical evidence in other regions and countries of the world, especially the developing poor countries. In the wake of climate risk, in order to create a balance between human needs for fuelwood and the climatic consequence of continuous dependence on its base, new adaptation strategies are needed.

Key words: fuelwood, impacts, climate change, adaptation.

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ID-352

DEVELOPING COMMUNITY FORESTRY MANAGEMENT FOR MITIGATING CLIMATE CHANGE IMPACT IN INDIAN HIMALAYAN REGION

Ashish Tewari[1], Vishal Singh[1], Pankaj Tewari[2] and Pushkin Phartyal[2]

The Indian Himalayan is potentially vulnerable to the impacts of global warming; the fragile ecosystems of mid-elevation ranges of the Indian Himalayas are under constant pressure from subsistence farming activities for survival living of the marginalized local population. Ecological degradation, deforestation, climatic change and human drudgery are some of the distinctive features of the Himalayan region. Impact of climate change in the region where dependence of the local population on the various ecosystem services, including fuel wood and fodder, is higher, the repercussions will not only be critical but also severe. Climate change, coupled with other anthropogenic activities, has affected moisture regimes, ground water recharge and related droughts. Three Communities-managed forests or Van Panchayats were supported by the Central Himalayan Environment Association's Kyoto; Think Global Act Local project through awareness programs, technological openings and consciousness of indigenous knowledge to adapt to the changing climate. Controlled leaf litter removal practices, minimized lopping intensities and digging of small earthen ponds in the catchments (lined with fodder grasses) has protected soil from leaching out, conserved water, regulated water supply and improved soil moisture regime in the lower areas. Introduction of fodder shrubs, grasses in lower degraded areas with horticulture trees and floriculture activities has not only reduced the pressure on the Van Panchayat forest but also enabled them to gain financial incentives and ultimately improved standard of living, thus heightening resilience against adverse climatic conditions. The better management strategies have resulted in higher carbon sequestration rates - 4.53 t ha^{-1} in Van Panchayat forests and 2.54 t ha^{-1} in forest under government jurisdiction.

Key words: global warming, Himalayas, Kyoto, sequester, Van Panchayats.

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ID-226

INTEGRATED FOREST MANAGEMENT FOR RESTORATION OF ECOSYSTEM SERVICES AND RURAL LIVELIHOOD SECURITY IN HIMALAYA, IN VIEW OF IMPACTS OF CLIMATE CHANGE

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The rich and diverse forests of Himalaya provide a variety of ecosystem services to both highland and upland, in addition to contributing significantly towards mitigating climate change though the capture and storage of carbon. During recent past, forests in the region have been depleted rapidly, mainly due to population growth and resultant increased demand of natural resources. Moreover, global climate changes have already stressed forest ecosystems through higher mean annual temperatures, altered precipitation patterns, more frequent and extreme weather events, and forest fires in Himalaya. These changes are adversely affecting basic ecosystem services, through reduced groundwater recharge and drying of natural springs (45%), undermining livelihood and food securities of regional population mainly dependent on subsistence agriculture, and lessening adaptive capacity of both natural and human system to climate changes in the region.

The prime goal of the paper is to present an integrated forest management framework that has been applied: Upper Kosi Catchment, Kumaon Himalaya in India, for mitigating climate change and enhancing the resilience of both natural and human system to its long-term impacts, restoring primary ecosystem services, and ensuring food and livelihood security to local people. Forest resources were assessed in terms of their status, availability, productivity, and community dependence employing Participatory Resource Appraisal (PRA) techniques. Village-level Forest Resources Information System (FRIS) was developed using remote sensing and Participatory GIS (P-GIS) methods. An integrated framework for sustainable and adaptive forest management was evolved through active participation of rural communities and involvement of local government agencies. Besides making provisions for protection and conservation of existing forests, appropriate Common Pool Land (CPL) was identified for afforestation for the purpose of water conservation, energy and fodder species, medicinal and aromatic plants. A grass-root institutional mechanism was also developed for their participatory management. This framework increases the adaptive capacity of local forest management to climate change.

Key words: population growth, reduced groundwater recharge, adaptive capacity, ecosystem services, Participatory Resource Appraisal.

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ID-034

MONITORING LARGE-SCALE TREE MORTALITY IN THE UNITED STATES OF AMERICA

Borys Tkacz[1]

The United States (US) Forest Service and its partners have been monitoring large-scale tree morality and other damages throughout the US for many years through the Forest Health Monitoring program. Annual damage surveys are conducted by trained aerial observers flying at low altitudes over forested areas. Recent advances include incorporation of automated digital sketch mapping systems linked to global positioning systems of aircraft and development of a national geospatial database. These advances have facilitated tracking tree mortality trends at state, regional and national scales. The information is used in planning pest suppression activities and for assessment of risks to future mortality. Future developments will include incorporation of remote sensing technologies to extend temporal and spatial coverage.

Key words: forest health monitoring, tree mortality, risk assessment.

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ID-367

FOREST HEALTH IN NORTH AMERICA: CURRENT CONDITIONS, HISTORIC TRENDS, AND FUTURE RISKS

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The forests of North America extend from the tropical areas of Mexico to the boreal regions of Canada. The health of these forests is threatened by a multitude of biotic and abiotic agents, including: fragmentation caused by development, drought, fires, native and invasive pests, and air pollutants. The effects of these stressors may also be exacerbated with changing climate. Forest health deterioration is often the result of abiotic and biotic stress complexes or multiple stress interactions. Increased damage caused by fires and some native insects and pathogens have been tied to climatic changes. Incursions of invasive forest pests have drastically changed many forest ecosystems and continue to threaten new areas. While deposition of some pollutants has decreased, damage to forests continues in many areas, particularly in response to ozone and N deposition. This presentation will review the current forest health conditions, historic trends, and present assessments of future risks to North American forests.

Key words: forest health, fires, forest pests, air pollution, climate change.

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ID-190

REGIONAL/COUNTRY SCALE FOREST RESOURCE SIMULATION IN A CHANGING ENVIRONMENT

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Paula Soares and Sónia Faias[1]

National Forest Inventory (NFI) provides information for the current status of the forest in a particular year. However, sustainable forest management requires detailed information on tree growth and forest dynamics, including structural development, biodiversity indicators, and effects of disturbances, at present and in the future. For a sound forest management planning, there is the need to predict future forest characteristics under alternative forest management, rate of expansion of the forest area, forest fire incidence, land-use conversion and climate change scenarios.

This presentation describes sIMfLOR, a system used in combination with NFI data at regional/ national level to estimate long-term forest resources in Portugal. The system, still under development, is based on several modules, i.e.: i) initialization; ii) forest growth; iii) harvest; iv) fire; and v) pests and diseases. Using a pre-established scenario, a list of forest resources sustainability indicators, including economic, environmental and social indicators, is provided for each year of the projection horizon. The forest growth module may use two forest growth models, GLOBULUS or GLOB-3PG. The first is a detailed whole stand empirical model used for projections without the effect of climate change. The second is a model that predicts biomass growth with a version of the 3PG model calibrated with Portuguese data. The output is complemented with a series of prediction functions, such as basal area, dominant height, merchantable volumes, developed with the database used to develop the GLOBULUS model.

At present sIMfLOR simulates long-term forest development and the associated sustainability indicators using climate change, wood harvest, annual area burnt, new planted areas per year and land-use changes for other uses as drivers, but in the near future it will include also other management alternatives such as biomass for energy or multifunctional forestry. Intensive plantations of Eucalyptus (*Eucalyptus globulus*) are used here as a case study. The use of the GLOB-3PG model at regional/ national level is not straightforward because the type of input needed, such as soil characteristics, is not available from the Portuguese NFI. The problems faced on the implementation of the model are discussed.

Key words: regional simulator, climate change, sustainability indicators, empirical forest growth models, process-based models.

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ID-326

CLIMATE CHANGE IN THE CONGOLESE DENSE FOREST

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The Congolese dense forest is the second world largest biosphere reserve after the Amazonian. In this region, deforestation (about 4% per year) has contributed to the emission of greenhouse gases which is responsible for global warming. However, little accurate information exists on the characteristics of the actual climate change in this dense forest, since data from meteorological stations have many gaps, and the meteorological network itself is very sparse and getting worse. In this study, we are trying to determine and regionalize the tendencies of rainfall variability in this region during the period 1951-2002 from multi-source data : (a) Climate Prediction Centre's (CPC) mean decadal position of ITCZ over Africa for the months of April to October for the period 1988 to 2007; and (b) Climatic Research Unit (CRU) of the University of East Anglia's rainfall file for the Central Africa between 8°N- 8°S latitude and 8°E and 30°E longitude for the same period.

Descriptive statistics and main components analysis with Varimax rotation have been used to characterize rainfall variability. The results obtained show the mean annual rainfall field, as well as the regional variability of the climate during this period and its main tendencies. On a monthly scale, excess precipitation is observed from May to September, while deficits tend to occur during the other months. On an inter-annual scale, results show that rainfall has been decreasing since the 1960s with a maximum rate of decrease in the 1970s and 1980s. Concerning the spatial organization of rainfall variability, severe rainfall deficits tend to occur at the western edge of the Congolese basin (Cameroon Highlands), in the central part of the dense forest and in the littoral regions.

To better appreciate the impact of climate change in the region, and the way the population is adapting to the different changes, it is urgent to develop meteorological measures at a smaller scale where communities exist. Developing a capacity to effectively monitor weather and climate over this large forest area is essential if we are to detect how climate change will impact this ecosystem.

Key words: Africa, climate change, rainfall variability, Congo dense forest.

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ID-349

EVALUATING MACROSCOPIC EFFECTS OF IMPREGNATION WITH HYDROPHOBIC OIL ON NORWAY SPRUCE (*PICEA ABIES* L. KARST) MATURE SAPWOOD STRUCTURE

Thomas Ulvcrona[1]

To avoid decay reducing their useful lifetimes or otherwise affecting their performance, manufactured wood products are generally treated by preservatives. In addition to the obvious financial benefits for their users, extending the longevity of the products reduces carbon emissions to the atmosphere and demands for raw materials. However, the preservatives currently used are generally toxic, so urgent attempts are being made to develop more environmentally friendly preservation techniques. Some potential systems involve the use of relatively high temperatures, pressures or vacuums, but such treatments may harm the wood's mechanical structure and thus limit its potential uses.

In order to evaluate the potentially adverse effects of one such treatment (hydrophobic oil impregnation), the variability of the Modulus of Elasticity (MOE) in treated and untreated mature sapwood samples was examined using data collected in standardized 3-p bending tests. Five batches of samples were examined: 1 = control/unimpregnated, 2-3 = shorter pressure time, and 4-5 = longer pressure time respectively. No distinguishable trends were found in the MOE of this material associated with batch or linseed oil uptake (in terms of either % of wood dry weight or basic density). Mean values (and ranges) of standard deviations of the MOE (in MPa) were 24278 (19629-30392), 26194 (21618-35613), 28506 (27724-35470), 27352 (20945-31963) and 27367 (22305- 31045) for batches 1, 2, 3, 4 and 5, respectively (eight samples in each case, except six for batch 5). There have been few previous studies of these relationships with comparable detail. However, the lack of significant differences found between the untreated and treated wood indicates that the material is not substantially damaged by the treatment at either of the tested settings or uptake levels. The findings also imply that Norway spruce wood could be used more extensively in projects aiming to develop more environmentally friendly preservation systems.

Key words: collapse, process settings, modification, mechanical short-term properties.

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ID-009

CANADA'S FOREST SECTOR CAPACITY TO ADAPT: THE NEED FOR INCREASED LEVELS OF INNOVATION

Laird Van Damme[1]

The scientific community is warning that the warming trend of the last thirty years will continue and may accelerate at a rate without precedent. This change and the associated changes to the forest environment and infrastructure, such as winter roads, will require the forest sector to be highly adaptive. Canada's forest sector is already in the midst of a crisis from a failure to adapt to globalization of trade and commerce. One factor leading to this crisis is an over reliance on cost reduction rather than innovation. Although the supply side of science and technology is well developed in Canada, the demand side has been weak within the private forest sector.

Three case studies of innovation within the forest sector are examined. It appears that some firms are highly innovative as a result of a corporate culture where leadership encourages innovation. This success factor is chief among others that include ownership, governance, social attitudes and finance. New public policies are being considered to further stimulate private sector innovation. One of these policies is tenure reform, i.e. the legal agreement by which government landowners allocate timber volumes to companies. A system with both greater private property rights and opportunities for competition would likely stimulate innovation. The degree to which the forest sector can adapt to the current economic crisis will indicate the level of adaptive capacity with which the sector will respond to challenges arising from climate change.

Key words: adaptation, Canada, climate change, forest sector innovation, corporate culture.

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ID-152

IMPACT OF CLIMATE CHANGE ON DISTRIBUTION AND PERFORMANCE OF TROPICAL PINE SPECIES IN CENTRAL AMERICA AND SOUTHEAST ASIA

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B. Vinceti[4] and L. Snook[4]

Tropical pines are economically important species and their natural populations are sources of genetic diversity that have been and can be used to sustain and improve plantation productivity under both present and future climatic conditions. Climate change is likely to affect the extent, distribution, growth and regeneration of populations of tropical pines, and can thus represent a threat to their long-term survival, particularly for those that are already considered threatened or endangered.

The objective of this work was therefore to evaluate the impact of climate change on both the distribution of natural populations and the suitable plantation areas for these species. We predicted changes in suitable areas for tropical pine species in Central America (*Pinus patula* and *Pinus tecunumanii*) and in South-East Asia (*Pinus merkusii* and *Pinus kesiya*) using the climate envelope modeling method of maximum entropy "Maxent". Climate envelope models (CEM) suggest fairly drastic impacts of climate change on wild stands, but their predictions contain considerable uncertainty related to the capacity of tree populations to persist or adapt. How trees can persist across a wide range of climates and environments depends on its plasticity. We assessed model predictions by coupling the modeling exercise to results from provenance trials where the performance of tree populations can be evaluated under climatic conditions different from those of their sources. The plasticity of pine populations was determined, based on growth responses and survival rates from provenance trial results. These results were projected to the future to predict both the persistence of natural populations to climate change and the changes in suitable plantation areas. Our results suggest that existing pine populations are likely to be more adaptable to climate change than is predicted by CEM modeling.

Key words: climate change impact predictions, climate envelope models, phenotypic plasticity, provenance trials, tropical pine species.

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ID-319

EARLY RESPONSE TO DROUGHT OF
PINUS PINASTER AITON CLONES

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Climate change and forests are intrinsically linked. One of the first forecasted consequences of climatic change is a decrease in water availability, with a concomitant effect on the productivity of natural forests. Factors related to the drought tolerance have not been frequently used on breeding programs owing to the difficult of testing early adaptative traits to drought.

A Spanish Tree Improvement Group was established for improving the plantation productivity in *Pinus pinaster* under low to medium rainfall conditions. The strategy developed involves a number of components, among which are the preliminary early screening of selected material for genetic variation in drought resistance and the establishment of longer-term field trials on target site types. In this work, we analyse the phenotipic variability of the adaptative traits in response to drought in *Pinus pinaster* Aiton clones arising from the results of the preliminary trials. Three-month old cuttings of clones from eight provenances of *P. pinaster* differing in climatic condition in their geographic origin were subjected to water stress, using polyethylene glycol 8000 in hydroponic assay for seven months. These provenances were grouped as xeric and mesic in function of geographical origin. We analysed various parameters relative to water stress which showed differences, depending on their origin. We observed a better correlation between biomass partitioning and survival rate in four xeric provenances (r^2 =0.2634, P = 0.087) than in four mesic provenances (r^2 = 0.0546, P = 0.1702).

These results suggest that it is possible to improve resistance to water stress of *P. pinaster* through genetic improvement. Although this project is still at a very early stage, it supports the view that genetic improvement of this species could be an important adaptation measure to the changing climate.

Key words: biomass partitioning, drought resistance, osmotic potential, *Pinus pinaster*, water stress.

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ID-322

CLIMATIC FACTORS AFFECTING THE NEEDLECAST EPIDEMICS CAUSED BY *LOPHODERMIUM SEDITIOSUM*

Martti Vuorinen[1]

Lophodermium seditiosum kills needles of young pine and causes needle cast in pine stands. It occurs periodically, with some years interval, and causes severe needle cast epidemics. There are more often needle cast epidemics caused by *L. seditiosum,* e.g. in Estonia and Germany than in Finland. Its occurrence is connected to humid growing season and perhaps the length of growing season is limiting factor in Finland. The other reason to the more unusual occurrence of *L. seditiosum* in Finland can be that the pines in Finland can be rather resistant to pine needle cast. According to earlier studies, German pine seedlings had been more susceptible to get pine needle cast than Finnish pine seedlings. Unfortunately the earlier test with German and Finnish provenances had not made any difference between *L. seditiosum* and *L. pinastri*

In this study, results of provenance test carried out in Finland and Estonia are presented, showing that there are more and more often epidemics in Estonia than in Finland. But the difference in susceptibility between Estonian and Finnish provenances is not so clear. In these results, the connection of the length of growing periods to Lophodermella needlecast epidemics is also presented. The discussion is on whether the epidemics will occur in future more often in Finland, when the growing seasons are longer and warmer than they have been until now, or whether the Finnish pine provenances are always more resistant to Lophdermella needlcast than the other more southern provenances.

Key words: *Lophodermium seditiosum*, resistance, provenance test, climate change.

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ID-262

TREE BREEDING IN A CHANGING ENVIRONMENT: GENETIC GAIN AND ENVIRONMENTAL CANALIZATION

Patrik Waldmann[1]

Tree breeding is one the most important ways to increase the productivity in forestry. In conventional tree breeding, the focus is on increasing the genetic gain in future generations by identification and crossing of superior individuals with high breeding values. The normal mixed linear model is the most commonly used statistical tool for estimation of breeding values. This model partitions the phenotypic variance into genetic and environmental components under the assumption that the variances are homogeneous and uncorrelated with each other. The current focus in breeding is almost exclusively on the genetic component. The future climate change has been predicted to induce directional changes in the environment, for example gradually increasing temperature. Additionally, it has also been suggested that fluctuations in the environment will be larger.

To accommodate these effects on the environment we need to develop new breeding strategies that focus on both the genetic and environmental components of the statistical models. From a breeding perspective, it would be of interest to increase the genetic gain as well as produce homogeneous phenotypes that are robust to changes in the environment, i.e. to breed for environmental canalization. I will here review some recent developments in statistical methodology that allows for heterogeneous environmental variance, and correlation between genetic and environmental effects. Moreover, I will make suggestions on how these rather complex methods can be transformed to a tree breeding context prepared for future climate changes.

Key words: environmental sensitivity, genetic gain, phenotypic robustness, tree breeding.

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ID-012

USE OF GENETIC VARIATION IN FOREST TREES TO ADAPT TO CHANGING CLIMATE

Tongli Wang, Andreas Hamann, Sally Aitken[1], Greg O'Neill, Alvin Yanchuk
and Dave Spittlehouse[2]

Through a long-term evolution, forest trees are in general adapted to their local climatic conditions. A rapid climate change will likely result in a bad adaptation of local species and populations. A better understanding of genetic and environmental variation in tree growth- and health-related climate is needed for formulating new strategies to help forest trees to adapt to the changing climate. We have conducted a series of related studies with the main objectives of (1) developing a high-resolution climate model; (2) predicting adaptive responses of populations to climate; (3) quantifying among-population genetic variation for climate-related traits; and (4) predicting potential impacts of climate change on ecosystems and species ranges in British Columbia (BC). Plant materials and data used for these studies are based on one of the most comprehensive provenance test in the world for lodgepole pine and the Biogeoclimatic Ecosystem Classification System.

ClimateBC has been developed to downscale PRISM climate data, and integrates both interpolated historical and predicted future climate data. It has become an essential tool for climate-related studies in BC and it is being expanded to cover much of Canada and the United States. We have also developed population response functions, transfer functions, and a universal response function for lodgepole pine to guide seed source selection and predict the impacts of climate change on stand productivity. The universal response function integrates population transfer and response functions into a single model to improve the prediction power and to reduce requirement for sample size of provenance tests for climate change analysis. Modeling and predicting ecosystem and species ranges shifts with different analytical approaches provides options for selecting species for future climates under various climate change scenarios. Results of our studies provide examples of using within- and among species genetic variation in forest trees to adapt to changing climates for reforestation and forest resources management.

Key words: adaptation, climate model, ecosystem, genetic variation, response function.

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ID-024

DISTURBANCE-DRIVEN LAND COVER CHANGES IN WESTERN CANADA UNDER OBSERVED AND PROJECTED CLIMATE CHANGE

Xianli Wang and Andreas Hamann[1]

We have developed a spatially explicit model of disturbance and succession as a function of climate for western Canada, including British Columbia, Alberta, and Saskatchewan. Calibrated with 20 years of satellite data from the NOAA/AVHRR sensor, we subsequently project the model forward in 10-year time steps until 2050. We present how land cover and forest types have change in extent, elevation, and spatial distribution in the last 20 years, and how they are projected to change under three future climate change scenarios, including a median (CGCM2-B2), a warm/dry (HADCM3-A1F1) and a cool/wet (PCM-B1) scenario.

Climate conditions suitable for sub-arctic, boreal, and montane ecosystems disappear rapidly from the study area, and the extent of spatial redistribution of land cover types is considerable even under the assumption of constant disturbance regimes. However, the changes in landcover projected by this disturbance and succession driven model are far less dramatic than what is projected by widely used bioclimate envelope modeling techniques. The value of the projections that we present in this study is to gain insights into the magnitude of land cover transformations that can be expected under the projected climate changes to help organize our thinking around reasonable adaptation strategies.

Key words: AVHRR, climate change impacts, ecosystem modeling, land cover.

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ID-103

MODELLING FOREST FIRE IGNITION AND PROPAGATION FOR TWO FIRE-PRONE REGIONS IN SWITZERLAND

P. Weibel[1], B. Reineking[2], M. Conedera[3] and H. Bugmann[1]

In many regions worldwide, climatic change is likely to bring about an accentuation of the wildfire regime. Adaptation measures to cope with changing wildfire regimes must be prepared early, and thus the development of predictive models of wildfires across different climatic regimes is highly needed. We focus on the analysis of the fire regime in Switzerland's most fire-prone regions, characterized by strongly different climates - the canton Ticino with an insubrian climate and the canton Valais with a continental climate. These differences lead to peculiar characteristics of the forest fire regimes. Climate change is expected to alter the number and sizes of forest fires in both areas, possibly leading to a loss of protection against avalanches and landslides.

We used two approaches to identify the key factors determining the historical fire regimes of Ticino and Valais. First, a variety of drought and forest fire danger indices was used to characterize ignition conditions in space and time, and the regional influence of forest composition, human impact, and elevation on ignition points was included as well. Second, the fire module of the forest succession model LANDCLIM was used to simulate fire properties in the two cantons. The LANDCLIM fire module is based on a cellular automaton, simulating fire propagation as a function of a drought index and topography.

The results showed distinct regional differences, with more frequent forest fires in the canton Ticino during the drier winter half-year, whereas in the canton Valais two peaks in spring and autumn were found. Fire ignition conditions differed between lightning- and human-induced forest fires. The models from one region cannot be transferred to predict forest fires in the other region, thus strongly limiting our ability to assess future forest fire danger in either area.

In conclusion, forest fire regimes not only depend on regional environmental variables (climate, weather, forest composition, fuel characteristics, human impact), but also on the ignition source. The fact that our predictive ability of future forest fire danger appears to be quite limited aggravates the problem of adaptation to climate change, and suggests that improved models should be a key focus in research.

Key words: drought and fire indices, forest composition, human impact, ignition source, LANDCLIM.

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ID-120

CHANCES AND CHALLENGES FOR A RESOURCE-DEPENDING SOCIETY TO MITIGATE NEGATIVE IMPACT OF FOREST LOSS THROUGH CLIMATE CHANGE (REDD) SUPPORT MECHANISMS

Horst Weyerhaeuser[1], Vanthong Phengvichith[2] and Nathan Badenoch[3]

This paper reports on the research and development efforts expanded by the Government of the PDR Lao in its preparation to gain full benefits from the developing international interest in supporting Reduced Emissions from forest Deforestation and Degradation (REDD) activities.

Rural Laos, and especially its upland area of the north, is experiencing a major shift in agriculture and a trend towards a general over-exploitation of its natural resources. Previously, the system was based on long-term shifting cultivation with sustainable fallow periods of 10-15 years. However, this has changed over the last 5-10 years and land use is becoming less sustainable. Sources of this pressure exerted on the system are diverse, but mostly due to the opening of markets across the borders to China, Vietnam and Thailand and to an increase of population. Highly diversified forest utilization has traditionally provided food and almost all material used in daily lives of the rural population. From the late 90's onwards, a major transition began. Tree crops, e.g. rubber, teak and eucalyptus, were introduced for medium- and large-scale plantations, and farmers were encouraged to grow commercial crops on a large scale. This combination had an immensely negative impact on the forests and the agro-ecological land-use mosaic of northern Laos. Recently, additional pressure was exerted through introduction of crops potentially suitable for bio-fuels, a change that has accelerated the shift from subsistence to commercialization, leading to an over-exploitation of natural resources.

In an effort to stem the negative impact of shifting cultivation with unsustainably short fallows, low quality plantations and the resulting increased vulnerability of local communities, the Lao Government is preparing the country and its forest communities to participate and gain from REDD-related activities in connection with general improvement of forest management and conservation. Preparations include the evolution of improved institutions, policies and the development of capacity at national and provincial level.

Key words: Laos, upland agro-ecosystems, shifting cultivation, conservation, plantations, REDD.

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ID-222

ADAPTIVE CAPACITY IN FOREST-BASED COMMUNITIES

Tim B. Williamson[1]

The adaptive capacity of a community at any point in time is a function of prior investments (time, skills, knowledge, money, etc.) in assets (social capital, etc.). Rates of investment are shaped by traditions, institutions and values, and by local social, cultural, and economic circumstances but fundamentally the amount invested will be based on some expected return (not necessarily financial) and expected risk. Historically, in developed economies, the portfolio of assets that contribute to local capacities is usually reasonably well matched to current demands. However, given expectations of rapid environmental changes combined with other social, economic, and technological changes, the portfolio of adaptive capacity assets in forest-based communities may not be well matched to future demands.

There are two main reasons. First, climate change can have feedbacks on adaptive capacity by modifying the availability of some assets that contribute to it (e.g. natural capital). Second, changed circumstances will require a different portfolio of assets over time and different types of investments. If climate risks are correctly perceived and anticipated (i.e., assuming rational expectations), one would expect that adaptive capacity asset portfolios would continue to grow and change consistent with community requirements. However, given expected rates of change, the uncertainty in future climate, and the tendency for humans to underestimate climate risks, autonomous investment in adaptive capacity resources may be lower and/or later than needed resulting in undersupply. This paper considers the evolution in thinking about adaptive capacity between the IPCC Third and Fourth Assessment reports and applies some of the new concepts to the specific case of adaptive capacity in forest-based communities using detailed results from three case study communities in Canada.

Key words: adaptive capacity, forest-based communities, emergent vulnerability.

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ID-157

IMPACT OF FUTURE DROUGHTS ON FORESTED MOUNTAIN CATCHMENTS: CARBON STORAGE AND HYDROLOGY

A. Wolf and H. Bugmann[1]

Forests store large amounts of carbon in living biomass (wood, leaves and roots) and in soils, but they also influence catchment hydrology *via* evapotranspiration and modification of runoff. As higher summer temperatures and a decrease in summer precipitation are anticipated for the European Alps, we expect that these two ecosystem processes, e.g. carbon storage and runoff modification, will change.

We use the biogeochemical model (LPJ-GUESS) to investigate the carbon and water budget of forest ecosystems and apply it to two catchments in the European Alps (Alptal and Saltinatal). We use climate scenarios that differ in the extent and duration of drought and heat waves to investigate the response of mountain forest ecosystems to extreme drought events compared to a steady decrease in growing season precipitation. We show how forests in these two catchments with different climate regimes (Pre-Alps *vs.*Central Alps) will respond to these future climatic changes. We assess the potential changes in tree species composition and distribution within the catchment, and we analyze how catchment carbon storage and the different aspects of catchment hydrology, such as evapotranspiration and runoff, will change. We discuss how carbon storage and runoff interact and how differences in tree species responses influence the results.

Key words: carbon storage, drought, hydrology, LPJ-GUESS.

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ID-231

A COGNITIVE MAPPING APPROACH TO ESTIMATE CURRENT AND FUTURE FUNCTIONALITY OF NON-TIMBER FOREST PRODUCTS AND SERVICES

Bernhard Wolfslehner[1] and Harald Vacik[2]

Non-timber forest products and services (NTFPS) play a vital role both in European forestry and in the Pan-European understanding of sustainable forest management. Yet, there is only little insight into potential impacts of climate change on the future pool of NTFPS nor is there in-depth analysis on hidden conflicts among pursuing NTFPS and timber production or other objectives such as climate change mitigation projects.

Against this background, we propose a cognitive mapping approach that can be used to integrate and evaluate trade-offs of management actions for NTFPS and for traditional forest products at the scale of a forest enterprise. Cognitive mapping is a technique by which we collect expert and stakeholder judgments and explore connections and relationships among elements of a system to provide evidence on tactical and strategic significance of NTFPS. Recognizing that NTFPS can be of independent, complementary or conflicting nature in relation to timber production and other management objectives, the analytical concepts of cognitive mapping can then be utilized to estimate the future roles and limitations of NTFPS, for instance, under climate change scenarios.

The proposed conceptual framework is contextualized for some typical Central-European production systems of NTFPS within a timber-dominated forestry. It is compared how sensitive conventional and traditional product-mixes (e.g., christmas trees, honey, hunting) as well as innovative production systems (e.g., conservation contracting, education, energy) are estimated with regard to climate change scenarios and it is analysed how to identify applicable and viable combinations of those NTFPS from a future perspective by means of the cognitive mapping interactions. This shall contribute both to a strategic decision support for managing NTFPS under changing conditions, and to fostering a realistic understanding of NTFPS in political sustainable forest management processes.

Key words: non-timber forest products and services (NTFPS), cognitive mapping, sustainable forest management, systems analysis.

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ID-328

PHOTOSYNTHESIS RATE AND ANTIOXDANT ENZYME ACTIVITIES OF *ERYTHRINA ORIENTALIS* IN POLLUTED AND NON-POLLUTED AREAS IN THE PHILIPPINES

S.Y. Woo[1],D.K. Lee[2], Y.K. Lee[3], S.Z. Ryang[1], S.H. Lee[1], S.M. Je[4],
C.H. Cheng[1], S.G. Baek[1] and E.D. Lee[1]

Environmental stress, such as air pollution, is among the factors most limiting to plant productivity and survivorship. Air pollution in Metro Manila in the Philippines has become a serious problem during the last several decades. In particular, SO_2 and O_3 concentrations in the cities of Makati and Quezon continue to rise as a direct consequence of human activity, such as emissions from an increasing number of automobiles. Emissions have not been successfully restricted: ambient SO_2 and O_3 concentrations rose by 4–5% by the end of 2004. Air pollutant affects tree physiological processes directly or indirectly; directly by affecting the major enzyme of photosynthesis, and indirectly by affecting stomatal aperture.

We investigated net photosynthetic rate and antioxidative enzyme activities in *Erythrina orientalis* grown in three different sites: Makati and Quezon (cities with high levels of air pollution) and La Mesa (a non-polluted area) in the Philippines. Photosynthetic activity of *E. orientalis* was significantly reduced in the high levels of air pollution cities. In contrast, activities of the antioxidative enzymes ascorbate peroxidase and glutathione reductase were significantly higher in high levels of air pollution cities than in the non-polluted area.

Key words: air pollution, net photosynthesis.

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ID-213

SWEDEN AND THE UNITED STATES: PARTNERS IN SOLVING THE PROBLEM OF GLOBAL CLIMATE CHANGE

Michael Wood[1]

Sweden is an important partner of the United States in the effort to address the serious challenge of global climate change. The U.S. Embassy's focus on alternative energy cooperation between the two countries has already resulted in concrete projects to develop alternative fuels and new technologies. We have also achieved progress on the policy front, with the signing of a Biofuels Cooperation Agreement. Together, we are seeking to develop a post-2012 framework that effectively addresses climate change and strengthens our energy security. Prime Minister Reinfeldt has made achievement of this agreement a goal of Sweden's EU Presidency in the second half of 2009. The United States believes that a post-2012 framework for climate change must be environmentally effective and economically sustainable. Emissions are global and the solution, to be effective, will need to be global. An approach in which only some are acting is not environmentally effective. Moreover, a future framework must be flexible and accommodate a diverse range of national circumstances, as well as broad social and economic goals.

The United States is working at home and abroad on a range of initiatives to reduce greenhouse gas emissions, improve energy security and cut harmful air pollution. We have a diverse portfolio of domestic policy measures, including dozens of mandatory, incentive-based, market-based, and voluntary programs to reduce our domestic emissions. We have also devoted US$37 billion to help develop and deploy innovative technologies to reduce greenhouse gas emissions while allowing for economic growth. The Bush administration's strong support for research into the potential of cellulosic ethanol as a fuel source and battery technology for plug-in hybrid vehicles is particularly important in reducing our dependence on petroleum-based transport fuels. While there will continue to be great demand around the world for oil and gas, developing alternatives and renewable sources now is in everyone's long-term interest.

Key words: United States, Sweden, climate change, cellulosic ethanol.

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ID-378

RELATIONSHIPS BETWEEN FOREST FINE AND COARSE WOODY DEBRIS CARBON STOCKS ACROSS LATITUDINAL GRADIENTS IN THE UNITED STATES AS AN INDICATOR OF CLIMATE CHANGE EFFECTS

C.W. Woodall[1] and G.C. Liknes[2]

Coarse and fine woody materials (CWD and FWD) are substantial forest ecosystem carbon (C) stocks. There is a lack of understanding how these detritus C stocks may respond to climate change. This study used a nation-wide inventory of CWD and FWD in the United States to examine how these C stocks vary by latitude. Results indicate that the highest CWD and FWD C stocks are found in forests with the highest latitude, while conversely the lowest C stocks are found in the most southerly forests. CWD and FWD respond differently to changes in latitude with CWD C stocks decreasing more rapidly as latitude decreased. If latitude can be broadly assumed to indicate temperature and potential rate of detrital decay, it may be postulated that CWD C stocks may be at the highest risk of becoming a net C source if temperatures increase. The latitude at which CWD and FWD C stocks roughly equal each other (equilibrium point) may serve as an indicator of changes in C stock equilibrium under a global warming scenario. Given the complex relationships between detrital C stocks, biomass production/decay, and climatic variables, further research is suggested to refine this study's indicator.

Key words: latitude, coarse woody debris, fine woody debris, carbon, climate change.

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ID-064

AN INDICATOR OF TREE MIGRATION IN FORESTS OF THE EASTERN UNITED STATES

C.W. Woodall[1], C.M. Oswalt[2], J.A. Westfall[3], C.H. Perry[4] and M.D. Nelson[5]

Changes in tree species distributions are a potential impact of climate change on forest ecosystems. Examination of tree species shifts has largely been limited to simulation activities due to the lack of consistent, long-term forest inventory datasets in forests of the eastern United States. The goal of this study was to compare the status of tree seedlings and biomass (trees with a diameter at breast height ≥ 2.54 cm) for sets of northern, southern, and general tree species in the eastern United States using a spatially-balanced, region-wide forest inventory. Study results indicated that the mean latitude of seedlings *versus* biomass was significantly farther north (> 20 km) for the northern study species, while southern species had no shift, and general species demonstrated southern expansion. The density of seedlings relative to tree biomass in northern latitudes compared to southern latitudes was tremendously higher for northern tree species (nearly 10 times higher). For plots between 44 and 47 degrees latitude where southern species were identified, their biomass averaged 0.46 tonnes/ha while their seedling counts averaged 2,600 per ha. It is hypothesized that as northern and southern tree species together move northward due to greater regeneration success at higher latitudes, general species may fill their vacated niches in southern locations.

The results of this study suggest that the process of northward tree migration in the eastern United States is currently underway with rates approaching 100 km/century for many species.

Key words*:* trees, climate change, migration, United States, forest, seedlings, latitude.

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ID-063

CARBON POOLS AND FLUXES FOR UNITED STATES FOREST ECOSYSTEMS AND PRODUCTS: RESULTS OF THE USDA FOREST SERVICE NATIONAL SUSTAINABILITY REPORT

C.W. Woodall[1], K.E. Skog[2], L.S. Heath[3], J. Smith[4], C.H. Perry[5] and R. Piva[6]

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 fluxes provide one of the largest offsets of annual greenhouse gas emissions. Current estimates of forest ecosystem and product pools and fluxes for the United States were developed by the USDA Forest Service under the framework of the Montreal Process Working Group on Criteria and Indicators in order to evaluate the sustainability of forest ecosystem processes that mitigate greenhouse gas emissions.

Results of this national assessment indicate that forest ecosystem carbon 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 carbon fluxes in the future is in question. In light of possible climate change effects, trends in national-scale forest ecosystem carbon pools and fluxes may contain even greater uncertainty into the future.

Key words: carbon, greenhouse gases, sustainability, United States, forest ecosystems.

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ID-065

THE IMPACTS OF TREE IMPROVEMENT PROGRAMMES ON FOREST HEALTH: THE PAST MODELS, AND FUTURE APPROACHES NEEDED IN CHANGING CLIMATES

Alvin Yanchuk[1] and Gillian Allard[2]

A substantial body of research is now present examining the projected impacts of climate change on the adaptation of forest trees. While physiological adaptations to climate change scenarios are critical components for forest geneticists to now consider in genetic resource management, the largest impacts are likely to come from new insect pest and disease distributions and subsequent host-pest interactions. In a recent world-wide survey of research programmes for insect or disease resistance, we identified ~260 'activities' that have been or are underway. However, in spite of this large volume of literature underpinning many programmes, insect or disease resistance breeding programmes have only been successful in a handful of major commercial species. Moreover, these targeted resistance programmes have taken decades to develop and our past approaches may not serve us well under rapid climate change. First, we will likely have fewer resources to understand specific host-pest interactions and resistance mechanisms. Second, researchers will need to be innovative in order to focus on species and programmes that can efficiently use, develop and test for 'durable cross resistances' that may help thwart off current and new unknown challenges. In other words, the large investments in host-pest disease interactions research will need to be better aligned with applied programmes that deliver resistant germplasm. Third, while studies carried out in the wild can be important for modelling purposes to predict future losses, they will not build towards more resistant germplasm. Fourth, the enormous investments in molecular biology, while being of great biological interest, must be carefully aligned with applied programmes. And finally, transgenic technology, while it has the ability to temporarily address some specific pest problems, will still have to operate within well developed breeding programmes that deploy trees at the landscape level, in space and time, and with rapid climate change.

Key words: pest resistance, disease resistance, climate change, tree breeding.

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IMPROVING SOIL CARBON ACCUMULATION THROUGH INTEGRATED SOIL FERTILITY MANAGEMENT

E. Yeboah[1] and S.P. Sohi[2]

Climate change is occurring and future changes are inevitable. These changes could result in economic losses of 5-20% of global GDP. Climate variability already affects Africa's water resources, land, forests, and biodiversity. These impacts are likely to worsen over time. Globally, soils hold approximately three times as much C as terrestrial vegetation, and twice as much as the atmosphere. The maintenance and enhancement of soil organic carbon (SOC) is, therefore, pivotal to sustainable land management.

In a field experiment initiated in 2003 in the semi-deciduous forest zone of Ghana, Integrated Soil Fertility Management (ISFM) approaches on soil organic matter (SOM) status and trajectory were evaluated on two dominant but contrasting soils. SOM was separated by density fractionation into four functionally distinct pools of free light fraction (FRLF), intra-aggregate light fraction (IALF), organo-mineral (OM) and the soluble (SOL). There was evidence of statistical significance of the amount of SOC stored ($P<0.001$) within the SOM pools. The IALF and the FRLF accounted for about 3% and 7% of total SOC respectively. The OM pool represented 70% of the total SOC while SOL pool accounted for 20%. Under continuous cultivation without fresh inputs of farm yard manure (FYM), the RothC model predicted 80% decline in current SOC within 20 years in the sandy loam soil. However, annual additions of 4t C ha^{-1} FYM will accumulate between 12-16% in SOC (30t ha^{-1}). Land management strategies need to include a consideration of SOC to prevent long-term land degradation and to have a positive global impact on atmospheric CO_2 levels. Biomass additions to the soil improved soil aggregation, water holding capacity and soil nutrients. These have positive impact on assimilation of atmospheric CO_2 by plants. Improving soil organic matter management through biomass addition thus plays a key role in both adaptation and mitigation to climate change.

Key words: climate change, density fractionation, integrated soil fertility management, soil organic matter, RothC model.

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ID-282

POSSIBILITIES AND LIMITATION IN CHANGING OF SPECIES COMPOSITION – TREE DISEASE PHENOMENA IN POLAND

Tadeusz Zachara and Wojciech Gil[1]

Silvicultural methods play an important role in the formation of sustainable and highly biologically diversified forest ecosystems. The choice of species composition is a decision taken essentially at the stage of the regeneration process. It depends first of all on climatic and habitat conditions. The paper provides a short description of the share of different forest habitat types and of different species predominating in Polish forests. The data concerning possible changes in species composition during the restoration process are presented.

The main difficulties are, in this case, oak (*Quercus* sp.) and ash (*Fraxinus excelsior* L.) dieback in Poland, which have been taking place during last years. These problems have been surveyed in the Forest Research Institute, by questionnaires sent to all forest districts and measurements on sample plots in selected objects. The total area of declining ash forest stands amounts to 10,800 ha. In most cases, the disease started between 1998 and 2001 and its culmination appeared between 1999 and 2003. The most susceptible to dieback were young stands (up to 20 years), artificially planted, especially in central Poland. The most resistant stands were located in south and south-west Poland

The analysis of long-term precipitation data in various parts of Poland was done. It was shown that current increment of sample trees is dependent on precipitation level during the vegetation period. The breakdown of increment appeared 3-5 years before the first visible symptoms of disease. Similar data concerning oak forests decline are currently in elaboration and will be presented. Oak is one of the most important broadleaved tree species, so its dieback problem is more serious than in ash case.

Key words: ash, forest decline, forest restoration, oak.

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DROUGHT RESPONSES OF DIFFERENT TREE SPECIES IN BAVARIA: EVIDENCE FROM TREE RING GROWTH AND WOOD $\delta^{13}C$

Christian Zang[1,2], Andreas Rothe[1] and Hans Pretzsch[2]

Global change climate is predicted to yield increases in both frequency and intensity of drought. Hence, the growth reaction of forest trees to increasing drought will be of considerable economical and ecological interest. The European heat waves of 1976 and 2003 provided a foretaste of future drought events and thus gave the opportunity to investigate drought-sensitivity of different tree species on a variety of sites with a comparable small methodological effort. We used increment growth and wood isotopic signature ($\delta^{13}C$) to derive measures of susceptibility and resilience with respect to these drought events.

Our investigations focus on the commercially most important species in Bavaria: *Picea abies* (L.) Karst., *Pinus sylvestris* L., *Abies alba* Mill., *Fagus sylvatica* L. and *Quercus robur* L., and on *Pseudotsuga menziesii* (Mirbel) Franco, as a possible alternative to *Picea abies*. The diversity of investigated sites ranges from regions with warm and dry climates in north western Bavaria to colder and humid sites in the south, with a variety of soil types being covered as well.

For *Picea abies,* we could derive clear patterns of drought impact on tree growth along environmental gradients: on the large scale (across Bavaria), drought impact follows the climatic gradient with a higher impact under drier conditions, whereas on the site scale (subsites with different soil conditions), this pattern is inverted. Consequently, the impact of drought on tree growth can be interpreted as a tradeoff between the species' autoecological limits and the individual site-specific adaptation. Further, a site-specific ranking of tree species regarding susceptibility and resilience with respect to global-change-type drought events could be obtained.

Key words*:* drought, tree growth response, stable isotopes.

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DISTURBANCE IN SUDANIAN SAVANNA WOODLANDS AND ECOLOGICAL RESPONSES UNDER CLIMATE CHANGE: THE CONTRIBUTION OF LONG-TERM ECOLOGICAL RESEARCH ON FIRE, GRAZING AND SELECTIVE TREE CUTTING

Didier Zida[1], Patrice Savadogo[2], Daniel Tiveau[3], Djibril Dayamba[2], Louis Sawadogo[1], Mulualem Tigabu[2] and Odén Per Christer[2]

Grazing, fire and tree cutting are major disturbances affecting plant population dynamics and productivity in savanna ecosystems; yet their effects are highly variable and are driven by stochastic environmental variability. Long-term ecological research is necessary to understand disturbance dynamics in the context of climate change. A factorial experiment was established in 1992 to examine the effects of grazing, prescribed early fire and selective tree cutting on herbaceous and ligneous vegetation on two sites in the Sudanian savanna-woodlands of Burkina Faso.

Overall the results suggest site-specific responses to disturbance; sites also differ quantitatively in structural and functional features, but these differences are confounded by other environmental factors, such as soil and rainfall variability. Grasses make up a large part of the biomass and significant inter-annual variation in species richness, abundance and diversity were found ($p<0.001$), while main or combined effects of the treatments were limited. At both sites, herbaceous mean total biomass was significantly reduced by grazing while it was not affected by fire or cutting. The three disturbances did not affect tree species richness. Livestock had significant effect ($p=0.021$) on the total basal area growth at the site with deep clayey soils, but not at the site with shallow sandy soils which are reported to be more resilient; livestock reduced stump mortality after cutting and increased number of stems while no significant impact was found on basal area growth of small trees. There was no effect of fire on total basal area growth whereas significant impact was found for basal area growth of small trees. Fire reduced sapling population recruitment while grazing had no effect.

In conclusion, better understanding of these disturbance regimes is crucial to project changes due to climate change, to develop recommendations for adaptation strategies, and increase knowledge supporting multiple-use management of the savanna-woodlands.

Key words: anthropogenic disturbance, dry forest, ecosystem resilience, forest management, productivity.

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