PROCEEDINGS

IUFRO Conference on Forest Landscape Restoration

Seoul, Republic of Korea
May 14 to 19, 2007

Hosted by

Korea Forest Research Institute
Korean Forest Society
US Forest Service Research and Development

Sponsored by

International Union of Forest Research Organizations, Divisions 1, 6 and 8
Seoul National University
Northeast Asia Forest Forum
Korea Forest Service
Yuhan-Kimberly, Ltd.
Global Partnership for Forest Landscape Restoration
US Forest Service International Programs
US Forest Service Southern Research Station
Society Ecological Restoration, International
IUCN Commission on Ecosystem Management
IUCN, The World Conservation Union
WWF, The Global Conservation Organization

Organizing Committee

Chair: Dr. Kwang-Soo Chung, Director General, Korea Forest Research Institute
Co-Chair: Dr. John Stanturf, IUFRO Interdivision Coordinator, Forest Landscape Restoration
Coordinator: Dr. Young Kul Kim (KFRI) Prof. Ki Weon Kim (Kookmin University)
Secretariat: Dr. Joo Han Sung (KFRI), Dr. Im Kyun Lee (KFRI), Prof. Yowhan Son (Korea University), Dr. Yeong Dae Park (US Forest Service)
Technical Program: Dr. Kyongha Kim (KFRI), Dr. Jong-Hwan Lim (KFRI),
Dr. Jae Hyoung Cho (KFRI), Randy McCracken (US Forest Service)
Hospitality: Dr. Myung Bo Lee (KFRI), Dr. Young Geun Lee (KFRI), Prof. Ji Hong Kim (Kangwon National University)
Planning and Local Arrangement: Dr. Yongho Jeong (KFRI), Dr. Eunsung Oh (KFRI), Prof. Se-Bin Kim (Chungnam National University)
Finance and Liaison: Dr. Sang Chul Shin (KFRI), Dr. Jino Kwon (KFRI), Prof. Heonho Lee (Yeungnam University) Jerilyn Levi (US Forest Service International Programs), Jennifer Conje (US Forest Service International Programs), Alexander Buck (IUFRO Secretariat)
Publicity: Dr. Suk Kuweon Kim (KFRI), Dr. Sun Hee Kim (KFRI), Prof. Byong-Min Song (Sangji University)
Publications: Dr. John Stanturf (US Forest Service), Dr. Joo Han Sung (KFRI), Dr. Yeong Dae Park (US Forest Service), Patricia Outcalt, (US Forest Service, Center for Forest Disturbance Science)

Scientific Committee

Dr. John Stanturf, IUFRO Divisions 1 and 3 and USDA Forest Service
Dr. John Parrotta, IUFRO Division 1 and USDA Forest Service (CSC, IUFRO 2010)
Dr. Palle Madsen, IUFRO Division 1 and Danish Forest and Landscape-KVL
Dr. Jeffrey Sayer, WWF and GFLRP
Dr. Emile Gardiner, IUFRO Division 1 and USDA Forest Service
Prof. Pil Sun Park, Seoul National University
Dr. Joon Hwan Shin, Korea Forest Research Institute

Dr. Alex Mosseler, IUFRO Division 8 and Natural Resources Canada
Dr. Shirong Liu, Chinese Academy of Forestry
Dr. Peter Herbst, IUFRO Division 6
Dr. Tom Crow, IUFRO Division 8 and USDA Forest Service
Dr. George Gann, Society for Ecological Restoration International
Dr. David Lamb, IUCN Commission on Ecosystem Management and University of Queensland

With Assistance and Support from

Rebecca Garner, Lynne Breland, and Janet Revell, USDA Forest Service, Center for Forest Disturbance Science

Suggested Citation: Stanturf, John (Ed.). 2007. Proceedings of the IUFRO Conference on Forest Landscape Restoration. Seoul, Korea 14-19 May 2007. Korea Forest Research Institute, 268pp.

INTERNATIONAL CONFERENCE ON FOREST LANDSCAPE RESTORATION
MAY 14-19, 2007
SEOUL, SOUTH KOREA

MAY 14, 2007

Moderator:	**Prof. Seong Il Kim**, Seoul National University
0830 - 0900	Registration
0900 - 0905	**Dr. Kwang-Soo Chung**, Director General, Korea Forest Research Institute, Seoul, Korea
0905 – 0910	**Dr. Seung-Jin Suh**, Chief, Korea Forest Service, Daejeon, Korea
0910 – 0920	**Dr. Jim Reaves**, Associate Deputy Chief US Forest Service, Washington, DC
0920 – 0925	**Prof. Don Koo Lee**, IUFRO President, Seoul National University
0925 – 0930	Group Photo
0930 – 1000	BREAK

Plenary Session I

Moderator:	**Prof. Peter Burbridge**, University of Newcastle-upon-Tyne, UK
1000 – 1030	The Global Partnership on Forest Landscape Restoration **James Carle**, FAO, Rome, Italy
1030 – 1100	Models for Urban Forest Restoration: Human and Environmental Values **Paul Gobster,** US Forest Service, Chicago, Illinois
1100 – 1130	Conflict Management in Multi-Party Restoration Projects **Jens Emborg**, Danish Forest and Landscape Institute, University of Copenhagen, Denmark
1130 – 1200	Forest Damage History and Future Directions for Forest Landscape Restoration in Korea **Joonhwan Shin**, Korea Forest Research Institute, Seoul, Korea
1200 – 1330	LUNCH

Concurrent Session I-A
Social Factors and Policy

Moderator: **Prof. Dong Yeop Kim**,
Sungkyunkwan University

Concurrent Session I-B
Technical Factors

Moderator: **Dr. Viachleslav Kharuk**,
Sukachev Institute of Forest, Krasnoyarsk, Russia

1330 Managing Restoration Conflicts - The Collaborative Learning Approach.
Jens Emborg, Danish Forest and Landscape Institute, University of Copenhagen, Denmark

1350 Incorporating Diverse Stakeholders' Interest in the Restoration of Grand Forest Park Sultan Thaha Syaifudin, Jambi, Indonesia
Ulfah J. Siregar, Bogor Agricultural University, Indonesia

1410 Integrating Scientific Research with Community Needs to Restore Forest Landscapes in Northern Thailand: A Case Study of Ban Mae Sa Mai
Stephen Elliot, Chiang Mai University, Thailand

1430 Landscape Restoration in the Netherlands: Policy Aspects and Knowledge Management
Rob J.J. Hendriks, The Netherlands Ministry of Agriculture, Ede

1450 Tropical Afforestation and Reforestation Strategies to Conserve Biological Diversity and Increase Global and Local Benefits
Anthony S. Davis, Purdue University, West Lafayette, Indiana, USA

1510 BREAK

1330 Successful Plant Production for Forest Restoration: What Foresters Should Ask Nursery Managers About Their Crops
R. Kasten Dumroese, US Forest Service, Moscow, Idaho

1350 Nursery Cultural Techniques to Facilitate Restoration of Koa (*Acacia Koa*) Competing with Exotic Kikuyu Grass (*Pennisetum Clandtstinum*) in a Dry Tropical Forest at Pu'u Wa'a Wa'a Hawai'i
Douglass F. Jacobs, Purdue University, West Lafayette, Indiana, USA

1410 Canopy Opening and Regeneration Dynamics on Young Lucidophyllous Forest Restored by Tree Plantation in Japan
Juyoung Lee, Chiba University, Japan

1430 Liming as a Method to Improve Natural Regeneration of Beech (*Fagus sylvatica* L.) on Acid Soils in Southern Sweden
Rolf Övergaard, Swedish University of Agricultural Sciences, Alnarp

1450 The Direct Seeding of Beech (*Fagus sylvatica* L.) and Oak (*Quercus robur* L., *Quercus petraea* (Matt.) Liebl.) as a Method for Forest Restoration - Some Problems and Possibilities
Maria Birkedal, Southern Swedish Forest Research Center, Alnarp

1510 BREAK

Moderator: **Dr. Victor Teplyakov**, IUCN, Russia

Moderator: **Dr. Eric Gustafson**, US Forest Service, Rhinelander, Wisconsin

1540 Planted Forests and Trees Can Restore Landscapes and Alleviate Poverty
James B. Carle, FAO, Italy

1540 The Relationship between Spatial Distribution Patterns of Forest and Characteristics of Forest Fire at Regional Scale in South Korea
Jungeun Song, Seoul National University, Korea

1600 Could Forest Management that Ensures a Balance of Stand Structures Enhance Biodiversity Conservation in Northeast China's Natural Forest Protection Program Need?
Xuemei Han, Yale University, New Haven, Connecticut, USA

1620 Spatial Variation in Amenity Value of Forest Landscape
Seong-Hoon Cho, The University of Tennessee, Knoxville, USA

1640 Appalachian Regional Reforestation Initiative: Restoring Forests on Mined Land in the United States
Victor Davis, US Department of the Interior, Knoxville, Tennessee; James Burger to deliver

1600 Deviation from Reference Conditions Varies with Site Quality in Longleaf Pine Woodlands
Joan Walker, US Forest Service, Clemson, South Carolina

1620 The Comparison of Stand Structure of *Pinus Koraiensis* Plantations with Adjacent Natural Stands in Korea
Pil Sun Park, Seoul National University, Korea

1640 Regional Climate Effects of the Northern China Forest Shelterbelt Project
Yongqiang Liu, US Forest Service, Athens, Georgia; delivered by John Stanturf

1800-2000 Welcome Reception, COEX Grand Ballroom

May 15, 2007
Plenary Session II

Moderator: **Dr. Dominic Blay**, Forest Research Institute of Ghana

0830 – 0900 Reducing Poverty and Environmental Degradation through Collaborative Forest Restoration Research in the Philippines: The ASEAN-Korea Environmental Cooperation Project (AKECOP)
Lucrecio Rebugio, University of the Philippines, Los Baños

0900 – 0930 Developing and Tracking Restoration Scenarios
Jeffrey Sayer, The World Conservation Union, Gland, Switzerland

0930 – 1000 Multi-stakeholder Governance in Forest Landscape Restoration: Issues of Scale, Knowledge and Collective Action
Doris Capistrano, CIFOR, Bogor, Indonesia

1000 – 1030 Understanding Landscapes through Spatial Modeling
Michael Wimberly, South Dakota State University, Brookings, South Dakota, USA

1030 – 1100 BREAK

1100-1130 Supporting Landscape Ecological Decisions Using the LANDIS-II Forest Dynamics Simulator
Eric Gustafson, US Forest Service, Rhinelander, Wisconsin

1130 – 1200 Landscape Restoration Projects and Research in Central and South America
Olga Marta Corrales, Tropical Agricultural Research and Higher Education Center and Latin American Network of Model Forests, CATIE, Costa Rica

1200 – 1330 LUNCH

Concurrent Session II-A
Ecosystem Services and Modeling

Moderator: **Dr. Paul Gobster**, USDA Forest Service, Chicago, Illinois

1330 Ecosystem Services of Bibosoop in the Korean Agricultural Landscape: Microclimate and Soil Fertility
Insu Koh, Seoul National University, Korea

1350 Symbiotic Service in Managed Forest Landscapes—Does Arbuscular Mycorrhizal Inoculation Potential Allow Restoration of Natural Vegetation?
Martin Zobel, The University of Tartu, Estonia

1410 Locations and Topographical Character of the Maeulsoop (Korean Village Groves) and a Role for the Community
Jino Kwon, Korea Forest Research Institute, Seoul

1430 Preservation and Restoration of Forests Associated with New Town Development in Hong Kong
C.Y. Jim, The University of Hong Kong, China

1450 Designing and Planning Urban Forest Landscapes
J. Bo Larsen, The University of Copenhagen, Denmark

1510 BREAK

Moderator: **Dr. Chun Yong Lee**
Korea Forest Research Institute

Concurrent Session II-B
Restoration Case Studies

Moderator: **Dr. J. Tsogtbaatar**, Institute of Geoecology, Ulaan Baatar, Mongolia

1330 Future Forest Landscapes: Wilding and Sustainability
Ian Convery, The University of Central Lancashire, UK

1350 Restoration of Deciduous Forest in Söderåsen National Park, Sweden
Oddvar Fiskesjö, Söderåsen National Park, Sweden

1410 Strategies for Successful Ecological Restoration of Degrade Forest Ecosystem in Mongolia
Yeong Dae Park, US Forest Service, Athens, Georgia

1430 Restoring a Mixed Species Forest Landscape on Private Forest Land Under Heavy Deer Browse Pressure
Palle Madsen, Danish Forest and Landscape Institute, University of Copenhagen, Denmark

1450 Rehabilitation Of Logged-Over Dipterocarp Forests Using the Indonesian Selective Cutting and Line Planting System
Prijanto Pameongkas, Bogor Agricultural University, Indonesia; delivered by Ulfah Siregar

1510 BREAK

Moderator: **Prof. Pil Sun Park**
Seoul National University

1540 Management Strategies and Designation of the Baekdudaegan Mountain System Protected Areas
Y. K. Kim, Korea Forest Research Institute, Seoul

1600 Landscape Modeling for Forest Restoration: Concepts and Applications
Weimin Xi, Texas A&M University, College Station, Texas, USA

1620 Prioritizing Forest Restoration to Improve Landscape Function Using GIS Scenario Modelling: An Example for Linkage Restoration
David Pullar, The University of Queensland, Brisbane, Australia

1640 The Community-based Forest Management Program as a Strategy for Forest Landscape Restoration in the Philippines
Romulo Aggangan, Philippine Council for Agriculture, Los Baños

1540 Forest Restoration Using Forest Canopy Density Mapping (FCDM) Technology
Merlinda Manila, DENR IV Calabarzon, The Philippines

1600 Restoring Forests for Multiple Values on Mined Land in the Appalachian Region, USA
James Burger, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA

1620 Restoration of Ex-Gold Mining Area by Recycling Tailing Waste in the Establishment of *Eucalyptus Pellita* and *Gmelina Arborea* Plantations in PT. Aneka Tambang Pongkor, Bogor, Indonesia.
Chairil A. Siregar, Forestry Research and Development Agency, Bogor, Indonesia

1640 The Impact of a Monoculture Plantation (Rubber Plantation) on Soil Quality Degradation
T.K. Weerasinghe, The Open University of Sri Lanka, Nawala, Nugegoda

1700-1900 POSTER SESSION

May 16, 2007
Plenary Session III

Moderator: **Prof. Eun-Shik Kim**, Kookmin University

0830 – 0900 Rehabilitation of Degraded Lands in Sub-Saharan Africa
Dominic Blay, Forest Research Institute of Ghana, Kumasi

0900 – 0930 Changes in Forest Soils as the Result of Exotic Diseases, Timber Harvest, and Fire Exclusion and Their Implications on Forest Restoration
Russell Graham, US Forest Service, Moscow Idaho

0930 – 1000 Broad-Scale Restoration of Landscape Function with Timber, Carbon, and Bioenergy Investment
Richard Harper, Forest Products Commission Western Australia, Perth

1000 – 1030 The Role of Forest Landscape Restoration in Supporting a Transition towards more Sustainable Coastal Development
Peter Burbridge, University of Newcastle-upon-Tyne, UK

1030 – 1100 BREAK

1100 – 1130 Perspectives on Forest Landscape Restoration and Stream Fishes of the Southeastern United States
Melvin Warren, US Forest Service, Oxford, Mississippi

1130 – 1200 Restoring Highly Modified Landscapes in Northwest Europe: Which Targets are Feasible?
Rudy van Diggelen, University of Groningen, The Netherlands

1200 – 1330 LUNCH

Concurrent Session III-A
Restoration Case Studies

Moderator: **Dr. Melvin Warren**, US Forest Service, Oxford, Mississippi

1330 Monitoring on Recovery of Forest Ecosystem Post-Forest Fire in Korea
Y. G. Lee, Korea Forest Research Institute, Seoul

Concurrent Session III-B
Multi-Purpose Restoration

Moderator: **Dr. Russ Graham**, Forest Service, Moscow, Idaho

1330 Economics of Community-Based Forest Management Program as a Strategy for Forest Landscape Restoration in the Philippines
Leni D. Camacho, University of the Philippines, Los Baños

1350 Early Successional Changes in Forest Ecosystems after a Gap-Forming Disturbance
Nina Ulanova, Moscow State University, Russia

1410 Restoring Broadleaved Forest in Southern Sweden
Magnus Löf, Swedish University of Agricultural Sciences, Alnarp

1430 Estimation of the Current Forest Landscape State and Dynamics Using a Topogenetic Forest Cover Classification
Vera Ryzhkova, V.N. Sukachev Institute of Forestry, Krasnoyarsk, Russia

1450 How Many Species Should be Mixed and How Much Genetic Diversity is Needed?
Markku Larjavaara, Bioversity International, Serdang, Malaysia

1510 BREAK

1350 Conservation Relay: Private Sector Participation in Restoration of Degraded Forest Landscapes in Mt. Makiling, Philippines
E.R.G. Abraham, University of the Philippines, Los Baños

1410 Developing Guidelines for Forest Restoration in the Philippines
Rex Victor Cruz, University of the Philippines Los Baños

1430 Role of Microenvironment for Restoration on Four Tropical Species in the La Mesa Watershed, Philippines
S.Y. Woo, University of Seoul, Korea

1450 Restoration of Post-Fire Oak-Korean Pine Forest with *Rhdodendron mucronulatum*, Russia
T.A. Komarova, Institute of Biology and Soil Sciences, Vladivostok, Russia

1510 BREAK

Moderator: **Dr. Victor Teplyakov**,
Moderator: **Su-Young Woo**,
IUCN-Russia
University of Seoul

1540 South Siberia Mountain Forest – Tundra Landscapes in the Context of Climate Change
Viacheslav Kharuk, V.N. Sukachev Institute of Forestry, Krasnoyarsk

1600 Mainstreaming Biodiversity Conservation in Restoration of Private Forests From Northern Western Ghats, India
Jayant Sarnaik, Applied Environmental Research Foundation, Maharashtra, India

1540 Assisted Natural Regeneration (ANR) as an Effective Technique of Rehabilitating Marginal Grasslands in the Philippines
Wilfredo M. Carandang, University of the Philippines, Los Baños

1600 Growth, Biomass Allocation and Water Use Efficiency of Two-Year-Old Siberian Larch (*Larix Sibirica* Ldb.) Seedlings Grown at Different Conditions from Diverse Seed Sources of Mongolia
Batkhuu Nyam-Osor, Seoul National University, Korea

1620 The Role of Various Types of Artificial Forest in Soil and Water Conservation an South China

Billy C H Hau, The University of Hong Kong, China

1640 Rehabilitation of Damaged Landscape of Open Cast Coal Mine Spoil in a Dry Tropical Environment of India: An Implication of Forest Restoration

A.N. Singh, Panjab University, Chandigarh India

1620 Restoration of Mt. Makiling - A Biodiversity Hotspot and Ecotourism Destination in the Philippines

Portia Gamboa-Lapitan, Makiling Center for Mountain Ecosystems, Laguna, The Philippines; Juancho B. Balatibat to deliver

1640 Forest Restoration through Mycorrhizal Technologies: The Case of Bukidnon Forest Industries, Philippines

Nelly Aggangan, University of the Philippines Los Baños

1530 to 1730 Special Workshop on FLR Tools, **David Lamb** and **David Pullar**, University of Queensland, Brisbane, Australia

1730 – 1800 Closing Ceremony—**John Stanturf**, US Forest Service

1800 – 2200 Farewell Dinner at Korea Forest Research Institute

TABLE OF CONTENTS

OPENING ADDRESS

Kwang-Soo Chung, Director General, Korea Forest Research Institute

Good morning distinguished participants!

It is my great pleasure and honor to welcome all of you who are joining to this IUFRO International Conference on “Forest Landscape Restoration,” in Seoul.

I deeply appreciate Korea Forest Service, Seoul National University, and Northeast Asian Forest Forum for their countless contributions for this conference. My special thanks are extended to USDA Forest Service as well.

Because forests have been degraded due to urban development and industrialization, we should conserve forests as countless natural assets for us as well as our future generation. In particular, forest lands are considered as the key aspect of landscape view, so these should be a priority to restore and beautify the landscape.

I believe this conference will contribute to verifying the role of forests for landscape restoration, and finally to communicate our knowledge to governments, NGOs, forest managers, and so on.

The Global Partnership on Forest Landscape Restoration includes a variety of governments, NGOs, committees, and individuals an international network, which was activated in 2003. A variety of organizations such as IUCN has joined into the partnership. Currently this partnership has devoted its efforts to strengthen the capacity of the network and to develop practical forest restoration models.

Ladies and gentlemen,

Today, we have ten sessions in this conference, including three plenary sessions, six concurrent technical sessions, and a poster session. Themes addressed in these sessions include forest landscape change and its estimation, landscape ecology, ecological services, forest landscape management, and so on. There are 107 papers to present technical findings during the Conference. It will definitely help to strengthen our network in the field of forest landscape restoration.

Finally, I would like to express my deepest thanks to
Prof. Don Koo Lee, President of IUFRO,
Dr. Seung-Jin Suh, Chief of Korea Forest Service,
Prof. Zin-Su Kim, President of Korean Forest Society, and
Dr. Jim Reaves, USDA Forest Service for attending.

Ladies and Gentlemen! Let the conference begin.

Thanks.

CONGRATULATORY ADDRESS

Seung-Jin Suh, Chief of Korea Forest Service

Thank you Chairman, your Excellencies, and distinguished participants.

First of all, I would like to express my sincere thanks to Dr. Don Koo Lee, President of IUFRO, Prof. Zin-Su Kim, President of the Korea Forest Society, and Dr. Jim Reaves from the USDA Forest Service for participating here.

It is my great pleasure to deliver a congratulatory speech for the IUFRO Conference on Forest Landscape Restoration and express my appreciation to all participants.

Distinguished participants,

As you all are aware, IUFRO has played a crucial role to provide an opportunity for international talks about forest roles for human well being, contributed to enhancing cooperation among forest research institutes and academic forest experts, and supporting research outcomes. So I would like to express my appreciation for IUFRO's great achievements in forestry science.

Ladies and gentlemen,

The Korea Forest Service has been taking part in international forestry research as part of the international community. Please allow me to introduce the state of forests in Korea as well as some of our endeavors in forest restoration. Korea's forests were in the state of severe devastation thirty years ago. In the 1950s, 68 million ha, 7% of the total forest area, was degraded due to indiscreet logging and the Korea War so floods and droughts repeatedly caused severe impacts every year. However, 56 ha of degraded forests were rehabilitated by 1972 but by 1988, the nationwide forest rehabilitation project was a huge success. Therefore, I believe that this success is significant as an outstanding achievement in Forest Landscape Restoration.

Further, I expect that Korea's forest rehabilitation experience can contribute to combating desertification in China and Mongolia, which is regarded as one of the most critical global issues.

In Korea, the Act on Protection of Baekdudaegan Mountain System was enacted in 2003 for conservation of biodiversity and ecosystem in the Baekdudaegan Mountains, which is considered as the core of the Korean landscape. 26 million ha of forests, accounting for 2.6 % of the total territorial land area, has been protected. Rehabilitation projects have been undertaken under this act. I expect that these efforts all will contribute to upgrading the knowledge and technology of Korean forest landscape restoration.

Ladies and gentlemen,

The Republic of Korea has been internationally recognized as a successful nation in forest rehabilitation by FAO and other international organizations. And Korea will continue to facilitate restoration projects considering landscape, since landscape is a critical component of the interaction between nature and human beings.

Considering the current trend that the international community has been more interested in forest benefits, I think this conference has a significant meaning in that forest health and vigour, in terms of ecosystem and landscape, can be considered and that diverse methods can be proposed for landscape restoration, thereby enhancing the international network.

Distinguished participants

I am convinced that IUFRO will play a leading role in forest-related international talks through positive activities. Korea is going to host the IUFRO World Congress in Seoul in 2010. I will support preparatory work for the Congress to be a great success.

I would like to take an opportunity to extend my deepest gratitude to the Korea Forest Research Institute and the Korea Forest Society for preparing for this conference, and special thanks to the USDA Forestry Service, Seoul National University and the Northeast Asia Forest Forum.

Once again I would like to wish the best success for the conference and thank all participants today.

Thank you very much.

ECOSYSTEM RESTORATION: A FOREST SERVICE PERSPECTIVE

Jim Reaves

Good morning. I bring you greetings from the Chief of the Forest Service, Gail Kimbell. I am excited about what is occurring here and want to commend the organizers of this conference and the country of South Korea for hosting such a prestigious event. Having such an event demonstrates that ecosystem restoration is worthy of being discussed on an international scale. I am confident that all participants will leave this conference with a better understanding of what we are doing in ecosystem restoration and continue to set the stage for more collaboration at the international level.

Ecosystem restoration is an overarching and unifying policy objective as the Forest Service embarks on restoring ecosystems from catastrophic natural disturbances such as fire, floods, hurricanes, or from past land management practices. Restoring processes and functions to ecosystems creates the resilience that helps sustain forests in our global environment. These sustainable healthy ecosystems produce multiple benefits such as improving wildlife and fish habitat and large-scale watersheds; and reducing invasion of forest ecosystems by invasive species. The Forest Service is making a fervent effort to address the aforementioned areas at landscape levels through the development of relevant policies and practices. Such an approach will help us in our ecosystem restoration efforts as we apply scientific knowledge to land management problems.

"The mission of the USDA Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations." Ecosystem restoration is consistent with our Mission and, indeed, a priority of our contemporary agenda for land management. We have recently developed a Restoration Framework that outlines our renewed urgency in this area. This Framework offers recommendations to improve the agency's ability to restore ecosystems through: (a) adopting a national policy regarding ecosystem restoration, (b) increasing the productivity of the agency's restoration efforts, (c) engaging stakeholders and partners as we develop our restoration priorities, and (d) using budget and performance incentives to increase accomplishments of ecosystem restoration objectives. As each of you well know, there are many definitions of restoration—no single definition fully captures the concept. For the purpose of our discussion, I will use the definition put forth by the Society for Ecological Restoration International (SER, 2004): Ecosystem (ecological) restoration *"is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed."* This definition aligns quite well with the Restoration Framework developed by the U.S. Forest Service.

There are two fundamental principles that pervade our Restoration Framework: (1) collaboration with the public and with partners because restoration needs to reflect diverse public values and transcend property lines, and (2) scientific knowledge is essential to effective ecosystem restoration and necessarily serves as its basis. Underpinning these two fundamental principles are a set of operational principles that will be used in the implementation of our restoration projects. We believe that these operational principles will serve us well as we address ecosystem restoration through planning, policy development, and collaboration with internal and external partners. They will also help us identify the most efficient and sustained approaches to ecosystem restoration using the best available science as our foundation.

The Forest Service is committed to casting as broad a net as we can in an attempt to increase our emphasis on ecosystem restoration. We are committed to seeking and setting goals for restoration that reflect societal choices—choices that require a keen knowledge of the benefits to society as well as maintain resilient and productive ecosystems. Thus, it is clear to us that success will be achieved by making operational decisions at the lowest possible levels in our agency, as well as in external organizations. This approach is important as we carry out collaborative ecosystem restoration across organizational and geographic boundaries. Such an effort will help the Forest Service implement ecosystem restoration more efficiently and strengthen partnerships.

Until recently, restoration efforts in the Forest Service were primarily undertaken at a stand level without much forethought about what the impacts might be at the landscape level. This occurred for several reasons—one of which was the lack of science concerning the benefits of restoration at the landscape level. Recent research has enabled a richer understanding of ecosystem response at different spatial scales and the importance of ecosystem function over large geographic domains. This forest landscape restoration conference will help us advance this knowledge and consider

Associate Deputy Chief for Research and Development USDA Forest Service, Washington, DC; jreaves@fs.fed.us

previously unaddressed land management challenges. An integrative approach to landscape and local-level restoration will help us establish restoration objectives for the long-term. These long-term objectives are necessary to help us identify valid benchmarks, craft well-though-out implementation strategies, and develop consistent monitoring methods and performance measures. Having consistent monitoring methods in place is imperative because ecosystems are rapidly changing systems. Their dynamics will become more evident in the coming years. For example, climate change will certainly have accelerated impacts on forest ecosystems at a rate we have not experienced in the past. According to Harris et al. (2005), ecological restoration including reforestation and afforestation, and rehabilitation of degraded land, will be included in the array of potential human responses to climate change. Therefore, using multiple sources of relevant information will provide better insight into what is occurring and may be the most reliable way to predict likely future events. For example, large-scale bark beetle infestations and the resulting tree mortality and their relationship to climate change may be better predicted by using multiple sources of information.

Similarly, events resulting from climate change can cause uncertainty in ecosystem restoration. We must deal with uncertainty by using adaptive approaches. This includes professional experience as well as traditional knowledge. In his book *"1491: New Revelations of the Americans Before Columbus Came,"* Charles Mann states that collective interventions of Native Americans on the landscape in the "New World" were both extensive, and in many cases, intensive. Mann goes on to say, "If there is a lesson it is to think like the original inhabitants of these lands we should not set our sight on rebuilding an environment from the past but concentrate on shaping a world to live in for the future." We, in the Forest Service, have come to realize that the science of restoration is moving away from looking backward to looking forward. More appropriately, the science is moving away from creating previous states and moving toward the restoration of ecological processes that create healthy, productive, diverse and perhaps most importantly, resilient ecosystems which is our desired future condition. We are comfortable with this concept and will continue to embrace it.

Addressing ecosystem restoration at a landscape scale is an appropriate approach for the Forest Service—especially since we manage almost 78 million ha of forest and grasslands in all geographic and ecological regions. In the past, addressing restoration at the stand level served us well but with the increasing complexity brought on by climate change and a growing number of catastrophic disturbances (fire, hurricanes, floods and insects and diseases) and diverse needs of forest landowners; restoration at the landscape scale level has taken on a renewed urgency. Given that these events will continue to occur, we find our land managers having to adapt to different situations in their ecosystem restoration efforts. Therefore, we are learning as we go.

Learning as we go may have the connotation that our past efforts in restoration were all wrong or flawed. To the contrary, we have made great strides in understanding and implementing restoration at the stand level. But now, given the increased complexity surrounding ecosystem restoration and the wide array of human dimensions that have to be factored in, learning as we go makes good sense. This is especially relevant as we increase our role in fostering restoration of our private forest lands. The key, however, will be for us to take what we have learned and integrate that into our future planning and implementation efforts.

Allow me to provide a few examples of how Forest Service research is better preparing us to cope with the significant restoration needs we face today. Recent research results suggest some basic principles important to addressing restoration of forests subject to fire suppression, a problem that affects millions of ha of western forests (Agee and Skinner 2005). These results suggest that in mixed conifer regions of the western United States forest restoration activities require reduction of surface fuels, increasing the height to live crown, decreasing crown density, and retaining large trees of fire-resistant species. Research at the Teakettle Experimental Forest in the southern Sierra Nevada mountains of California show that thinning combined with prescribed fire can be useful tools to achieve these objectives (North et al. 2006). Thinning treatments alone fail to approximate historic composition, spatial pattern or diameter distribution. Current stands of most mixed conifer forests contain fewer large trees than historic conditions, suggesting treatments should retain more intermediate-size trees to provide for future large tree recruitment. Evidence of the research at Teakettle suggests that mixed-conifer restoration needs thinning prescriptions that vary by tree species and flexible rather than rigid upper diameter limits to retain some trees in all size classes. This prescription of understory thinning combined with prescribed fire significantly reduced stem density and produced a spatial and compositional pattern closest to historic conditions. Such management activities will thus restore the resiliency and diversity we hope to have in the crucially important forest lands of the western United States.

In the restoration of Great Basin watersheds, research is focused on increasing our understanding of the effects of both long-term climate change processes and more recent natural and anthropogenic disturbances on Great Basin ecosystems and watersheds. We then use this understanding to devise meaningful scenarios for their restoration and management.

In our efforts to restore longleaf pine ecosystems in the South, scientists are conducting research that is directed at developing reliable restoration management systems through the investigation of physiological processes and ecological relationships to silviculture systems and models.

The last example I would like to share with you is the work we are doing in tropical forestry. This research is aimed at accelerating forest recovery on degraded lands and management of secondary forests. It's being conducted in the Caribbean region, continental areas of Latin America, as well as Africa, Australia, and Hawaii.

I have provided you with some insight of how the Forest Service is approaching ecosystem restoration. Now I would like to talk for just a few minute about some of the tools we are using to help us move forward. On some occasions, we are met with opposition by various publics when we try to implement ecosystem projects. Some opposition is grounded in law, regulations or policy. Other opposition arises from personal perspectives and values. In addition, we are sometimes hindered by laws that make it difficult to implement scientifically sound restoration activities. In some cases, we have been able to appease the opposition by demonstrating that our efforts are not detrimental to the integrity of forests and that our efforts are actually enhancing or accelerating the resiliency of forests. We have done this by holding workshops, establishing demonstration forests, and working collaboratively with external partners. We have also been helped by new legislation such as the Healthy Forest Restoration Act (HFRA). HFRA is designed to help States, Tribes, rural communities and landowners restore healthy forest and rangeland conditions on State, Tribal, and private lands. Embedded in this legislation are directions that relieve the agency of some of the unnecessary burdens that hinder our ability to implement ecosystem restoration projects. Likewise, with the Ecosystem Framework, the Forest Service is becoming more diligent in its efforts to establish consistent restoration policy and develop clear guidance and directions. We are confident we are headed in the right direction with ecosystem restoration.

In summary, the Forest Service's basic approach to ecosystem restoration is threefold:

1) We are taking a forward-looking concept—the reference is the desired future condition;
2) We believe partnerships are essential to involve people and gain public support; and
3) We will continue our focus on restoring ecological processes that create resilient and healthy ecosystems.

Thank you for this opportunity to provide the U.S Forest Service perspective on such an important topic.

Literature Cited

Agee, J.K., Skinner, C.N. 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* 211: 83-96.

Day, K., J. Berg, R. Brown, T. Crow, J. Morrison, G. Nowacki, D. Plunkett, D. Puckett, R. Sallee, T. Schenck, and B. Wood. 2006. USDA Forest Service. Ecosystem Restoration: A Framework for Restoring and Maintaining the National Forests and Grasslands. 24 p.

Harris, J. A., Hobbs, R.J., Higgs, E., Anderson, J. 2005. Ecological restoration and global climate change. *Restoration Ecology* 14(2): 170-176.

Mann, C.C. 2005. 1491: *New revelations of the Americas before Columbus.* Knopf, New York. 480 p.

North, M., J. Innes, and H. Zald. 2006. Comparison of thinning and prescribed fire restoration treatments to Sierran mixed-conifer historic conditions. In Review.

WELCOME REMARKS

Don Koo Lee, IUFRO President

Dr. Seung-Jin Suh, Chief of Korea Forest Service, Dr. Kwang Soo Chung, Director General of Korea Forest Research Institute, Dr. Jim Reaves, Associate Deputy Chief of US Forest Service; Dr. Jeffrey Sayer of World Wildlife Fund in Switzerland; and Dr. John Stanturf, Co-Chair of IUFRO Conference Organizing Committee.

Distinguished colleagues, Ladies and gentlemen, Good morning!

Welcome to this Conference on Forest Landscape Restoration being held under the auspices of IUFRO Divisions 1, 6, and 8 and IUFRO Korea in cooperation with the Global Partnership on Forest Landscape Restoration and member organizations, the International Union for the Conservation of Nature and Natural Resources (IUCN), the World Wildlife Fund (WWF), and the Society for Ecological Restoration.

The Global Partnership recognizes the importance of the international forest community in participating to the quest for forest landscape restoration. IUCN and WWF, for instance, have been working with other government and non-government organizations to establish the Global Partnership on Forest Landscape Restoration. Several joint activities and meetings have been conducted by them since 1996. During the IUFRO Congress side event in Brisbane 2005, this Global Partnership on Forest Landscape Restoration has also been tackled. And this is the first time that a Conference on Forest Landscape Restoration is being held in Korea.

The objective of this Conference, of examining the scientific basis for forest landscape restoration and its linkages to practice and policy is very crucial to understand, as this concerns us all.

Forests play important roles for the people and the environment. Yet in spite of their significance, forests around the world are disappearing and are being degraded at an alarming rate. Around 14 million hectares of world's forest per year are being destroyed mostly in the tropical and developing countries because of a variety of human and natural factors. Forest landscapes universally are being simplified and fragmented by modern land use practices. From the pristine forest we had before, with fresh air, verdant and lush vegetation, clean water, and abundant resources providing lots of goods and services for the people to the dramatic loss of forest cover and degradation of forest land, I believe there is still a remaining hope.

Forest landscape is not merely composed of forests… and a forest is not merely composed of trees…it is an entity, which contributes to the quality of all life on Earth. It provides a home for myriads of plants and animals and without this, life would cease to exist.

This concern over forest and life paved way to the conceptualization of restoring our forest landscapes. Forest landscape is complex and restoration is not an easy task. 'Restoration' effort per se is concerned with the bringing a forest back to its original state. We cannot actually bring back the original one, but we can mimic the functions that it serves.

Ladies and gentlemen!

In this era of environmental dilemma, I would like to emphasize that there is really a need to restore our forest landscapes, but I guess there is something more important to be restored first…the people. We, as part of this large ecosystem, can make an enormous difference in restoring our devastated or degraded forest landscapes. This will of course require flexible and multiple approaches, hence, decision-makers, scientists, and the public should work together.

The continuous deforestation and forest degradation we are facing right now either in the tropical, temperate, or boreal region is a global concern affecting biodiversity, climate change, and human survival. The causes are many and varied among countries and regions. Thus, the need for restoring the lost and degraded forests is an urgent task.

In the Agenda 21, people and an ecosystem-centered restoration approach were highly recommended to address this issue. Forest landscape restoration, thus, which is known to many as the process that aims to regain ecological integrity and enhance human well-being, could be the best way to deal with this. Forest landscape restoration as well could offer major opportunities to address the issues of climate change, biodiversity conservation, and sustainable livelihoods particularly under the Clean Development Mechanism (CDM).

Many conventions arise globally to address this issue of forest degradation; to name a few there are the Convention to Combat Desertification, Convention on Biological Diversity, Kyoto Protocol of the Framework Convention on Climate Change, and the like. These somehow initiated change in the management of the forest and the environment. In addition, the Intergovernmental Panel on Forests (IPF) as well encourages countries to formulate and implement national strategies for addressing the underlying causes of deforestation, to define policy goals for national forest cover as inputs to the implementation of national forest programmes.

For three days we will hear particularly interesting topics on landscape history; landscape ecology; governance, land tenure, and equity; ecosystem services; future landscapes; managed landscapes; and how to do landscape restoration. It is important that we should recognize the opportunity we have here to present our best thinking about forest landscape restoration and to work toward what is best for our forest landscapes.

Before I end, I would like to thank the Korea Forest Research Institute and the Korean Forest Society for hosting this important Conference. I would also like to give my sincere appreciation to the sponsors such as the Korea Forest Service, USDA Forest Service, Seoul National University, and Northeast Asian Forest Forum.

As President of IUFRO, I welcome you all again to this Conference and I hope you enjoy your stay with the beautiful landscape as well as springtime here in Korea.

THE GLOBAL PARTNERSHIP ON FOREST LANDSCAPE RESTORATION

J. B. Carle

Abstract—Forest landscape restoration brings people together to identify, negotiate and implement practices that restore an optimal balance of the ecological, social, cultural and economic benefits of forests and trees within the broader pattern of land uses. It involves practical approaches that do not try to re-establish the pristine forests of the past. Rather, the goal is to adopt holistic approaches to restore the functions of forests and trees and enhance their contribution to sustainable livelihoods and land-use.

The Global Partnership on Forest Landscape Restoration is a worldwide network of more than 25 Governments and organizations working to strengthen forest landscape restoration efforts globally. Partners share their expertise and experiences with other practitioners, Governments, communities and businesses. Several members of the Collaborative Partnership on Forests are active in the Global Partnership on Forest Landscape Restoration.

During Phase I (2003-2005) of the Global Partnership on Forest Landscape Restoration the focus was on raising the profile and understanding of FLR, establishing national working groups, securing funds and providing technical support to its advocates. An International Forest Landscape Restoration Implementation Workshop was held in Petropolis, Brazil, 4-8 April 2005.

During Phase II (2005-2009) aims to: increase the active partnership; extend the network of learning sites to improve understanding and practices in forest landscape restoration; encourage wider multi-stakeholder participation; strengthen the legal, policy, regulatory and institutional frameworks for forest landscape restoration; provide critical information and tools; and conduct another International Workshop.

Forest landscape restoration can be a vehicle to deliver on commitments regarding forests, biodiversity, climate change and desertification as well as contributing towards meeting the Millennium Development Goals. It involves a multi-disciplinary approach that integrates policies, plans and practices across sectors in national development processes, including eradicating hunger, reducing poverty and managing natural resources on a sustainable basis. Consequently, it also involves the integration of national forest programmes, policies and plans into national development programmes.

Experience has shown that successful forest landscape restoration starts from the ground up, with the people who live in the landscape and stakeholders directly affected by the management of that landscape. There is no single blueprint for success, as each situation depends upon unique local circumstances and processes.

Forestry Department, FAO of the United Nations, E-m: Jim.Carle@fao.org

MODELS FOR URBAN FOREST RESTORATION: HUMAN AND ENVIRONMENTAL VALUES

Paul H. Gobster

Introduction

Urban forest restoration programs have been increasing worldwide in recent decades. A mail survey by Borneman and Hostetler (2004) gathered basic information on 33 urban natural areas programs in the United States and Canada and found the programs differed considerably along key variables such as budget, hectares under jurisdiction, and staffing. In terms of their commonalities, most programs were engaged in some form of restoration activity such as invasive plant removal and all relied at least in part on volunteer stewardship efforts. Along with such survey data, more detailed information about the implementation of urban restoration is also needed to assist in the development of successful programs that satisfy a range of human and environmental goals.

In this paper I look in depth at two such programs—in Chicago, Illinois and San Francisco, California—to better understand some of the key issues faced by practitioners and public stakeholder groups when restoration programs are instituted within metropolitan areas. From an analysis of key issues and constraints I suggest that the "classical" model of restoration, where historical authenticity is emphasized in restoring ecological structure and function, may not always provide the best guidance for urban forest restoration programs. My analysis shows such programs may be better conceived along a spectrum of different model types, with different principles and practices emphasized to accommodate human and ecological values in nature.

Case Study: Key Issues and Constraints

I examined restoration activity in Chicago, Illinois and San Francisco, California to better understand some of the key issues faced by practitioners and public stakeholder groups when restoration programs are instituted within metropolitan areas. Both locations have significant amounts of protected open space within their metropolitan boundaries, and while extensive restorative management is happening in urban fringe areas, I focused my case studies on sites within the two cities and their surrounding county because of the diverse range of issues that are being dealt with (Gobster 2001, 2004, 2006). In Chicago there are 49 restoration sites in City of Chicago parks and another 70 sites in the Forest Preserve District of Cook County. These sites range in size from a fraction of a hectare in size to 1500 hectares and include prairie, savanna, woodland, and wetland communities. In San Francisco there are 30 restoration sites in City of San Francisco parks and another 12 sites in Golden Gate National Recreation Area within the County of San Francisco. These sites range in size from less than 1 ha to more than 160 ha in size and include coastal dune, scrub, grassland, wetland, and non-native forest communities.

The fragmented character of these urban natural areas imposes significant restrictions on what ecological conditions *can* be restored through management programs. For example, a prairie restoration at the scale of even the largest of urban sites is unlikely to become home to a bison. Instead, most restorations focus on recovering or reintroducing the key flora of a target community and hope to attract smaller fauna such as butterflies and reptiles. By the same token, a dune restoration cannot be given the freedom to shift across a park road or into a neighbor's backyard. Instead, communities are artificially fixed in space and any movement of elements in the community must take place within site boundaries. And while prescribed burning may be used to manage the understory of an open oak woodland or savanna restoration, setting back succession with a stand-consuming crown fire is not in the urban restorationist's playbook. Thus temporal dynamics are also fixed and give the impression that such communities are stable and climax in character.

Along with these structural constraints there is a host of social and political issues that further define what conditions *should* be restored in urban forest settings. Demand for open space by a diverse range of user and interest groups not only limits the number and size of restoration projects within a program but also what other uses might take place there, how they are managed, and by whom. In San Francisco, restrictions on the use of natural areas for off-leash dog access has led to a major conflict between natural area restorationists and dog owners and threatened progress toward adoption of the city's Significant Natural Resources Area Management Plan. Removal of exotic trees from these restoration sites, especially Australian

USDA Forest Service, Northern Research Station, 1003 University Place, Suite 360,
Evanston, Illinois 60201 USA; pgobster@fs.fed.us

blue gum eucalyptus, has also been a point of conflict in plan adoption, and along with tight air quality restrictions and strong attitudes against the use of prescribed burning has forced restoration managers to consider alternative ways for managing natural area sites. In Chicago, while volunteer-based restoration has long been a hallmark of the metropolitan region's restoration movement, many of the Chicago Park District's larger restoration efforts have been done under contract with professional firms, with volunteers entering the scene to assist with maintenance only after the restoration design has been implemented. The magnitude and complexity of the transformation is a major reason for this, but desire for professionalism, accountability, warranty on plant materials, and time frame for implementation are also important considerations.

Urban Restoration Models

Constraints can often spark creativity, and in the case of natural areas management, practitioners and scholars are beginning to advocate for a broader conception of restoration and document a diversity of restoration models that are more in tune with the human and environmental goals they seek to achieve (e.g., Choi 2004, Gross 2003, Low 2000, Rosenzweig 2003). The following models observed in San Francisco and Chicago illustrate the range of possibilities that may be suited to urban restoration sites:

"Classical" model: Steep topography in San Francisco and broad floodplains in Chicago have been good deterrents to prior development of many of the now-designated natural areas in these two cities, and while most sites have been damaged by overgrazing in the past they retain significant populations of indigenous flora. Restoration of these sites conforms most closely to a "classical" model of ecological restoration, where native plant diversity is maintained and enhanced through invasive species control and other management practices, though these activities are sometimes accomplished in uncommon ways to deal with structural and social constraints. Natural Areas Program gardeners in San Francisco, aided by a substantial force of volunteers, often resort to "boutique," labor intensive methods that would be impractical in larger restorations. For invasive species control this includes hand-pulling to avoid herbicide application and the proposed use of goats to maintain grassland areas in lieu of prescribed burning. In the Cook County forest preserves, restorationists use hand-pollination to revive dwindling populations of the prairie white fringed orchid and keep locations of individual plants secret to avoid theft of this beautiful flower.

Sensitive species model: Some sites in San Francisco harbor plant or animal species that have been identified as rare, threatened, and/or endemic to the Franciscan floristic region that the city nearly completely covers. In contrast to the plant community focus of the classical model, restoration of these sites focuses in significant part on protection and enhancement of the populations of these sensitive individual species, such as the San Francisco lessingia, Western Pond turtle, and California red-legged frog. The weight these species are given in restorative management invokes a kind of "ecological primacy" that makes the existence of incompatible exotics such as eucalyptus or bullfrogs and access by uses such as off-leash dogs much less negotiable. This primacy is particularly controversial when sensitive species are re-introduced into a restoration area where they have been extirpated, and is seen by some critics as a move by restorationists to close off public open space to a special interest. Incompatibilities do not always happen, and in other cases sensitive species might be maintained under novel conditions, such as the anise swallowtail butterfly in San Francisco that relies upon the invasive exotic Italian fennel plant as a major food source.

Habitat model: More broadly conceived than the sensitive species model, the habitat model of restoration aims at providing the appropriate set of conditions for a range of species of interest. Birding is a favored recreational activity in urban natural areas, and while Chicago birders have been vocal proponents of enhancing city parks for bird habitat, their concern has focused more on what provides good food, cover, and nesting rather than on what is native or how authentic a restoration project is. A key part of the Chicago Park District's Nature Areas program focuses on providing habitat for migratory birds in the parks that line the city's 67 km-long Lake Michigan shoreline. The lake is an important flyway and based on recent research the city has installed a system of bird sanctuaries at strategic intervals along the lakefront, characterized as "fast food" stopovers where birds can rest and feed on berries or insects before heading back out on the flyway. Grassland, woodland, wetland and shore habitats provide variety, and sites are managed to restrict some uses to help reduce birds' stress from human disturbance.

Naturalistic model: In most of the larger parks in San Francisco and Chicago, the indigenous landscape has been so thoroughly modified that few vestiges of indigenous nature remain. Yet in their quest to create a human habitat for aesthetic pleasure and recreational use, the original designers of these parks developed naturalistic landscapes that often have considerable ecological potential. Restoration efforts in these parks thus must often work to integrate two (or more) periods of significance—one focusing on ecological restoration and another on restoration of the historic landscape design. Successful projects of this type respect the goals and intent underlying both ideas of restoration yet can produce a hybrid landscape that is its own unique expression of human and ecological values. Examples of this "third way" restoration model in Chicago include the Lily Pool and Montrose Point, two naturalistic oases in Lincoln Park designed in the 1930s by Prairie School landscape architect Alfred Caldwell, where a primarily native plant palette is used to create symbolic renditions of the Illinois landscape as it existed prior to European settlement. An example in San Francisco is the restoration of the historic forests of the U.S. Army Presidio, originally planted in the 1880s by Major William Jones and now part of Golden Gate National Recreation Area, where native grasses and shrubs are being planted under a dominant canopy of exotic trees.

Nature garden model: Contemporary urban garden design is increasingly sympathetic to restoration goals such as the use of native plants and sustainable landscape practices, but often incorporates these considerations in highly artistic and "unnatural" ways. One such example in Chicago is the 3-acre Lurie Garden in the city's new Millennium Park, where designers used plant materials to create a highly symbolic landscape. "Dark" and "light" sections of plantings represent the Chicago region's marshy past and prairie-farmland present landscapes, and are embraced by a hedge of trees symbolic of the northern boreal forest shaped to invoke poet Carl Sandburg's image of Chicago as the "City of Big Shoulders." Native and introduced plants are used in combination to accentuate these themes and provide variety within and across the seasons, and native species such as purple coneflower juxtaposed with their horticultural variants reinforce the idea of the garden as a nexus of nature and culture. While the Lurie Garden may be an uncommon example, designed and vernacular nature gardens can provide key ways of bringing the functional, educational, and symbolic values of restoration into small urban spaces.

Designer ecosystems: A final model I observed looks at the creation of entirely new ecosystems, ones that result from human designs on the land yet also support non-human needs and in some cases allow valued species to flourish that may never have done so with native ecosystems. At Alcatraz Island in San Francisco, exotic vegetation and the foundations of old prison buildings provide a habitat for rare black-crowned night herons that was absent in the island's original landscape. While many designer ecosystems are created accidentally, there are also cases where vegetation such as the Bill Jarvis Migratory Bird Sanctuary in Chicago's Lincoln Park where tree snags and artificial nesting boxes are purposefully created to provide designer habitat.

Discussion and Conclusions

As these models and their examples suggest, the restoration of urban forests can be a highly interpretive endeavor. While the classical model assumes there is an "original nature" out there to be restored as authentically as possible, the goals and constraints inherent in urban restoration often requires the restorationist to improvise upon the theme of original nature. If a comparison could be made to music, much of urban restoration would fall into the realm of jazz improvisation rather than classical composition.

Given the examples identified in these case studies of Chicago and San Francisco, further investigation of alternative models of restoration is warranted. Indeed, evidence from other cities in the U.S. and other countries shows that models focusing on rehabilitation, utilization, and the provision of environmental services such as moderation of urban heat island effects are increasing in use. By examining the human and environmental goals of restoration projects as well as the social and structural constraints, it may be possible to develop guidelines to advise practitioners and policymakers on which model might be most appropriately applied to a given site. Such a "restoration opportunity spectrum" could help to maximize sought-after values and minimize potential conflicts.

Should all of these different models be referred to as restoration? Some have argued that the term restoration should be reserved only for uses that most closely parallel what I have referred to here as classical restoration. But in their own unique ways each of these models contributes to the ideals of restoring nature and culture that have been expressed in the growing literature on the philosophy of restoration (e.g., Higgs 2004, Jordan 2003, Light 2000). My aim here is to clarify rather than confuse, and together these examples suggest that there are many models of nature that provide promising foundations for urban forest restoration efforts (Hull 2006).

Literature Cited

Borneman, D., and Hostetler, M. (2004). Urban natural areas survey results. Presented at 31st Natural Areas Conference, Chicago, IL, October 16, 2004.

Choi, Y.D. (2004). Theories for ecological restoration in changing environment: Toward ‘futuristic’ restoration. *Ecological Research* 19: 75–81.

Gobster, P.H. (2001). Visions of nature: Conflict and compatibility in urban park restoration. *Landscape and Urban Planning* 56: 35-51.

Gobster, P.H. (2004). Stakeholder conflicts over urban natural areas restoration: Issues and values in Chicago and San Francisco. Presented at 4th Social Aspects and Recreation Research Symposium, February 4-6, 2004, San Francisco, CA.

Gobster, P.H. (2006). Urban nature: Human and environmental values. Presented at Commonwealth Club of California, San Francisco, CA, April 7, 2006. Online at: http://www.sfneighborhoodparks.org/events/Gobster2006ValuesUrbanNature.pdf

Gross, M. (2003). *Inventing Nature: Ecological Restoration by Public Experiments.* Lanham, MD: *Lexington Books.*

Higgs, E. (2003). *Nature by Design: People, Natural Process, and Ecological Restoration.* Cambridge, MA: *MIT Press.*

Hull, R.B. (2006). *Infinite Nature*. Chicago: University of Chicago Press.

Jordan, W. III. (2003). *The Sunflower Forest: Restoration and the New Communion with Nature*. Berkeley: University of California Press.

Light, A. (2000). Ecological restoration and the culture of nature: A pragmatic perspective. In: Gobster, P.H., and Hull, R.B. (Eds.), *Restoring Nature*: *Perspectives from the Social Sciences and Humanities.* Covelo, CA: Island Press.

Low, T. (2002). *The New Nature: Winners and Losers in Wild Australia.* Victoria, Australia: Viking.

Rosenzweig, M.L. (2003). *Win-win Ecology: How the Earth’s Species can Survive in the Midst of Human Enterprise.* New York: Oxford University Press.

CONFLICT AND FOREST LANDSCAPE RESTORATION – A COLLABORATIVE LEARNING APPROACH

Jens Emborg

Introduction

Even though Forest Landscape Restoration (FLR) indeed represents deep genuine positive intentions, there certainly are conflicts related to forest landscape restoration projects (Emborg 2007). When forest restoration grows into the landscape level, the social aspects become much more predominant. A positive side of conflict is that it has the potential for mobilising energy – to change and improve un-desired, deadlocked, or otherwise "bad" situations. The big question is how to catch this energy and turn it into positive change? The aim of this article is to present some thoughts and ideas on this question.

To deal efficiently with FLR we have to design and implement work processes in which many people together discuss and decide on complex ecological issues of importance for peoples lives and livelihood. Basically FLR is about (desired) change - and whenever individuals, groups or societies are confronted with change, there is a potential for conflicts to develop and escalate. In this paper I discuss core characteristics of conflicted FLR situations and present practical approaches and tools to the kind of work processes we need to design. The approaches and tools presented are all derived from conflict management theory and practice and played into the field of FLR.

Biodiversity concerns, for example the northern spotted owl in the Pacific Northwest United States and salmon in the Columbia River basin, represent major conflicts between production and conservation interests, leaving many small societies in entrenched conflict (Daniels and Walker 2001). The Collaborative Learning (CL) approach (Daniels and Walker 2001) was developed to assist societies absorbed in environmental conflicts to constructively move forward to improve their environment and livelihood. CL has been applied in a multitude of environmental conflict and land-use planning situations in the US and elsewhere over the last decade (Walker et al. 2006). The Collaborative Learning approach is here presented as a conflict management approach of interest for FLR.

Core Characteristics of FLR Conflict Situations

FLR implies that overall concerns (e.g., sustainable development) have to be balanced against local or individual concerns (e.g., economic interests, deeply held values). The individual (and local) concerns might not all be in harmony with the overall concerns and they might be highly variable depending on who you ask. The process we design must find a way to bridge across the overall concerns and the individual/local concerns (Emborg 2007).

FLR requires a strong input of expert knowledge (e.g., about ecosystems, social factors, and economy). In a complex modern world we, as citizens, expect that major decisions of our society are based on sound technological knowledge. We also expect that we as citizens have a say in decisions potentially impacting our livelihood. In fact there is a paradox on how to achieve the best possible technological (expert) solution; while at the same time leaving room for "ordinary people's" desires and opinions in the decision making process. The process we design must find a way to balance this fundamental paradox of modern democracy (Daniels and Walker 2001).

These balances and trade-offs between overall and local concerns, and between expert and lay-man knowledge are important paradoxes related to how we want to perform modern democracy. This counts when we restore forest landscapes, when we plan for future land-use, as well as in many other cases.

Reframing Conflict Situations to Learning Opportunities

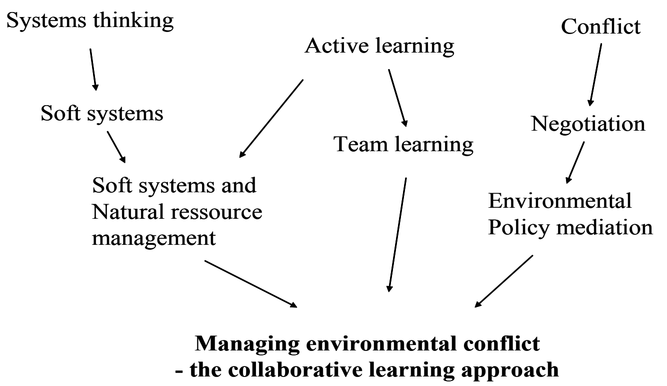


Figure 1: The collaborative learning approach to environmental conflict management is based on a combination of systems thinking theory, knowledge from negotiation and conflict management theory and practice and learning theory (modified from Daniels and Walker 2001). From these three bases of knowledge basic principles for how to address problem situations and design constructive processes has been developed. It is not a key-ready concept at all – every social conflict will be unique in terms of history, actual situation and desired future. Each situation must be analysed and actions must be tailored to the current situation. In this sense there certainly are similarities to FLR and the ideas of adaptive management and adaptive co-management.

Forest & Landscape, University of Copenhagen, Denmark; email-jee@life.ku.dk

A specifically promising approach to these balances in social conflicts is to *reframe* conflict situations (for example FLR cases) and consider them as *learning situations* – in which the parties need to learn from each other in order to make decisions and act together. The potential of reframing of such situations is well known from conflict management theory and practice, for example when parties in conflict engage in war-like competitive games typically resulting in win-lose solutions to the conflict. The mediator seeks to reframe the situation to a collaboration exercise in which the parties must collaborate to explore, understand, and resolve problems for mutual satisfaction (Deutsch 2000).

In complex conflict (decision making or planning) situations in which multiple parties are interacting over several issues, typically having strong interests and deeply held values at stake – it has proven constructive, in several cases, to frame the situation as a mutual learning situation under the modest ambition of improving the situation (Lee 1999, Daniels and Walker 2001).

Learning theory has fundamental features in common with planning and conflict management theory. Considering such situations in a learning perspective allows us to bring in a whole portfolio of learning theory into play. It is as an example striking to see and experience how the well-developed theory of experiential learning (Kolb 1984) can be utilised in planning and conflict management. Planning and conflict management can be structured according to the learning cycle – concrete experience, reflective observation, abstract conceptualization, active experimentation, - concrete experience, reflective….. This cycle equals the basic planning and conflict management approaches - assess situation, reflect and analyze, make strategy, implement strategy and evaluate result (=assess situation) … These common features has also been utilised to develop the adaptive management approach (Lee 1999) and further developed in the adaptive co-management concept (Ruitenbeek and Cartier 2001, Olsson and Folke 2004).

The collaborative learning approach (Daniels and Walker 2001) draws heavily on learning theory in an attempt to develop ways to address the above described democratic paradoxes related to environmental and land-use planning and decision making (including FLR). The learning and group-learning approach is combined with a systems thinking approach and battered with conflict management and negotiation theory and practice into a theoretically well-founded, comprehensive and coherent approach to manage difficult multiparty conflicts or decision making situations in land-use and environmental settings (Fig. 1). The basic idea and principles of the systems thinking and the conflict management strains are described in more detail below.

Systems Thinking As a Tool for Dialogue and Mutual Understanding

FLR situations often deal with complex and large-scale ecological problem settings. These situations plays out in a just as complex social context (ITTO 2005, Maginnis et al. 2005, Maginnis and Jackson 2005). Decisions and plans regarding the ecological systems might have implications for the social systems and vice versa (Gunderson and Holling 2001). Systems thinking is a classical approach to deal with ecological as well as social systems (Emborg 2007). By constructing models experts seek to isolate the most important elements, structures, and dynamics of the systems in question. The borders of the system are defined, feed-back mechanisms identified and described, input and output considered etc. The process of *constructing* the models is usually equally important as the model itself – by constructing the model we learn about the system.

Collaborative learning emphasises the substantial results and the process equally and utilises systems thinking to achieve a good balance. Many of the more soft desired outcomes (e.g., improved mutual understanding, trust and relationships among parties in a conflict) are actually strongly related to the process itself. A typical activity in collaborative learning workshops is that participants with hugely variable backgrounds and expertise engage in collaborative efforts to map and model the problem situation in question in its full complexity. Such

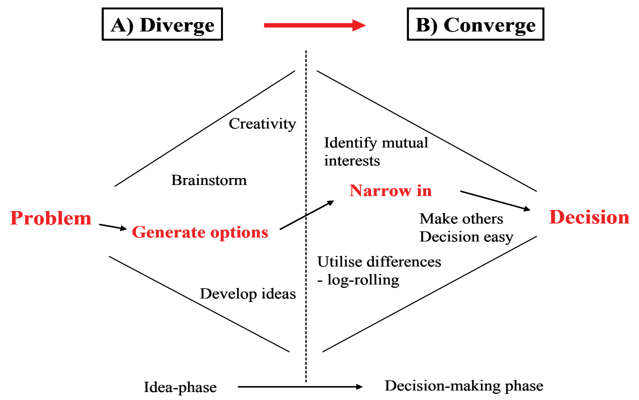


Figure 2: The "group-decision-making diamond" is followed in the BTNF forest planning process (inspired by Kaner et al. 1996). The diamond symbolises how a group first has to understand (and agree on) the problem at hand, and then generate options for possible actions (divergent process) before they narrow in (convergent process) and decide upon specific future actions. Often, in fact, a process will include many diamond processes. The decision making process itself can be understood, analysed and constructively be debated in a group by help of this figure. E.g. if the group leader for one reason or another suddenly jumps to the decision phase by picking "a quick solution" – long before the rest of the group is ready to converge. Such "premature decision making" and other difficult procedural issues can in some cases be collectively understood and discussed openly and constructively by use of the model.

collaborative efforts help each participant to see and consider the *whole* situation rather than just the bits and pieces of particular individual interest and importance. People are forced, step by step, to see their own viewpoints in a broader context. This in turn helps people to stay more open to the interests and viewpoints of the other parties. Eventually the modelling exercises prepare the ground for more listening and more constructive integrative solutions. Further, the parties may agree on key features of the model and identify strategically suitable places to attack discovered problems in order to generate mutually desired improvements of the system.

Conflict and Negotiation Theory and Tools

To supplement and support the two overall components of the collaborative learning approach to environmental and land-use conflicts (including FLR), a bucket-full of theory from conflict management is brought into play. From this body of theory, a toolbox-full of analytical frameworks, diagnostic tools, and procedural guidelines has been developed. These tools are available for the facilitators and conveners of public participation processes, FLR project management, adaptive, and co-adaptive management initiatives etc.

As an example the well-known *principled negotiation* ("win-win") approach to negotiation (Fisher and Ury 1991), based on research results from the Harvard Negotiation Project, has been utilised in the collaborative learning approach. Parties often get blinded or at least narrowly focused on their own positions, which in turn leads to deadlocked negotiation or destructive conflict. If parties focus on their interests and needs rather than specific positions – and actually also try to learn about the interests behind their opponent's positions – there is a fair chance to avoid such destructive dynamics. Focus on interests and needs instead of specific positions creates much more space for mutually satisfactory (win-win) solutions. Further, if parties actually try to listen actively to what the other parties want and need there is a much greater chance to produce mutual gains.

Collaborative Learning and other approaches to conflict management and negotiation include activities that seek to stimulate parties to focus on their interests and needs rather than sticking to rigid positions. The aim is to create decision making and planning procedures in which the parties engage in collaborative rather than competitive behaviours, together trying to understand the problem from all sides and creatively generate good solutions attempting to meet the needs of all – as far as possible. The dialogue and deliberation processes (around the systems and around the difficult issues) also seek to generate a realistic perception of *the whole* and in this light be able to set realistic and fair aspirations. If parties tend to set unrealistically high aspirations they are at risk of disappointment, potentially leading to conflict escalation (Pruitt and Kim 2004).

A case example – The Bridger-Teton National Forest in the US

The Bridger-Teton National Forest (BTNF) in Wyoming, USA is currently developing a forest management plan with a high level of citizen involvement and closely coordinated with other institutions and NGO's from the area (Walker et al. 2006). BTNF covers about 2 million ha and the planning process itself is scheduled to last some 3-years. The collaborative learning approach has been chosen for this planning process and after 3-years it is likely that more than 200 public workshops and meetings will have been held. A two-track procedure has been developed to cope with the complexity of the situation. First track is the co-operators group of organised and formal representatives (county commissioners, agency people, conservation districts etc.) who meet to discuss and deliberate on various planning issues – with a special emphasis on overall and general issues. Second track is open to the general public and is organised as series of topical workshops for citizens with interest in specific parts of the forest (e.g. the BTNF forests in the vicinity of the city of Kemmerer).

The whole planning and decision making process at BTNF can be perceived as a diamond (Fig. 2). The first step is to better understand the problem-situation - to understand the problem before you solve it! The second step is to generate options – possible ways to improve the situation – this is done as a creative collaborative effort in which individual mapping of needs/desires/interests, brainstorming and open dialogue in smaller groups would be typical activities. The third step is to negotiate and develop mutual beneficial improvements of the system. Fourth step is to actually decide what to do – design actions.

The whole process can be perceived as one big diamond-process – understand the problem, brainstorm for options, negotiate solutions, and decide on actions. However, in practice the whole process represents a large number of diamond-sub-processes on various issues (e.g., economy, wildlife, recreation) and/or locations. Each diamond-process represents a collective pumping action in which *participants diverge* (e.g. brainstorming) to create options - and converge to make decisions – to given problems. At the BTNF case the diamond group-decision-making model promises to generate mutually beneficial solutions – and, what may be more important, to work as a transparent medium to discuss the decision making procedure as such. The overall aim of involving the stakeholders is to formulate a common vision among the stakeholders – and, even more importantly, to generate ownership to the process, the area and the vision. It is a long-term goal is to improve the relationship between the agency (Forest Service) and the public – in terms of trust, communication, and levels of discretion.

In total, the whole process is designed to make progress regarding:

1) Substantial outcome – how to use the forest, economy, wildlife, environment, etc.?
2) Relationship building – how to improve the relations among citizens, stakeholders and agencies in the local society?
3) Improved decision making procedures – how to address the paradoxes of modern democracy (as outlined in the introduction)?

Under guidance of some key principles – e.g., work towards improvement of situation rather than solution of problem and guide participants into collaborative behaviour rather than competitive warfare and provide time enough in the process for individuals to learn, adapt and change. At the detailed level various principles, methods and techniques are applied and combined in order to achieve desired results at BTNF.

Lessons learned from the practice of collaborative learning

What can FLR then learn from collaborative learning – and the BTNF case? Combining Conflict management theory and practice to FLR is all very new – but I would not hesitate to outline the following lessons learned so far:

1) Working with nice tools and principles (e.g. the group-decision diamond) derived from good and strong theory may sound easy, logical and straight forward. However, it is not always easy at all to keep things on track, i.e., the desired constructive collaborative learning track. Every situation is unique, immensely complex, interactions and dynamics are unpredictable, etc. These facts point to another level in which conflict management theory and practice plays an important role: Conflicts do and will occur during these kinds of working processes, things do run out of hand, people lose control, vent anger, and blame others for past events. Facilitators, staff – and participants skilled in communication, constructive negotiation, conflict management etc. will make a difference – also in FLR projects.

2) Various strategies on how to attack (potential) conflicts in FLR projects can be developed based on conflict theory and practice. A promising (but by no means easy) strategy is to catch the energy of conflict – whenever there is a (serious) conflict the parties are ready to invest energy maybe to win maybe to survive – and if possible transform this energy into productive collaboration (De

Literature Cited

Deutsch, M. 2000. Cooperation and competition. In: Deutsch, M. and Coleman, P.T. (eds.). *The Handbook of Conflict Resolution.* Theory and Practice. Jossey-Bass. Pp. 21-40.

Daniels, S.E., Walker, G.B. 2001. *Working Through Environmental Conflict. The Collaborative Learning Approach*. Preager.

Emborg, J. 2007. Conflict management and forest landscape restoration. In Stanturf, J., (ed.) Proceedings of the IUFRO Conference on Forest Landscape Restoration, Seoul, Korea May 2007. Korea Forest Research Institute.

Fisher, R., Ury, W., 2nd ed. 1991. *Getting To Yes – Negotiating an Agreement without Giving In* Random House.

ITTO. 2005. *Restoring Forest Landscapes. An Introduction to the Art and Science of Forest Landscape Restoration.* ITTO Technical series no. 23. ITTO, Yokohama, Japan.

Kaner, S., Lind, L., Toldi, C., Fisk, S., Berger, D. 1996. *Facilitator's Guide to Participatory Decision-Making.* New Society Publishers.

Lee, K.N. 1993. *Compass and Gyroscope. Integrating Science and Politics for the Environment.* Island Press.

Maginnis, S., Jackson, W., 2005: What is FLR and how does it differ from current approaches? In: *Restoring Forest Landscapes. An Introduction to the Art and Science of Forest Landscape Restoration.* ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 15-27.

Maginnis, S., Rietbergen-McCracken, Jackson, W. 2005. Introduction. In: *Restoring Forest Landscapes. An Introduction to the Art and Science of Forest Landscape Restoration.* ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 11-14.

Pruitt, D.G. and Kim, S.H. 2004. *Social Conflict: Escalation, Stalemate, and Settlement.* McGraw-Hill Higher Education.

De Dreu, C. and Van der Vliert, E. (eds.). 1997. *Using Conflict in Organizations*. Sage.

Walker, G.B., Daniels, S.E., Senecah, S.L., Peterson, T.R., Cheng. A.S., and Emborg, J. 2006. Pluralistic public participation: Case studies in collaborative learning. Proceedings of the World Congress on communication for development, FAO, UN, Rome, October 2006. www.devcomm.org.

FOREST DAMAGE HISTORY AND FUTURE DIRECTIONS FOR FOREST LANDSCAPE RESTORATION IN KOREA

Joon Hwan Shin

Abstract—Forests in Korea have suffered from several disturbances caused by human activities or natural events since the Chosun Dynasty was founded in 1392. For example, outbreaks of pine moth as a native pest in Korea were recorded in 'The Annals of the Chosun Dynasty' from 1392 to 1863. Major disturbances include illegal logging and Korea War from 1950 to 1953 as the factor of human activities. Natural disasters such as landslides and forest fires have also disturbed forest landscape. Most of the forests in early 1950s were denuded with only 10.6m^3 ha^{-1} of growing stock. With successful implementation of the First and Second 10-year Forest Development Plans from 1973 to 1987, fuel wood plantations have been successfully established. Most of the degraded forests also have been rehabilitated by all the efforts and cooperation among Government organizations, NGOs, individuals and foresters. Among the natural disasters, pests such as pine moth, pine needle gall midge, black pine blast scale, pine wilt disease and oak wilt disease have prevailed in the whole country. Pine needle gall midge is one of the major pests in pine forests. Pine wilt disease is also an invasive species and is known as a lethal disease to *Pinus* species. Until 2005, Japanese red pine and black pine, which are hard pines, were infected by pine wilt disease but Korean white pine, which is a soft pine, also was found infected by pine wilt disease in 2006. Other disturbance factors are landslides and torrential earth flows. Landslides and torrential earth flows are major influencing factors on forest landscape disturbances. Landslides and torrential earth flows have frequently occurred since 2000. Typhoon Rusa in 2002 and Typhoon Maemi in 2003 caused numerous landslides on the east mountainous area with serious damage. The areas damaged by landslides and torrential earth flows have been restored by the method of vegetative and engineering measures. Forest fire is one of the most important factors that disturbed forest landscapes in Korea. It burned out vegetation, insects and wild animals in the forests. To restore the forest-fire damaged area, the Korean government has adopted the natural or artificial methods depending on the site condition or the management objective since 1996. Climate change affects forest landscape disturbances. Montane habitats may be showing the effects of climate change. Dieback of montane trees is consistent with the effects of a warmer climate. It seems that the alpine and sub-alpine forests are vulnerable to global warming and monitoring and conservation activities for the communities would be needed.

The Korean peninsula is geographically located in the eastern part of the Eurasian Continent of Asia and in the western part of the Pacific Ocean, and lies in the East-Asian Monsoon belt climatically. The Korean Peninsula encompasses 221,000km^2, of which 45% (99,600km^2) makes up the Republic of Korea. Korean topography is largely complex with two major mountain ranges. The mountains of north-to-south direction in the east part form the geological backbone and constitute the drainage divide between western and eastern slopes. Smaller mountain ranges run parallel to each other in a northeast-to-southwest direction (Kong 2002). Consequently, while the western and southern coasts have thousands of islands and small peninsulas and bays, steep mountains along the east sweep down almost to the shoreline creating a relatively smooth coast with only small streams and narrow strips of alluvial beaches.

Because of the location and topography of the Korean Peninsula, its climate is unique and has four clearly distinct seasons. Spring and autumn are relatively short while summer and winter are rather long. Summer is hot, humid and wet. From June to September, summer monsoons hit the Peninsula, bringing about 60% of the annual total rainfall. Heavy showers with thunder and lightning are common, with periodic flooding. Winter is dry and freezing cold due to north-westerly Siberian air masses that sweep down from the north. The average temperature of Korea is hotter in summer and colder in winter than that of the countries located in the same latitude zone on the continent. Mean temperatures are 12-14^{o}C in the middle and south region, and 3-10 ^{o}C in the north. Annual mean rainfall ranges from 600 mm to 1600 mm and its seasonal distribution is irregular. The rainy season beginning in late June lasts approximately 30 days and commonly more than two typhoons generated between June and October strike the

Director, Department of Forest Environment, Leader of National Research Project on Pine Wilt Disease, Korea Forest Research Institute; email-kecology@foa.gov.kr

Peninsula every year, resulting in concentrated rainfall in this season (Shin 2002).

Pests

Changes in pest composition and dynamics in pine forest of Korea—As hazard agents for forests, insect pests are continuously being monitored from the 1960s in Korea. Because of the cultural value of pine trees in Korea, pests of pine forests such as pine moth, pine needle gall midge, black pine blast scale, and pine wilt disease are intensively surveyed and studied. Therefore, composition and dynamics of these pests are proper examples that show relationships between changes in landscape of forest and forest pests. In this section, we will discuss changes in the occurrence of pine forest pest and its implication for forest landscape.

Pine moth (PM)

Pine moth (hereafter referred as PM) is a native pest in Korea and its outbreaks were recorded in *The Annals of the Chosun Dynasty* from 1392 to 1863. Recently its occurrence decreased after mid-1970s (Figure 1) and now it is considered as an occasional pest in the inland of Korea. Periodicity of its occurrence was analyzed on the basis of recent changes in the density of PM and past records in *The Annals of the Chosun Dynasty.* The analysis showed that major and minor periodicities of PM were about 160 and 4~5 years, respectively (KFRI 2004). We guessed that reduction of PM cannot be explained by the periodicity because minor fluctuations in the density of PM were not observed. Probably, changes in pine forest landscapes could be one reason for the decline of PM. One hypothesis can explain this reason. In high density, PM suffered from high mortality induced entomo-pathogenic microorganism that acted like a density dependent factor. As Korean people stopped raking up litter on the forest floor and the pine forest stabilized, microclimate in the pine forest would be humid. This environment favored the micro-organism.

Interestingly, changes in the phenology and the biology of PM were reported (Park 2001). Usually, PM develops one generation per year whereas in their researches, two generation per year was observed by field survey on the basis of changes in the density of egg, larvae and pupae and by light trap on the basis of adult density. Park (2001) suggested that increase in temperature induced this change because PM can complete two generations under temperature observed in the field.

Pine needle gall midge (PNGM)

Pine needle gall midge (hereafter referred as PNGM) is one of the major pests in pine forest and it is an invasive species. Its occurrence was reported in Seoul and Mokpo in 1929 and then was spread. The area damaged from 1960s shows some fluctuation and has a trend of decrease (Figure 1).

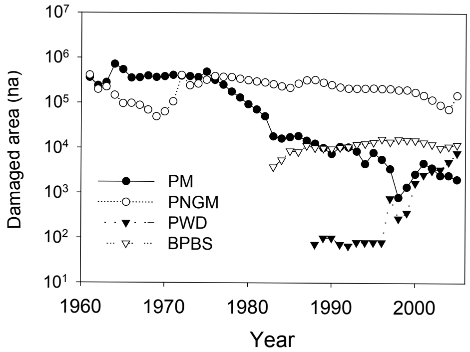


Figure 1. Sequential changes in the area damaged of PM, PNGM, PWD and BPBS in Korea.

In 1964, PNGM invaded to Danyang in Chungbuk then it spread to adjacent areas. Dispersal process of PNGM is shown in Figure 2. In 1996, PNGM was dispersed to all pine forests in Korea. Recently, the pattern of gall formation in each survey area was analyzed. Interestingly, 3 or 4 clusters were identified by cluster analysis using gall formation data from 1986 to 2005 as shown in Figure 3. Moreover, the pattern of clusters was similar to the dispersal pattern of PNGM. These results suggested that infestation history related with population dynamics of PNGM in each area. When recent five-

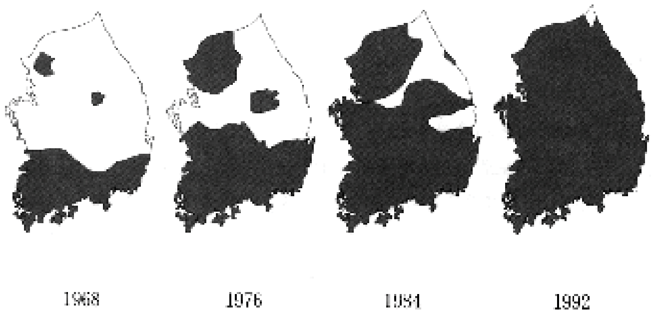


Figure 2. The spread of the distribution of pine needle gall midge infestations in Korea from 1968 through 1992 at eight-year intervals (Lee et al. 1997).

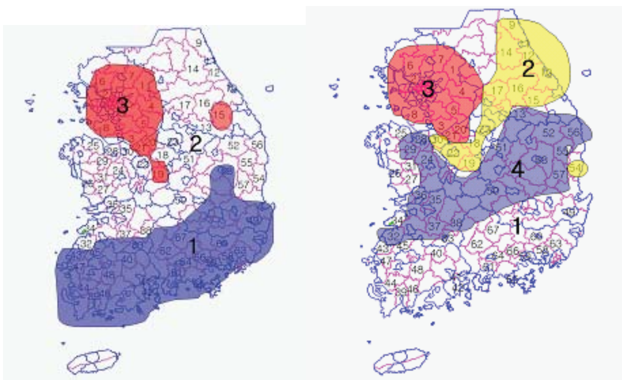


Figure 3. Clusters of gall formation on the basis of 20 years observation data. Left and right figures show patterns of 3 and 4 clusters, respectively.

As biological control agents, parasitoids parasitizing PNGM have been studied by many researchers (Jeon et al. 2006, Park et al. 2001 and references therein). At initial stage of interaction between PNGM and its parasitoids, the relationship between parasitoid and PNGM was weak but positive relationship between PNGM and parasitoids density was observed after early stage of interaction (Jeon et al. 2006). However, this did not mean that the parasitoids would completely suppress PNGM because population dynamics of PNGM had a periodicity and the parasitoids could not suppress PNGM at the outbreak stage. Therefore, to protect pine forest from damages of PNGM, supplemental method such as chemical control is needed when outbreak of PNGM occurs.

Black Pine Blast Scale (BPBS)

Black Pine Blast Scale (hereafter referred as BPBS) is also an invasive species and its first occurrence was reported in Goheung, Jeonnam. Then it was dispersed to southern area of Korea and it is known that its host is restricted to black pine. Currently, its dispersal has slowed down, and thus its distribution is restricted to southern Korea. The reason for the restriction of its distribution is not clarified yet. However, its host distribution and microclimate are possible causes for slowing down its dispersal.

Pine Wilt Disease (PWD)

Pine Wilt Disease (hereafter referred as PWD) is also an invasive species and is known as a lethal disease to *Pinus* species. Until 2005, Japanese red pine and black pine which are hard pines were infected by pine wilt disease but Korean white pine which is a soft pine was found infected by pine wilt disease in 2006. Interestingly, it is suspected that vectors and symptom of PWD and PWD in Korean white pine are different from those in red pine. This new disease in Korean pine forests will be a new selective pressure to Korea pine forests, and thus it will induce changes in Korean forest landscape.

For protection of the pine forest landscape, many control methods have been applied. Basically pine trees infected by Pine wilt nematode were cut and then fumigated, burned or crushed. In addition, chemical control methods have been used to reduce density of vectors of PWD or to protect valuable pine trees. Moreover, biological control methods using parasitic wasp and microorganism are under testing.

Oak Wilt Disease (OWD)

The first occurrence of Oak Wilt Disease (OWD) in Korea was reported in 2004 and then it is under process of dispersal. The cause of OWD is known as a fungus of *Raffaelea* spp. and a bark beetle, *Platypus koryoensis*, is known as a vector of the fungus. This disease is considered as a hazard agent to oak forest landscapes in Korea. Unfortunately, the reason for outbreak of the bark beetle is not clear. The infected oak trees were cut and fumigated to reduce density of the bark beetle. In addition, new control methods are under development.

Forest Fire

Forest fire in Korea—Forest fire is one of the most important factors of ecosystem disturbance in Korea, because it burns vegetation, insects and wild animals on the ground. Forest fire occurrence is 543 cases a year on average and damaged 1,844 ha of forest in Korea. Seventy percent of forest fires in Korea occur in the spring because spring is the windy and driest season in Korea. More than 80% of forest fires are accidental fires by mountaineers, tomb visitors and children, levee fires and cigarette butts.

Restoration of forest fire damaged sites after East Coast Fire in 2000—The East Coast Fire in April 2000, in which 24,000 ha of forest burned, brought social debate between traditional foresters who insisted on traditional post-fire restoration of artificial regeneration and environmentalists who insisted on natural regeneration. Traditional forestry was criticized and experts and local organizations participated in the 5-year forest restoration plan of Korea Forest Service. The plan was established with the combination of natural regeneration and artificial planting, i.e. 48.5% of fire damaged area would be restored by natural regeneration, and the others (51.5%) would be done by artificial planting. Container red pine seedlings were planted in the coastal mountainous area, and site preparation and planting of container red pine seedlings were treated in the inland mountainous area in the East Coast Fire region. Emergency restoration, erosion control, restoration for pine mushroom (*T. matsutake*) were the main restoration objectives by 2001.

The restoration strategy of the East Coast Fire damaged region is as follows:

1. Ecological restoration method should be suggested
2. Harmonious combination of natural and artificial regeneration
3. Rapid restoration of landslide hazard area
4. Direct seeding or planting of container tree seedlings of red pine for pine mushroom *T. matsutake*
5. Natural restoration of areas where crown layer is alive, or habitats for specific animals or plants
6. Restoration for scenic value
7. Most appropriate restoration should be applied
8. Building of forest road should be decided

based on policy.

Post-fire restoration uses natural or artificial methods depending on site condition and management goals. Not only efforts to restore fire damaged areas should be required but also more effort for prevention of forest fires.

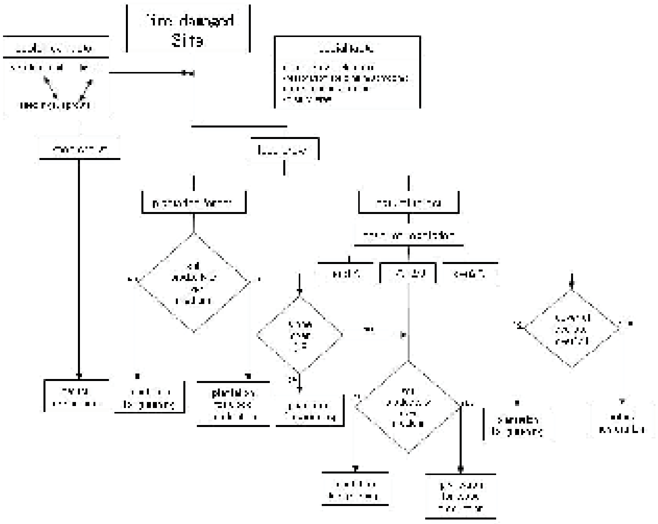


Figure 4. Flowchart of decision-making for the restoration of forest fire damaged areas.

Research activity after forest fire for restoration—After a large-scale forest fire in Goseong occurred in 1996, many people were interested in the effect of forest fire on ecosystems and the method of restoration. A 100 ha long-term ecological research (LTER) site was installed in Goseong for the investigation of fire effects on ecosystems (soil erosion, water quality, vegetation, and wildlife). After the large East Coast Fire in 2000, about 4,000 ha of a new LTER site in Samcheok, Gangwon-do, Korea was established. In this site, almost all kinds of research on forest ecology and silviculture are pursued; forest meteorology for illumination of mountain climate, vegetation changes, insects, birds and small mammals, soil productivity, erosion control effects for reducing of post-fire erosion, hydrological influence, characteristics of fire damage according to stand structure, and forest stand control for building of forest fire resistant forests, etc.

Sediment runoff was very intense in the first year post-fire but reduced to natural levels in the third year. Water quality was restored in the year after the forest fire. Recovery of tree species was progressed by the sprout of *Quercus* spp., and recovery of herbaceous was perennial. Figure 5 and 6 shows that sprout canopy in permanent research plot increased with year, while seedlings of *Pinus densiflora* decreased. The number and species of insects increased at the beginning, but decreased gradually later. The number of bird species was decreased after fire and increased in the limited number of species that live in grassland. Pine mushrooms haven't been recovered yet since the fire.

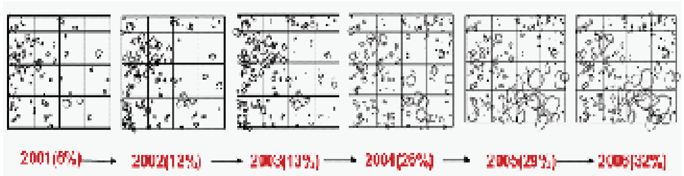
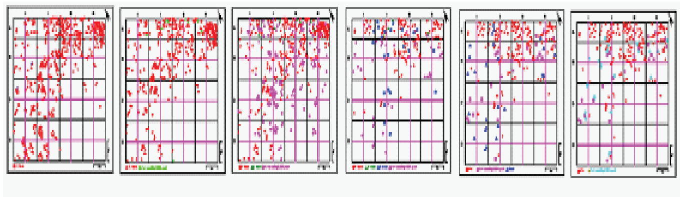


Figure 5. Annual changes of sprout coverage (%) in Samcheok.



2001(477) —> 2002(372) —> 2003(426) —> 2004(172)—>2005(152)—> 2006(196)

Figure 6. Annual changes of *Pinus densiflora* seedlings in Samcheok.

Changes in Disturbance Regime in Korea

The forest area in Korea occupies 6.4 million ha, about 64% of the entire land area in 2005. *Pinus densiflora* and *Quercus* species are the dominant tree species and form mixed forests in lower elevations. *P. densiflora* naturally grows in relatively dry and poor sites and can successfully regenerate after disturbances. Pine forests were protected for a long time, particularly during the Chosun Dynasty (1392-1910) and had affected the cultural life of many people. The forest control system at the national level in Chosun Dynasty was initiated by removing the provisions of the Shiji (lands for collecting fuelwood) and Geumsan system which regulated forests for the specific national uses (e.g. coffins for the Royal family) (Park 1998).

Large forested areas have been devastated by overexploitation until 1950s for fuel wood supply. In 1960 there were about 2.4 million households in the country and about 0.5 ha per household was needed. In order to meet the demand of these households, about 1.2 million ha of total fuel wood plantations were required (Lee and Suh 2005). Most of the forests were denuded, resulting in serious soil erosion problems, and degraded with only 10.6m^3 of growing stock. With successful implementation of the First and Second 10-Year Forest Development Plans from 1973 to 1987, fuel wood plantations have been successfully established and most of the degraded forests have been also rehabilitated by all the efforts and cooperation among Government organizations, NGOs, individuals, and foresters. In this period, Korean forests were dominated by *P. densiflora,* a pioneer species because of denuded soil condition.

However, during the period, because of rapid economic development and urbanization of Korea, there has been an unprecedented demand for new land. Clearance of forests for the construction of various types of social infrastructure, industrial estates, and new towns has been the primary factor for the destruction and fragmentation of the forests. The Korean economy grew in this period and the major energy source was changed from fuel wood to fossil fuels. Therefore, growing stock increased and forest site condition improved, although forest area decreased somewhat. As a result of both anthropogenic activities (e.g., land-use change and planting) and natural processes including succession and biological effects (insects and pathogens), the coverage of *P. densiflora* forests has decreased and replaced with *Q. serrata, Q. mongolica* and plantations.

As shown in Figure 7, forest area disturbed by forest fires and landslides in Korea recently increased. It is surmised that these extreme climate-related events were driven by the early stages of ongoing global warming caused by increased artificial emissions of greenhouse gases. The recent tendency of frequent climate-related disturbances is worldwide (IPCC 2001). I plotted annual landslide area in Korea against annual precipitation, and could find a linear limitation line below which each point located (Figure 8). However, the plotted point of landslide area in 2002 was beyond the line due to the uncommon destruction by heavy rainfall accompanied by Typhoon Rusa. The typhoon destroyed the same area previously burned by a

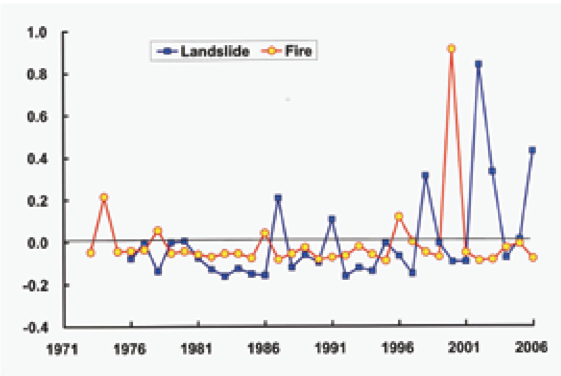


Figure 7. Changes of forest area disturbed by landslides and forest fires in Korea. Y-axis is anomaly standardized as $(X_i - X_{mean})/(X_{max}-X_{min})$. Forest fire areas were from KFS (2006) and landslide area from internal data of Korea Forest Service.

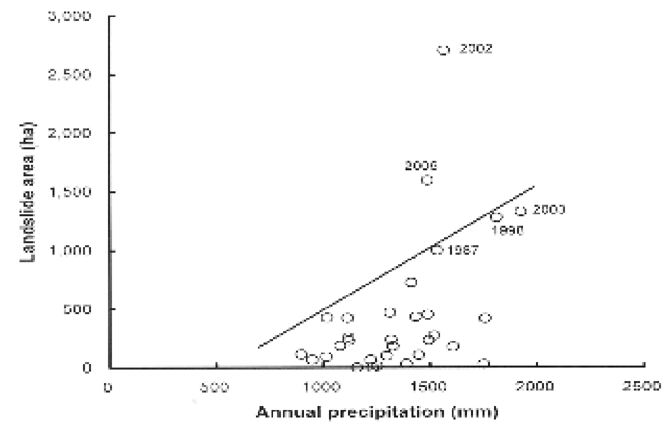


Figure 8. Relationship between annual precipitation and landslide area in Korea. In 2002, Typhoon Rusa with heavy rainfall destroyed the area previously damaged by a large forest fire in 2000 and showed amplified effect.

Future Changes of Vegetation by Climate Change

Climate is an important determinant of geographic range for many species. Recent northward movements of species' range boundaries consistent with warming have been observed in birds (Thomas and Lennon 1999), mammals (Payette 1987), and butterflies (Dennis 1993, Parmesan *et al.* 1999). Parmesan *et al.* (1999) examined changes in the northern range boundaries of 52 species of European butterflies over the past 30-100 years, and found that 34 species shifted northward, 1 species southward and 17 species unchanged.

Air temperature in mountain regions changes with elevation at about 1^{0}C per 160 m and changes with latitude at about 1^{0}C per 150 km (IPCC 1996). Grabherr *et al*. (1994) surveyed montane plants on 26 mountain communities in the Swiss Alps and compared species distributions to historical records. The rate of upward shift was estimated to be 1-4 m per decade. These movements were slower than the 8-9 m per decade expected based solely on the change in mean temperature over the last 90 years. In Korea, using the scenario of climatic warming 2^{0}C by 2100, the shifts of the potential ranges of the several native trees including *Camellia japonica* which is an evergreen broadleaved tree, *Quercus mongolica* and *Abies nephrolepis* were predicted based on the thermal ranges of the species (Lim and Shin 2005). The predicted changes of distribution ranges were dramatically shifted northward in latitude, and toward the top of the mountains. Distribution ranges of the trees in the warm temperate forest zone, such as *Camellia japonica* were predicted to expand about two times, and extend 100 m higher in elevation (Lim and Shin 2005). Trees of the cool-temperate forest and sub-alpine forest zones were predicted to become confined to half of the current potential ranges. Since forests in Korea are located mainly on the mountainous area, altitudinal shifts of the distribution ranges are also important factors. Thus the vegetation in the sub-alpine zone will be most vulnerable. Priority should be given to the conservation of the high mountains vegetation and species of the habitat ranges in anticipation of significant global warming. Kong (2005) suggested some plant species vulnerable to global warming using a climatic indicator of high summer temperature in Korea. The author mentioned the further research on bioclimatic ranges and adaptation abilities of plant species would be required to assess the possible impacts of climatic warming.

Other montane habitats may also be showing the effects of climatic change. Dieback of montane trees (Hamburg and Cogbill 1988, Fisher 1997) is consistent with the effects of warmer climate. It seems that the alpine and sub-alpine forests are vulnerable to global warming and monitoring and conservation activities for the communities would be needed.

It seems that plenty of forest vegetation zones would be shifted after alteration of the structure and species composition in each forest stand resulting from changed competitive ability among species in anticipated rapidly changing climate of 21st century as described above. The changes of forest zone and forest stand structure and species composition might bring about significant changes of Korean landscape and forest biodiversity. Deciduous forest that dominates in Korea and consists mainly of oaks would move northward and be substituted by broadleaved evergreen forest of warm temperate zone in warmer climate.

However, it is doubtful that the tree species migration will be successful to such a rapid changing climate in the situation of highly fragmented and topographically rugged landscape of Korea. To adapt the rapidly changing climate for the conservation of biodiversity and sustaining forest productivity, it will be needed to establish effective networking of protective areas which will allow free movement of living organisms and to conserve vulnerable species in-situ and ex-situ, and to apply a new planting and silvicultural system which considers the future changing climate, i.e. choosing planting species that are better adapted to a warmer climate.

Restoration of Baekdudaegan Mountains System

The Baekdu Daegan Mountain System (BDMS) is the main series of mountain ranges forming the backbone of the Korean peninsula's topography. Conceptually it came from traditional perception of Korean people on topographic feature of Korean peninsula. Consisting of the major mountains, it stretches around 1,400km long from Mt. Baekdu down to Mt. Jiri. In South Korea, it is 684 km long with the elevation ranges of 200 m to 1,915 m. In the Republic of Korea, 684 km of BDMS covers nine national and provincial parks and encompasses six provinces. The ecological significance of the BDMS cannot be overstated. Serving as the principal habitat for wild fauna and flora, 1,326 species which is 33% of total 4,071 plant species in Korea, grow in BDMS including 10 endangered and protected species.

The BDMS is important not only for a topographic backbone but also major sources of various ecosystem goods and services including forest products, clean water, biodiversity, tourism, landscape scenery and so on. However for several decades, Korea has experienced rapid industrialization. In this process, the BDMS forest ecosystem has been severely fragmented and deteriorated. Various development activities have taken place throughout BDMS including 72 paved and unpaved roads, 5 railways, 12 mines, and 6 dams.

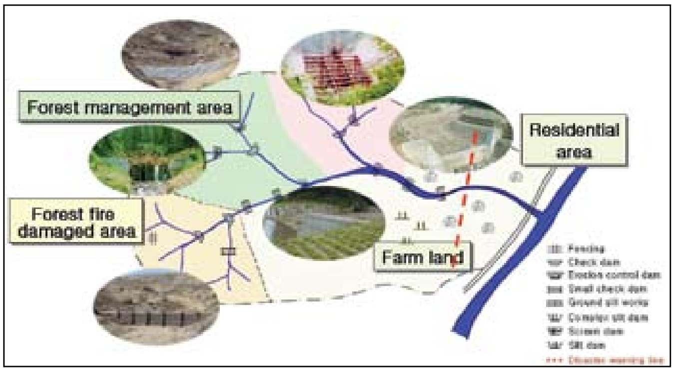


Figure 9. The schematic map of forested-watershed management system.

With regard to this matter, the Republic of Korea formulated the Act on the Protection of BDMS on December 30, 2003 and it went into effect on January 1, 2005. The Act aims at establishing connectivity of whole BDMS to ensure the maintenance of fundamental landscape and ecosystem services by protection and restoration of the area. The protected area consists of Core and Buffer Zones, in order to ensure the connectivity of the ecosystem without fragmentation and the ecological restoration of devastated areas. The total designated area is 263,427 ha which covers 2.6% of the land and 4% of the forest area.

To achieve the goal of the Act effectively, implementation strategies were established by stage on December 2005. The first stage (2006~2008) is for establishment of management framework for the BDMS. At this stage, legal institutions and organizations for effective management are reinforced. Basic survey on the ecosystem and forest resources as well as research framework should be developed, while establishing other general structures for resident assistance projects and land purchase systems. The second stage (2009~2012) is for setting up and implementation of the management system. The expertise for the management of BDMS needs to be developed and cooperative and participative relationships with the local residents should be built. Model rehabilitation projects and monitoring processes should be developed while implementing the actions for the protection of the BDMS. In addition, framework for south-north cooperation should be facilitated. The third stage (2013~2015) is for restoration and enhancement of structure and functions of the BDMS toward the effective conservation and sustainable forest management (KFS 2005).

Forested Watershed Management

Forested watershed management projects have been implemented to reduce the damage of lives and fortunes caused by the natural disaster since 2002. Watershed includes all components of landscape ecology, i.e. matrix, patch, and corridor. The input energy such as rainfall moves to the downstream through stream channels in forested watersheds. The natural disaster in a forested watershed may be understood as the processes that the input energy causes to land failure and moves to the downstream with the damages of lives and fortunes. Traditional erosion control works usually are the focus of rehabilitation for the damaged land and stream, but on the other hand a forested watershed management project aims to prevent the natural disaster from taking place in a specific watershed through the several kinds of facilities like erosion control dams and revetments.

The forested uplands as a matrix component are managed to prevent landslides through forest practices such as thinning and pruning. The forest-fire damaged areas are patches restored to environmental soundness. The stream channel corridor is managed to establish the erosion control dam and several stabilization facilities. All components mentioned above must be managed systematically from a viewpoint of landscape ecology. Watershed where large village are located downstream meets the conditions for the project because the project must be highly effective to save lives and fortunes. Presently this project focuses on establishing civil engineering structures such as concrete and steel dams. In the future, environment-friendly structures will be adopted rather than civil engineering structures in forested watershed management project.

Conclusions

Forests in Korea have been affected by human activities and natural events. For example, outbreaks of pine moth were recorded from 1392 to 1863 in *The Annals of the Chosun Dynasty*. Forests of early 1950s in Korea were denuded by illegal logging and the Korean War. The Korean government and people united to rehabilitate devastated forest lands during the 1970s and 1980s. The Korean government declared the completion of 'Greening' in the late 1980s. The area damaged by pine moth and pine needle gall midge has tended to decrease since 1960. It seems to be caused by development of forest stands. Pine wilt disease shows a tendency to increase in a wide range of Korea. Not only red pines but also Korean white pines are infested in the northern part of Korea. This new disease in Korean pine forests will be a new selective pressure on Korea pine forests, and thus it will induce changes in the Korean forest landscape. One of the impact factors on forest disturbances includes forest land disasters such as landslides and torrential earth flows. Korea is vulnerable to geological disaster due to an intensified rainfall in summer and a steep mountainous land. Areas damaged by landslides and torrential earth flows are rehabilitated in a manner of civil engineering as soon as possible. In future, the ecological restoration processes for the damaged area by landslides and torrential earth flows should be clarified. Information on such restoration processes helps to adopt the ecological engineering in the damaged area.

Forest fires impact forest ecosystems in an instant. The scales of the area damaged by forest fire tended to increase in the beginning of 2000s. The East Coast Fire in April 2000, in which 24,000 ha of forest burned, brought social debate between traditional foresters who insist on traditional post-fire restoration by artificial regeneration and environmentalists who insist on natural regeneration. Information on ecological restoration processes in the area damaged by forest fire helps to restore the damaged area in a manner of ecological engineering. Climate change will disturb the order of forest ecosystem including vegetation distribution and interaction between ecosystems. Monitoring on the distribution of tree species will let us know the finger print of climate change. In Korea, forested watershed management projects have been implemented to reduce the damage of lives and fortunes since 2002. In the future, we will have to adopt more sound ecosystem approaches.

Literature cited

Dennis, R.L. 1993. *Butterflies and Climate Change.* Manchester University Press. Manchester and New York. 302pp.

Fisher, M. 1997. Decline in the juniper woodlands of Raydah Reserve in southwestern Saudi Arabia: a response to climatic change? *Global Ecology and Biogeography Letters* 6: 379-386

Grabherr, G., Gottfried, M., Pauli, H. 1994. Climate effects on mountain plants. *Nature* 369: 448

Hamburg, S.P, Cogbill, C.V. 1988. Historical decline of red spruce populations and climatic warming. *Nature* 331: 428-431

IPCC. 1996. Climate Change 1995; *Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses.* Cambridge University Press, London. 878pp.

IPCC. 2001. Technical Summary - Climate Change 2001: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses. 73pp.

Jeon, M.J., Choi, W.I., Choi, K.-S., Chung, Y.-J. and Shin, S.-C. 2006. Population dynamics of *Thecodiplosis japonensis* (*Diptera: Cecidomyiidae*) under influence of parasitism by *Inostemma matsutama* and *Inostemma seoulis* (Hymenoptera: Platygastridae). *Journal Asia-Pacific Entomology* 9: 269-274.

KFS (Korea Forest Service). 2005. A General Plan for the Protection of Baekdudaegan Mountains Systems. Korea Forest Service, Daejeon. 133pp. (*in Korean*)

KFS (Korea Forest Service). 2006. 2005 Major Statistics of Forestry. Korea Forest Service, Daejeon. (*in Korean*)

Kong, W.S. 2002. Mountain geoecology of Korea. Pages 47-65, in D.W.Lee et al. (eds.) *Ecology of Korea*. Bumwoo Publ. Co., Seoul. 406pp.

Kong, W.S. 2005. Selection of vulnerable indicator plants by global warming. *Journal of the Korean Meteorological Society* 41: 263-273 (*in Korean with English abstract*)

KFRI (Korea Forest Research Institute). 2004. Annual Report of Monitoring for Forest Insect Pests and Diseases in Korea. SungMun-sa, Seoul, pp. 170. (*in Korean*)

Lee, B.-Y, Chung, Y.J., Park, K.-N., Byun B.-H., Bae, W.-I. 1997. Distribution of Pine Needle Gall Midge, T*hecodiplosis japonenesis* Uchida et Inouye (Diptera: Cecidomyiidae), Infestations in Korea: a Brief History. *FRI Journal of Forest Science* 56: 13-20. (*in Korean*)

Lee, D.K. and Suh, S.J. 2005. Forest restoration and rehabilitation in Republic of Korea. pp. 383-396. In: Stanturf, J.A. and Madsen, P.(*eds.*) *Restoration of Boreal and Temperate Forests.* CRC Press. U.S.A.

Lim, J.H., Shin, J.H. 2005. Forest vegetation shifts and plant phenological changes according to global warming. *Nature Conservation* 130: 8-17 (*in Korean*)

Lim, J.H., 2000. Eastcoast fire and climate. *The Korean Society of Agricultural and Forest Meteorology* 2(2): 62-67.

Lim, J.H., Shin, J.H., Lee, D.K., Suh, S.J. 2006. Climate change impacts on forest ecosystems: research status and challenges in Korea. *Korean Journal of Agricultural and Forest Meteorology* 8: 199-207

Park, K.S. 1998. Change and establishment of Gumsan, Bongsan system in the Chosun dynasty. *Journal of Forest Science* 57: 86-102. (*in Korean*)

Park, Y.K. 2001. Changes in Population Biology of Pine Moth, *Dendrolimus spectabilis* (Butler) (Lepidoptera: Lasiocampidae) and Its Biological Control by *Trichogramma dendrolimi* Matsumura (Hymenoptera: Trichogrammatidae). PhD Thesis, Dongguk University, Seoul, 123pp

Park, Y.-S., Chung, Y.-J., Chon, T.-S. Lee, B.-Y. and Lee, J.-H. 2001. Interactions between pine needle gall midge, Thecodiplosis japonensis (Diptera: Cecidomyiidae), and its parasitoids in newly invaded areas. *Korean Journal of Applied Entomology* 40: 301-307.

Parmesan, C., N. Ryrholm, C. Stefanescu, J.K. Hill, C.D. Thomas, H. Descimon, B. Huntley, L. Kaila, J. Kullberg, T. Tammaru, J. Tennent, J.A. Thomas, M. Warren. 1999. Poleward shift of butterfly species' ranges associated with regional warming. *Nature* 399: 579-583

Payette, S. 1987. Recent porcupine expansion at tree line: a dendro-ecological analysis. *Canadian Journal of Zoology* 65: 551-557

Shin, J.H. 2002. Ecosystem geography of Korea. Pages 19-46, in D.W.Lee et al. (eds.) *Ecology of Korea*. Bumwoo Publ. Co., Seoul. 406pp.

Thomas, C.D. and J.J. Lennon. 1999. Birds extend their ranges northwards. *Nature* 399: 213

CONFLICT MANAGEMENT AND FOREST LANDSCAPE RESTORATION

Jens Emborg

Introduction

This interdisciplinary conference (Forest landscape restoration, IUFRO, Seoul 2007) brings the issue of *forest restoration* on to the landscape level. Working in the landscape scale implies that we have to consider forests in a broader socio-ecological context. This change is certainly reflected in the call for this conference and in various recent publications on forest landscape restoration (e.g. Barrow et al. 2002, ITTO 2002, ITTO 2005).

Most foresters in research and practice have reflected over the dramatic changes in forestry since the Rio Summit in 1992 – and realised that "nothing is certain except change." As forestry (in a relative sense) has grown out of its own world into the rest of the world it is no longer enough to know everything about ecology and forest economics – we must know more if we want to see our expert knowledge manifested in the real world. It is all about people!

Figure 1: Aerial photograph from Nepal – degraded forest landscape. Moving to the landscape level implies that forest management has to be considered in a social context of human activity and interaction.

Wherever there are people there are differing interests, various worldviews, values, emotions, positions, face, pride, rationality, irrationality, relations, will, desire, dreams, livelihood and much more at stake. In fact, it is a true wonder that the world is not more violent than it is…!

The scientific field of conflict management deals with the above aspects of human interaction with close attention to basic questions like: What is conflict? What causes conflict? Why and how does conflict escalate? Is conflict positive or negative? How can we benefit from conflict? How can we deal constructively with conflict? In this paper I seek to bring elements of this theory in play – into the field of forest landscape restoration.

Ecosystems and Social Systems

As trained foresters we are used to understanding nature in terms of *ecosystems* and production *systems.* When we push forest restoration to the landscape level we have to deal with social systems as well. If we in a professional sense want to answer *why* we do what we do – when we interact with a social system – we have to understand the dynamics of the system. If we do not understand the system and the dynamics that plays out - we may feel incompetent, unsure, unsafe, blind, un-decisive, or we may even fear for the (unknown) consequences of our possible actions.

Social systems are just like ecosystems – we define the borders of the system to a surrounding environment, identify key elements, there is input, output, interaction among elements, feed-back loops, feed-forward mechanisms, emergent properties etc. However, in general social systems seem to be much more complex and unpredictable than ecosystems. Human actions and reactions are less predictable than those of plants and animals and the surrounding environment is often much less stable. Fortunately, foresters, ecologists and the like should have an advantage while working in and with social systems, because they are familiar with ecosystems and systems thinking approaches.

Long-term (sustainable) solutions require that we

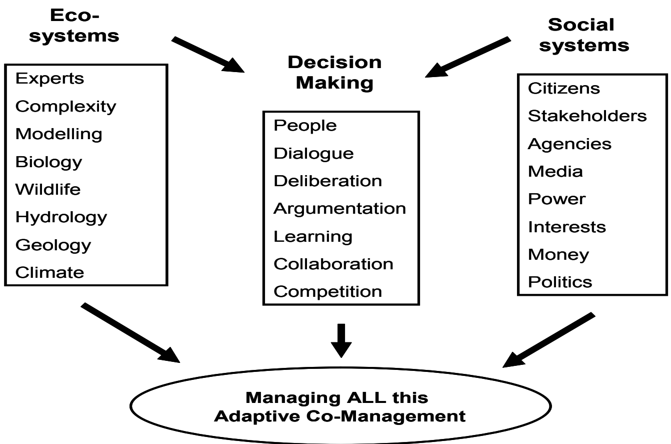


Figure 2: Competent Forest Landscape Restoration requires that knowledge about ecological and social systems is combined with knowledge in how to design and manage complex collaboration and decision making processes. The required competencies matches the definition of FLR (Maginnis et al. 2005) explicitly pinpointing FLR as a process integrating ecological integrity and human well-being.

Forest & Landscape, University of Copenhagen, Denmark; email-jec@life.ku.dk

understand the system fairly well, because we then can address the problem at the systemic level – i.e. change the system so the problem does not reoccur, rather than just fixing the problem in isolation from the system it is part of. As an example of the fix-the-problem approach could be neutralisation of acid rain problems in Swedish lakes by massive dispersal (or dumping) of chalk. A systemic approach would be to change our use of fossil fuels, thereby reducing the sulphur emissions to the atmosphere. The same logic can be applied to social systems – a sustainable solution may require that we not only fix the problems but that we actually change the systems. To do so we must be able to describe, analyse and understand the dynamics involved in human interaction. Conflict theory is very much about describing and analysing human interaction in a systems perspective.

From such analysis and understanding of social systems conflict management is about transforming this understanding into appropriate and effective actions – to achieve desired outcomes, improve relations or change systems to the better. Often conflicts are deeply rooted in very old systems of social interactions that have to be changed in order to achieve desired long lasting change (Lederach 1997, Tillet 1999, Pruitt and Kim 2004). This might not be an easy task in all cases – sometimes carefully designed processes are required to achieve even a modest improvement of a given situation. Conflict management, in general, is multi-disciplinary and has a strong focus on dynamics and processes – e.g. communication, decision making, learning, competition, collaboration, escalation, de-escalation, negotiation, problem solving etc. (e.g. Tillet 1999, Coleman 2000, Daniels and Walker 2001).

To change systems and design effective and constructive processes of FLR will require a solid understanding of the ecosystems in question as well as an equally solid understanding of the human and social systems involved. The processes designed should work ecologically as well as socially – which is a huge challenge that requires intelligent combination of knowledge and skills from indeed very different bodies of theory and practice. I believe that practitioners and researchers of FLR can learn and benefit from a rich base of scientific literature about negotiation, conflict management, environmental conflict, social conflict, mediation, facilitation etc.

The theory and practice of conflict management can support the description and analysis of social systems as well as assist the design and practice of planning, decision making, implementation and management processes. Adaptive management has been suggested as a promising approach to FLR (Gilmour 2005). Interestingly the adaptive "learning-along-the-way" management approach is very similar to typical approaches to social conflict – where uncertainty and complexity call for modest expectations – improvements rather than solutions – and incremental progress over long time (Moore 1996, Lederach 1997, Daniels and Walker 2001).

Forest landscape restoration - managing conflicts?

Forest landscape restoration can be defined as: "A process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes."

This definition was coined in 2001 at an expert meeting in Spain (Maginnis et al. 2005). FLR is a new concept including a broad selection of highly complex issues, matters and their related theory and practice. As a young field of research and practice there is an encouraging spirit, optimism and enthusiasm in the presentations of FLR. Indeed the writings represent high ambitions and a wealth of good will, hope and excellent thoughts and ideas.

Certainly it is difficult to disagree that FLR as described in the definition is a good idea! Who would not like to regain ecological integrity? Who would not like to enhance human well-being? Who would not like to turn degraded landscapes into green forests?

Are there any conflicts in FLR, then? Where should the resistance against FLR come from? I believe that in practice there certainly are plenty of conflicts related to forest landscape restoration. Accordingly, I have been surprised about the limited role of conflict and conflict management in the evolving literature on FLR. The issue is touched upon in relation to issues such as stakeholder analysis (Gilmour 2005), adaptive management (Kusumanto 2005), and scenario modelling (Lamb 2005) – but to my knowledge the conflict issue has never been specifically addressed in the FLR literature.

Many different definitions of conflict exist – and are used depending on the context and purpose. To most people conflict is something unpleasant, expensive and stress provoking that distracts from more constructive endeavours (Carpenter and Kennedy 2001). This perception is in line with older definitions of conflict, e.g. Coser (1956): "Social conflict is a struggle between opponents over values and claims to scarce status, power and resources." A modern definition of conflict (Pruitt and Kim 2004) suggests that "conflict means perceived divergence of interest, a belief that the parties' current aspirations are incompatible. In other words, conflict is a belief that if one party gets what it wants, the other (or others) will not be able to do so." Another interesting definition of conflict suggests that conflict is caused not so much by the divergence of interests in themselves - but rather caused by the way we handle the differences – i.e., conflict perceived as a breakdown in the communication among the parties (Bush and Folger 2005).

Regardless of which definition we chose the potential for conflicts at various levels and stages of almost any FLR process seems obvious. It is interesting to observe that there seems to be an increasing recognition of the positive potential of conflict – as a motor for change and development (Pruitt and Kim 2004, De Dreu and Van de Vliert 1997).

Possible conflicts in FLR

The notion of FLR covers a wide variety of situations. I have been involved in a number of situations which all can be regarded as forest landscape restoration with reference to the above definition of FLR, e.g.: 1) Reforestation in degraded agro-forestry landscapes in Nepal, 2) Enhancement of forest productivity in virgin forest landscapes in Bhutan,

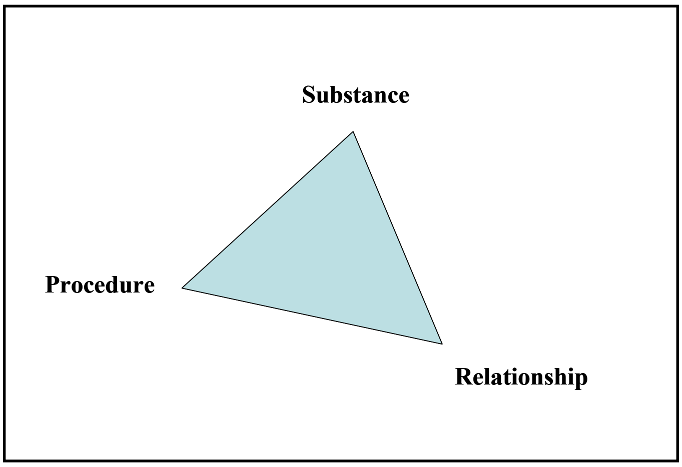


Figure 3: The progress triangle analytical framework (modified from Daniels and Walker 2005). The substance dimension includes issues such as facts, money, and values at stake. The relationship dimension includes issues such as the history of their relationship, trust level, and relative power. The procedure dimension includes who are involved, distribution of power in the process, decision making principles and negotiation procedures, resources available for the process.

3) Land-use planning and conflict management in public forest- and rangelands in the United States, 4) Expansion of the Bialowieza National Park in Poland, and 5) Establishment of national parks and protected forest areas in Denmark.

Despite huge differences in the social, economic and ecological contexts these five cases have a lot in common as seen from a conflict management perspective:

- Many stakeholders
- Multiple issues
- Strong and conflicting interests
- Complex ecological and social settings and dynamics – expert requirement
- Formal/legal rights and informal historically agreed land-use rights/practices
- Differing values and worldviews – some deeply held
- Cultural differences
- Overall and local concerns
- Expert knowledge and traditional knowledge

These common features of the five FLR cases do not differ much from the general characteristics of environmental, natural resource and land-use conflicts (Daniels and Walker 2001), or public disputes in general (Carpenter and Kennedy 2001). One way to get a first impression of possible conflicts hidden in cases like these those presented is to ask simple questions like "who" and "why", e.g.:

- "Human well-being – for whom?"
- "Ecological integrity – why?"

The answers to these questions will possibly depend on who you ask – various stakeholders will have differing perspectives on these and a lot of other questions related to a FLR project in question. What is perceived as a benefit for some might represent diminishing livelihood for others. In any case it is worth reflecting on the fact that the forces and causes that lead to the starting point of a FLR process (e.g. degraded forest) most likely still will be active if nothing systemically is changed. Accordingly, a successful and long lasting solution (or improvement) of the situation probably depends on the *change* of fundamental features and or dynamics of the current social and ecological systems. Change usually means opportunity for some and threat for others – excitement and hope mixed with fear for the future, uncertainty, sentimentality are all normal reactions to change, together with emotions, alertness and maybe some degree of intuitive resistance and cautiousness. Such reactions and behaviours will not always play out in a logical, rational or predictable manner. Often the mix of real interests at stake, perceived differences and emotions can lead to perceived conflict by the parties. Conflict escalation can easily be induced by the prospects of change (e.g., related to a FLR project) and the derived reactions and behaviours.

On the other hand the excitement, arousal of energy and emotions can help to set issues on the agenda and prepare for common actions. In fact this represents a positive potential for (desired) development of society. Contrary to most people's intuitive belief, conflict escalation in some cases might represent a desired source of energy to develop the basis for concerted social action – e.g., in relation to an important FLR project.

Conflict behaviour and conflict assessment

Parties can and will choose various (more or less constructive) strategies to address the challenge of forthcoming change and achieve their goals (Pruitt and Kim 2004). Notions like power and trust become particularly important. Relationships are sometimes at stake and parties will usually be concerned about which procedure will be chosen (or dictated), because the procedure itself may influence the outcome. The local history might come into memory and the sense of justice, rights, fairness and maybe oppression might be evoked. Deeply-held values and culture might be at stake for some of the parties. Strategic and tactical concerns might influence honesty and communication patterns among the parties – alliances etc. might be formed. Over time (un-managed) conflict situations might get pretty complicated, developing according to characteristic spiralling dynamics (Carpenter and Kennedy 2001).

The overall outcome of all these forces and dynamics will depend on the substance (e.g., how important are the interests at stake for the parties) and the relation between the parties (trust, history, relative power). Further, the outcome will to a large extent be determined by the process used to make decisions and design the future - e.g., who will be involved, who decides what, the role of experts, openness and transparency (Moore 1996). Daniels and Walker (2001) developed the Progress Triangle framework as a relevant tool to assess and analyse environmental conflicts (Figure 3). The tool is developed to assess the collaborative potential among parties in larger environmental conflict situations – like for example the FLR case examples presented above. The assessment can guide the design of conflict management processes, and indicate good strategic choices on how to attack conflict situations.

The progress triangle framework represents a typical tool derived from theory and practice of conflict management. The tool might seem very simple – which in fact is a point in conflict management theory and practice. The tools need to be simple to allow for instant (*in situ*) conflict analysis. Simultaneously the tool should accurately reflect reality - to be reliable and useful. A number of simple tools exist to diagnose conflicts, identify indicators for collaboration and competition, map and analyse positions, concerns and interests of stakeholders and many other purposes related to conflict situations. These and other tools might be very useful to assess and understand conflict situations as a basis for strategic choice on how to attack the project and address potential conflict situations related to FLR processes. Since FLR situations in most aspects resemble the characteristics of other social/environmental conflict situations (the social processes are basically the same – the ecological context is different) I conclude that existing conflict management theory obviously is relevant for FLR.

To this end it is interesting to note how the concepts of adaptive management (Lee 1993, Gunderson and Holling 2001) and co-management (Ruitenbeek and Cartier 2001, Olsson et al. 2004) – both closely related to FLR - to a large extent draw on theory and guiding ideas of conflict management theory and practice. In particular I find a clear parallel of thinking between the adaptive cycles within interwoven social, economic and ecological systems (Gunderson and Holling 2001, utilised in adaptive co-management by Ruitenbeek and Cartier 2001) and the collaborative learning approach designed to work through environmental conflict in iterative learning cycles (Daniels and Walker 2001). I hope you accept that learning actually is adapting (or changing) yourself to new demands/requirements/ situations – the similarities are striking.

Preliminary conclusions regarding conflict and FLR

Even at the forest level and even under single ownership we have to deal with interest groups, indicating that handling the forest issues must be done in a social context (Northern Spotted Owl in the US North-West Pacific, for example). Moving on to the landscape scale with its complexity of shareholders and stakeholders operating on the local, regional and global level of interest the handling of social issues becomes imperative. We cannot decide and manage without taking people into account: Within a forest (e.g., under private ownership – or in the good old days in national forest service organisations – held a high level of discretion and freedom to act) we might be able to manage for the optimal ecological solution and/or optimal economic solution. Working with landscapes inevitably implies that ecological knowledge somehow must be seen in a social context, i.e. combined with political and economic concerns, stakeholder interests. To function and be effective in such social contexts, experts must be sensitive to values, culture, relations, emotions and the like.

Forest landscape restoration implies some overall concerns (e.g., for the common good, enhance human well-being, achieve sustainable development, economic growth, policy matters) maybe formulated at national, regional, or municipality level. These overall concerns have to be balanced against local or individual concerns (e.g., economic concerns, deeply held values, culture, freedom to decide on one's own land or have influence on local community decisions). The individual and local concerns might not be in harmony with the overall concerns and they might be highly variable depending on who you ask. The question is how to decide in such multiparty settings? The possible answers and the reasoning behind will not be easy ones – they will depend on how you perceive democracy, power distribution, the relationships among the parties, culture, tradition and much more.

Future Trends and a Basic Strategy

As player in a (so far) 20-year-long drama called "Forestry – a slow business undergoing rapid change," forestry as a global phenomenon has developed from a relatively narrow economic production-oriented business into a business encompassing recreational aspects and many aspects of ecology (biodiversity, protection, conservation). It has also moved from a business of local and regional interest (livelihood, production) into an issue of global concern (biodiversity, global change). In my crystal ball I see we are approaching an era with a much stronger focus on the social and human aspects of forest management. Forests perceived as integral parts of the landscape require much more social sensitivity and a whole new bucket of management tools and strategies. Conflict management theory and practice will definitely have a role to play in this exciting forthcoming drama.

Basically, the strategies we choose in FLR and similar social processes can be viewed as (maybe new) ways to perform democracy – from the local to the global level. How do we negotiate and balance the need for overall concerns (e.g. sustainability) against an increasingly individualistic culture (e.g. expanding private property rights). This balancing act implies the simultaneous management of a lot of conflicting interests and concerns at various levels of society. The good news about conflict in this context is that conflict has a huge potential to develop energy and readiness to invest resources. Handled constructively the conflicts, due to this mobilisation of energy, can catalyse a highly desired (re)vitalisation of our democracies – through active public involvement. However, such constructive involvement requires that a fair amount of influence is allocated to those who have a stake – which is not always easy to do for those in power. Equally difficult will be for the possible powerless stakeholders – possessing only limited resources (of any kind) to contribute effectively. This, in turn, points to the important and very difficult issue of empowerment – which also constitutes an extremely important part of conflict management theory and practice.

Bottom line is that *forest landscape restoration* and *conflict management* have a lot in common and a fair potential for mutual gain.

Literature cited

Barrow, E., Timmer, D., White, S., and Maginnis, S. 2002. *Forest Landscape Restoration: Building Assets For People And Nature – Experience From East Africa*. IUCN, Cambridge, UK.

Bush, R.A.B. and Folger: J.P. 2005. *The Promise of Mediation. The Transformative Approach To Mediation.* Jossey-Bass.

Carpenter, S.L. and Kennedy, W.J.D. 2001. *Managing Public Disputes. A Practical Guide for Government, Business and Citizens' Groups.* Jossey-Bass.

Coleman, P.T. 2000. Intractable conflict. In: Deutsch, M. and Coleman, P.T. (eds.): *The Handbook of Conflict Resolution. Theory and Practice.* Jossey-Bass. Pp. 428-450.

Coser, L. 1956. *The Functions of Social Conflict*. The Free Press.

Daniels, S.E. and Walker G.B., 2001. *Working Through Environmental Conflict. The Collaborative Learning Approach.* Preager.

De Dreu, C. and Van de Vliert, E. 1997. *Using Conflict In Organizations.* Sage.

Deutsch, M. 1973. *The Resolution of Conflict*. Yale University Press.

ITTO 2002. ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. ITTO policy development series no. 13. ITTO, Yokohama, Japan.

ITTO 2005. Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan.

Jackson, W. and Maginnis, S., 2005. Building support for FLR. In: ITTO: Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 15-27.

Gilmour, D., 2005. Applying an adaptive management approach in FLR. In: ITTO: Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 35-42.

Gunderson, L.H. and Holling, C.S. (eds.) 2001. *Panarchy. Understanding Transformations in Human and Natural Systems.* Island Press.

Kaner, S., Lind, L., Toldi, C., Fisk, S. and Berger, D., 1996. *Facilitator's Guide to Participatory Decision-Making.* New Society Publishers.

Lamb, D., 2005. Scenario modelling to optimize outcomes. In: ITTO: Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 117-124.

Lederach, P. 1997. *Building Peace. Sustainable Reconciliation in Divided Societies.* US Institute of Peace Press.

Lee, K.N. 1993. *Compass and Gyroscope. Integrating Science and Politics for the Environment.* Island Press.

Maginnis, S. and Jackson, W. 2005. What is FLR and how does it differ from current approaches? In: ITTO: Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 15-27.

Maginnis, S., Rietbergen-McCracken, and Jackson, W. 2005. Introduction. In: ITTO: Restoring forest landscapes. An introduction to the art and science of forest landscape restoration. ITTO Technical series no. 23. ITTO, Yokohama, Japan. Pp. 11-14.

Moore, C. 1996. *The Mediation Process. Practical Strategies for Resolving Conflict.* Jossey-Bass.

Olsson, P. and Folke, C. and Berkes, F. 2004. Adaptive co-management for building resilience in social-ecological systems. *Environmental Management* 34: 75-90.

Pruitt, D.G. and Kim, S.H. 2004. *Social Conflict: Escalation, Stalemate, and Settlement.* McGraw-Hill Higher Education.

Ruitenbeek, J. and Cartier, C. 2001. The invisible wand: Adaptive co-management as an emergent strategy in complex bio-economic systems. CIFOR Occasional paper no. 34. CIFOR, Jakarta, Indonesia.

Tillet, G. 1999. *Resolving Conflict. A Practical Approach.* Oxford University Press.

INCORPORATING DIVERSE STAKEHOLDERS' INTEREST IN THE RESTORATION OF GRAND FOREST PARK SULTAN THAHA SYAIFUDIN, JAMBI, INDONESIA

Ulfah J. Siregar, Iskandar Z. Siregar, and Sri Wilarso Budi

Abstract—The Grand Forest Park Sultan Thaha Syaifudin, Jambi, Indonesia is severely encroached and degraded, such that the original ecosystem is almost unrecognizable. Restoration is very difficult, due to severe conflicts among stakeholders over land use. Negotiations have resulted in re-classification of the area into three zones, i.e. conservative, utilizable, and buffer zone. Species composition in the conservative zone should be 90% forest trees, preferably native to the area, and 10% MPTS (Multipurpose Tree Species), limited to fruit trees commonly found in natural forest, without rubber tree. The utilizable zone should consist of 60% forest trees and 40% MPTS, which can be rubber (30%) and 10% fruit trees. In the buffer zone, agroforestry is allowed as a transition phase. Although species choice is made by local community and agreed by the Government, some legal aspects of tenure are still under discussion. In the whole process, the role of a facilitator was significant.

The land use of the Grand Forest Park Sultan Thaha Syaifudin, Jambi, Indonesia, was already designated as forested since the Dutch occupation, with clear boundaries. Later, by the Governor's Decision Letter No.18, in 1983 the 15,830 ha forest, formerly known as Senami Forest, was classified into two functions, i.e., some critical area nearby a watershed was for protective forest, whereas the rest of the area could be utilized as a limited production forest. At that time any limited production forest in Indonesia was usually managed by a certain concession company. The company held a logging right from the Government for certain period of time, with an agreement that the company would manage the forest area sustainably. At the end of the contract, this right could be terminated or extended, depending on the company's performance record. For the Senami Forest case, apparently the contract was terminated, and the authority was put under Local Forest Service (Dinas Kehutanan). Due to worsening condition of the forest, in 1993 the Provincial Regulation No. 9/1993 changed the status of Senami forest and assigned the whole area as a conservation forest area. The political campaign for this change was again done in 1995 by the Ministry of Forestry (MoF), and later strengthened by MoF decree in 2001. Changes in the political situation in Indonesia, followed by economic crisis in 1997 had negatively affected Senami Forest. Severe encroachment and degradation, even occupation by local and immigrant people was happening uncontrollably, such that the original ecosystem is almost unrecognizable. Lack of capable persons as well as funding of the Dinas Kehutanan has made the destruction continue up till now, and crippled the effort to restore the ecosystem.

Efforts to rehabilitate and restore the conservation area are very difficult, especially due to severe conflict among stakeholders over the land use and land tenure. The Government on one side, as the legal owner of the land, and represented by the Dinas Kehutanan, wants to restore the forest function as a conservation area, while the local community at the opposite side, has deforested and wants to occupy the area for agriculture. Several efforts of law enforcement in the past, to drive out the illegal occupants and plant trees in the area had failed. The illegal occupants kept coming back, removed the planted trees, and replaced them with rubber trees or even oil palms. This paper presents some achievements obtained during the implementation of an action-research project on rehabilitation and restoration of the area using a different approach, i.e. local community participation towards collaborative forest management.

Methodology

Basically the action-research project adopted a multidisciplinary approach to solve the restoration problem. The social investigation usually precedes the biophysical work, and only sometimes are the two approaches combined. For the social aspect, besides surveys on social condition of the local communities, a series of group discussions and workshops among stakeholders, several trainings, extensions, advocating etc. were also done. The strategy employed was first identification of stakeholders, their interests, and the main issue among them. This was followed by discussions and workshops to reach mutual understanding among stakeholders, and building their commitment to manage the forest area sustainably. In between those processes, some work on extension, advocating, and training on several cultivation techniques, as well as on management and

Department of Silviculture, Faculty of Forestry, Bogor Agricultural University, Kampus IPB Darmaga, PO Box 168, Bogor. 16001. Indonesia. Email: ulfahjsiregar@yahoo.com

economical aspects were conducted. The main objective was building capacity of the local community and empowering them. The ultimate goal was to establish a management plan for the area and adoption of a collaborative forest management. The accompanying biophysical work consisted of a survey of forest condition, soil properties, climate, vegetation analysis, nursery practice, and availability of planting materials, before finally establishing a nursery for the rehabilitation and restoration process. Most plans on biophysical work should be in accordance with the result of social processes.

Results and Discussion

Social and Biophysical Condition of the Grand Forest Park Sultan Thaha Syaifudin, Jambi--The Grand Forest Park area lies between 1° 45′ 55″ and 2°14′ 30″ south latitudes and between 103° 12′ 30″ and 104°47′ 30″ east longitudes. The land is flat to undulating with an altitude range of 10 – 100 m above seal level. The area is surrounded by 13 villages, and in 2004 the total population of villages around the Grand Forest Park was 23,156 people consisting of 12,192 males (53 %) and 10,964 females (47 %). Most population is concentrated in three villages, namely Bungku, Sridadi, and Jangga Baru. The population density is 57.7 people per km^2. There is one indigenous forest-dweller community inside the forest area, namely Suku Anak Dalam, however, they have opened up their community to immigrants from outside. The main stakeholders identified (Suharjito 2005) were Government side, which consisted of local Government, Dinas Kehutanan, District Forest Research and Conservation Agency, local police and army, also neutral stakeholders, such as local and other universities and NGOs, and the local community, which consisted of indigenous people, farmers living nearby the forest area, as well as illegal loggers, who have donors for illegal logging, living in a distance from the forest area.

The main issue was conflict over land use and land tenure, creating excessive illegal logging and forest destruction. Local communities want to occupy and utilize the land for agriculture, rubber tree, or oil palm plantations. About 5500 ha have been converted to rubber or oil palm plantations. Encouragement for land use conversion was received from nearby oil palm industry, the high price of rubber, and also high demand for agricultural land. There was no trust among stakeholders; everyone was suspicious of others, assuming that the others were having similar attitudes, which was to get as high a benefit as possible from the forested area. The main occupation of local people is farming; however they also depend on the forest. Even though other stakeholders recognize the authority of the Dinas Kehutanan over the forested area, in practice they tend to undermine this. Therefore, later it was found out that empowering Dinas Kehutanan was important and necessary step.

Zone	Forest Tree Species	Multi-Purpose Tree Species
Conservation Zone (restoration work)	Bulian (*Eusideroxylon zwagerii*) Meranti (*Shorea spp* and *Hopea spp*) Jelutung (*Dyera costulata*) Damar mata kucing (*Shorea javanica*) Rattan jernang dan manau(*Calamus spp*) Red Balam (*Palaquium spp*) Tembesu (*Fragrarea spp*)	Durian (*Durio zibethius*) Duku (*Lancium domesticum*)
Utilizable Zone (Rehabilitation work)	Mahoni (*Swietenia macrophylla*) Sungkai (*Peronema canescence*) Pulai (*Alstonia scularis*) Gmelina (*Gmeliba arborea*)	Rubber (*Hevea braziliensis*) Nangka (*Artocarpus integra*) Duku (*Lancium domesticum*) Mangga (*Mangifera indica*)
Buffer Zone (Agroforestry work)	None	Rubber (*Hevea braziliensis*)

Table 1. Selected species for each zone of The Grand Forest Park Sultan Thaha Syaifudin, Jambi,

The average temperature for the period 2001 to 2005 was 28° C, humidity was more than 80%, and monthly rainfall ranged from 174.5 mm to 221.7 mm. Previously the forest area was famous as a natural habitat and rich source of excellent timber species, e.g., iron wood (*Eusideroxylon zwagerii*), many species of Dipterocarps, balam (*Palaquium* spp.), jelutung (*Dyera costulata*) etc. However, recent vegetation analysis showed that very few of those tree species were found in the area. The whole forest area could fall into three conditions, i.e. secondary forest, degraded forest land, or rubber tree plantation. Secondary forest was dominated by less economically important species, with the total 15.6 m^2 ha^{-1} basal area (Pamoengkas and others 2005). Degraded forest land consisted of bushy grassland and bare land, upon which the community will usually establish rubber tree or oil palm plantations. Dominant soils are red yellow podzolic (70%) followed by alluvial (18%), granosol (3.24%) and other soil types (8.58%). The bulk density was between 0.91-1.42, normal porosity ranges from 49.18% - 65.78%, and permeability to water was 2.11-13.18 cm hr^{-1}. From the percentage of silt (12.68% - 43.18%) and clay (19.28% - 42.35%), the soil can be classified as sandy loam to light loam (Wilde and others 1979). Although soil exchange capacity (6.16-13.56 me/100g) is moderate, degree of base saturation (7.60% - 28.99%) is relatively low.

Building Trust by Accommodating Stakeholders' Interests

From series of interviews, dialog, group discussions and workshops, it was becoming clear that basically most stakeholders recognized the importance of forest function. Most of them have witnessed the negative impact of forest destruction in recent years, such as higher temperature, unpredictable climate change, frequent forest fire, scarcity of water, declining forest production, etc. This recognition, however, did not prevent them from destroying the forest. The main reason behind this contradictory attitude was always an effort to generate higher income. The solution of this situation was then formulated as, how to establish a new kind of conservation forest, which could give as high as possible benefit to all stakeholders. Tenure was also a problem yet to be solved. During this process it was realized that Dinas Kehutanan as the legal authority of the forest would not be able to guard the forest by itself, due to lack of capable persons and funding. Therefore, Dinas Kehutanan would be best to rely on the local community to control the forest, thus adopting a collaborative forest management with the local community. The local community was willing to do so, given a legal authorization to do so, including clear tenure on the forest resources.

Further consultations and discussions have identified each stakeholder's idea and interest in the establishment of the new conservation forest. The Ministry of Forestry, through Dinas Kehutanan and District Forest Research and Conservation Agency, gave guidelines that a conservation forest can be divided into three zones, i.e. conservation, utilization, and buffer zone, with each zone having different function. The conservation zone is strictly to preserve and conserve native species. The utilization zone is also used to conserve native species, with some degree of utilization permitted. In the buffer zone more freedom is allowed to utilize and modify the species composition. In the further discussion concerning restoration work on each zone, different levels of species composition was agreed on. In the conservation zone, 90% of the species to be planted should be forest tree species, preferably native to the area, and 10% could be MPTS (Multipurpose Tree Species). The MPTS for conservation zone are limited to some fruit trees commonly found in natural forest, and rubber tree is not allowed. In the utilizable zone the species to be planted consisted of 60% forest tree species and 40% MPTS. The MPTS for utilizable zone can be rubber tree (30%) and 10% fruit trees. In the buffer zone, which is usually already occupied by the local community, agroforestry systems will be established as a transition phase, before finally becoming an utilizable zone. List of the selected species can be viewed in Table 1.

Although choice of species is made by local community and agreed to by the Government, some legal aspects of tenure are still under discussion. The negotiation on this topic was clearly very tough and time consuming. A very strong encouragement was needed to convince the Government to give some of its authority. Previous attempts to delegate some authority to a certain community in the area, to establish a forest plantation and manage it, was misused by the community. Some community members sold the land to immigrants, who then used the land for other purposes. This fact has strongly affected the Government opinion towards local communities. All stakeholders at the moment are seeking ways to overcome the tenure problem, by proposing various arrangements. In the whole process, the role of a facilitator in the communication and extension was very significantly important. Facilitators usually came from neutral stakeholders, such as universities and some NGOs.

Conclusions

Restoration and rehabilitation of a conservation forest area such as The Grand Forest Park Sultan Thaha Syaifudin, Jambi, Indonesia, requires multi-disciplinary approaches, of which a social approach usually precedes any biophysical work. The severely degraded area, with many stakeholders involved, needs careful planning and powerful facilitators to facilitate, advocate, negotiate, and give extension to bridge the gap of knowledge. By a careful process some of the diverse interests could be accommodated in the management plan of the restored area, for example by assigning different zones, and different species selections for each zone. The most difficult negotiation and discussion was on tenure, due to disappointing previous experience.

Acknowledgments

This work is supported by ITTO Project PD 210/03 Rev 3 (F) entitled "Participatory Establishment of Collaborative Sustainable Forest Management in Dusun Aro, Jambi". The authors are grateful to Dr. Hardjanto, and Dr. Didik Suharjito for their useful comments.

Literature Cited

Prijanto P., I.Z. Siregar and S.W. Budi. 2005. Vegetation structure and composition of degraded primary forest, secondary forest and degraded forest land at the Grand Forest Park Sultan Thaha Syaifudin, Jambi, Indonesia. Technical Report No 4. ITTO Project PD 210/03 Rev 3 (F). ITTO, Yokohama Japan.

Suharjito D. 2005. Building collaboration forest management: A preliminary result. Technical Report No.2. ITTO Project PD 203/03 REV 3(F). ITTO, Yokohama, Japan.

Wilde, SA, R.B. Corey, J.G. Iyer and G.K. Voigt. 1979. *Soil and Plant Analysis for Tree Culture*. Oxford & IBH Publishing Co. New Delhi. 224pp.

INTEGRATING SCIENTIFIC RESEARCH WITH COMMUNITY NEEDS TO RESTORE A FOREST LANDSCAPE IN NORTHERN THAILAND: A CASE STUDY OF BAN MAE SA MAI

Stephen Elliott, Cherdsak Kuaraksa, Panitnard Tunjai, Tiderach Toktang, Kunakorn Boonsai, Sudarat Sangkum, Sutthathorn Suwanaratanna and David Blakesley

Abstract—This paper describes a forest restoration research project in Doi Suthep-Pui National Park, northern Thailand, which successfully combined the needs of science with those of local villagers. Field trials were established by Chiang Mai University's Forest Restoration Research Unit (FORRU-CMU) to test the framework species method of forest restoration, in collaboration with the Hmong hill tribe community of Ban Mae Sa Mai. The project generated a successful method to restore evergreen forest on deforested land, as well as insights into the factors that influence villagers' participation in forest restoration. Canopy closure was achieved 3 years after planting 20-30 framework tree species. Within 6 years, plots were colonized by 61 recruit tree species and bird species richness increased from 30 to 88. The environmental benefits of this project, most appreciated by villagers, were increased "forest quantity" and "forest quality," followed by "improved water quality." Utilitarian benefits such as higher production of forest products and income from eco-tourists visiting the project, were also highly ranked. Intangible benefits, most valued by the villagers, included "improved social harmony" (reduced conflicts over resource shortages) and "improved public image," which villagers recognized as strengthening their right to remain living in the national park.

Like all tropical countries, Thailand has suffered from severe deforestation. Despite a commercial logging ban since 1989, natural forest cover has declined below 20% and the annual deforestation rate remains about 0.5%. The result has been loss of biodiversity and increased rural poverty, as local people are forced to purchase substitutes for products formerly gathered from forests. Increases in landslides, droughts and flash floods have also been attributed to deforestation. Part of the government's responses to this crisis has been to "protect" remaining forest in national parks and wildlife sanctuaries, which now cover about 17% of the country. However, many such "protected" areas were established on former logging concessions, so large parts of them are, in fact, deforested. Previous reforestation programs mostly involved establishing plantations of pines and eucalypts, which do not constitute suitable wildlife habitat and provide far fewer products and ecological services to local people than the original forest formerly did. If protected areas are to fulfill their purpose of conserving biodiversity, reforestation should be designed to restore the forest ecosystems that were present before deforestation occurred. However, such "forest restoration" is constrained by lack of knowledge of the reproductive ecology and horticulture of the hundreds of tree species that comprise Thailand's varied tropical forest ecosystems. Therefore, in 1994, Chiang Mai University established a Forest Restoration Research Unit (FORRU-CMU) to develop appropriate techniques to restore tropical forest ecosystems on degraded land in protected areas for biodiversity conservation and environmental protection.

Methods

Extensive research was carried out on the tree species of tropical evergreen forest in Doi Suthep-Pui National Park (including phenology, seed germination and seedling growth in an experimental tree nursery) to identify candidate "framework tree species" i.e. indigenous forest tree species likely to i) survive and grow well in deforested sites, ii) shade out competing weeds, and iii) attract seed-dispersing wildlife. The method relies on planted trees to restore forest structure and function, whilst the animals that they attract bring about biodiversity recovery, by dispersing the seeds of non-planted tree species (recruits) into planted plots. Every rainy season since 1997, trial plots, ranging in size from 1.4 to 3.2 ha, have been planted with 20-30 candidate framework tree species in the Upper Mae Sa Valley (1,300 m elevation) of Doi Suthep-Pui National Park, in collaboration with the park authority and the villagers of Ban Mae Sa Mai, a large Hmong community resident in the valley. The objectives of these plots were to i) assess the potential of the planted tree species to perform as framework species, ii) test the responses of the trees to various silvicultural treatments applied to maximize field performance, and iii) assess biodiversity recovery. Before planting, the plots were cleared of weeds by slashing and spraying with glyphosate, taking care not to damage any existing natural regeneration. Saplings (30-50 cm tall), grown from locally-collected seeds, were planted randomly across the plots, averaging 1.8 m apart. Various fertilizer, mulching and weeding regimes were applied as experimental treatments during the first two

Forest Restoration Research Unit, Chiang Mai University (FORRU-CMU) Chiang Mai Thailand; email-forru@science.cmu.ac.th

rainy seasons after planting. Fire breaks were cut every January and fire prevention patrols worked throughout the dry season. All planted trees were labeled and monitored 2 weeks after planting and at the end of each subsequent rainy season. Surveys of naturally established trees and birds were carried out before planting and at various intervals thereafter, both in planted plots and in non-planted control plots.

Researchers worked closely with a grass roots organization, already established in the village, the Natural Resources Conservation Group of Ban Mae Sa Mai. Project planning was carried out with the village conservation committee and the national park authority. The project built a tree nursery in the village and one family in the village was employed to collect seeds and grow the trees. Planting and fire prevention during the dry season were declared "community activities" by the village committee, requiring every household to volunteer one family member to join these activities. For weeding, fertilizer application and monitoring, standard daily labour rates were paid to those villagers who participated. Villagers regularly welcome visitors to the project and have described their work in national and international conferences. In 2006-07, questionnaire surveys were carried out in 70 households to explore the villagers' motivation for participating in this project.

Results

Technical Achievements—Monitoring of planted trees enabled determination of the best-performing framework tree species (Elliott et al. 2003) and optimal silvicultural treatments (FORRU 2006). Canopy closure was achieved in most plots by 3 years after planting. After 6 years, more than 60 recruit tree species had colonized the plots, mostly germinating from seeds dispersed from nearby forest by birds (particularly bulbuls), fruit bats and civets, increasing total tree species richness to 91; equal to 41% of all tree species recorded in primary evergreen forest at the same elevation. Bird species richness also increased markedly from about 30 before planting to 88 after 6 years, representing about 54% of birds recorded in nearby mature forest (Toktang 2005).

Community Perceptions—villagers ranked "fire prevention" and "tree-planting" as the most highly appreciated project activities. The most strongly recognized environmental benefits of the project were increases in "forest quantity" and "forest quality," followed closely by "improved water quality." Increased production of forest products, particularly medicinal plants, bamboos (shoots and canes) and wild vegetables were also ranked highly. Villagers variously estimated the value of such forest products as 700-11,000 baht per household per year (US$ 20-314). The attraction of eco-tourists to the village to view the project also increased the incomes of some families (through provision of accommodation and food). Intangible benefits, most highly ranked by the villagers, were "improved social harmony" (by reducing internal conflicts over resource shortages) and "improved public image," which villagers recognized as strengthening their right to remain living within the national park (where occupation is actually illegal). "Increased environmental awareness" among the villagers and "improved relationships" with both local government and NGO's were also highly ranked benefits. The latter has enabled the village committee to secure "matching funds" for various other conservation works. The project has also resulted in the revival of various cultural traditions such as veneration of forest spirits and animistic ceremonies to prevent fire forest fire.

Conclusions

Although this project is not universally appreciated by all villagers in the community, it is accepted by the majority and not a single planted tree has ever been cut down by the villagers. By careful planning, with both the park authority and the villagers, forest restoration has been achieved with minimal disturbance to the villagers' agriculture-based livelihoods. Much of the success this project can be attributed to the highly organized nature of this community, particularly the pre-existence of a conservation group within the village, which has gained greater political influence within the community, as appreciation of the benefits of the project has increased. The area is now being developed as a demonstration site, for teaching both the technical and social aspects of Forest Landscape Restoration to other communities from Thailand and neighbouring countries.

Acknowledgements

The authors thank the villagers of Ban Mae Sa Mai and Doi Suthep-Pui National Park Authority (currently led by Kuhn Surachai Tuamsomboon) for their co-operation with this project. Project activities in the Upper Mae Sa Valley have been sponsored by Thailand's Biodiversity Research and Training Program, Britain's Eden Project, Plant a Tree Today Foundation and WWF-Thailand Program with King Power Duty Free. We thank them all.

LITERATURE CITED

Elliott, S., P. Navakitbumrung, C. Kuarak, S. Zangkum, V. Anusarnsunthorn and D. Blakesley. 2003. Selecting framework tree species for restoring seasonally dry tropical forests in northern Thailand based on field performance. *Forest Ecology and Management* 184: 177-191.

Forest Restoration Research Unit. 2006. How to Plant a Forest: The Principles and Practice of Restoring Tropical Forests. Biology Department, Science Faculty, Chiang Mai University, Thailand.

Toktang, T. 2005. The Effects of Forest Restoration on the Species Diversity and Composition of a Bird Community in Doi Suthep-Pui National Park Thailand from 2002-2003. MSc. thesis, Chiang Mai University, Thailand.

LANDSCAPE RESTORATION IN THE NETHERLANDS: POLICY ASPECTS AND KNOWLEDGE MANAGEMENT

Stephen Rob J.J. Hendriks

Abstract—The Netherlands is a densely populated and industrialized country with corresponding environmental problems and loss of natural habitat. The "leading position" in destroying our natural capital also resulted in a relatively early awareness of the necessity and possibilities of Ecological Restoration. Over the past decades restoration efforts have been undertaken to counteract the effects of habitat loss, degradation of environmental quality and loss of landscape connectivity.

In this contribution to the IUFRO Forest Landscape Restoration conference, I will give an overview of the position of Ecological Restoration in Dutch Nature Policy over the years. A number of examples of restoration projects will be presented and the Dutch experiences will be discussed in relation to European and Global legislation and initiatives on nature conservation and restoration. I will pay special attention towards effective management of the knowledge that is necessary for successful Landscape Restoration. In the Netherlands we have reached very satisfying results from the functioning of so called expert groups. Key element of success of these groups is the fact that they include representatives of NGOs, the research community and governmental policy makers. Recent and future developments in this respect will be sketched and the relation with the learning network of the Global Partership on Forest Landscape Restoration will be indicated.

Ministry of Agriculture, Nature and Food Quality, PO Box 482, 6710 BL Ede, The Netherlands; email-r.j.j.hendriks@minlnv.nl.

TROPICAL AFFORESTATION AND REFORESTATION STRATEGIES TO CONSERVE BIOLOGICAL DIVERSITY AND INCREASE GLOBAL AND LOCAL BENEFITS

Anthony S. Davis and Douglass F. Jacobs

Summary—The rapid rate of global deforestation, estimated at an average of 9.4 million ha per annum between 1990 and 2000, draws attention to the need to minimize future loss of forest cover. This paper outlines potential afforestation and reforestation strategies that could improve the state of tropical forest management by conserving biological diversity in tropical regions and increasing potential economic benefits to local communities. Plantation establishment with native species will more closely mimic natural forests and provide many of the non-timber forest products that could be marketed beyond their current range through use of more aggressive strategies. An increase in global consumption of wood products, potential financial gains from carbon sequestration, and acceptance of the need for erosion control to maintain clean water and ground structure will lead to enlargement of tropical forest plantation area. By addressing concerns over future stand composition prior to plantation establishment, there is a greater chance of maintaining key components of natural ecosystems. Over time, ecological restoration will become increasingly important towards the conservation of biodiversity. Currently, practices are being developed to rehabilitate and restore habitat for a multitude of species. However, these practices are expensive and experimental. By limiting the establishment of sites which, in the future, may need to be restored, future costs can be avoided through present actions. Several points that should be considered when dealing with plantation establishment in the tropics include:

1. Plantations are a necessary part of resource management, both for wood supply and for ameliorating the pressures placed on natural forests
2. The composition and structure of the plantation can have great effects on both monetary and ecological values
3. Diversification of species (i.e., multi-species management) can reduce the risk associated with disease, market fluctuations, and fire damage, while increasing the contribution to ecosystem diversity
4. Use of native species does not preclude obtaining the same remuneration as exotic species, increases the contribution to ecosystem diversity, and maintains cultural traditions associated with indigenous forest trees

As a method of conserving biological diversity, maintaining natural ecosystem processes, and increasing local and global benefits, the following recommendations should be considered as guidelines for tropical forest plantation establishment:

1. Use native species, within their native range (paying close attention to species suited to the site conditions)
2. Use multiple species to allow for access to diverse markets
3. Select species that facilitate, or at minimum do not restrict, native understory development
4. Consider the ability of species to sequester carbon

Recent research in tropical regions towards identification of native species suitable for plantation establishment is encouraging and necessary. Dedication of researchers in industrialized countries to assist with the development of strategies to conserve tropical forests will decrease the chance of repeating mistakes made in boreal and temperate ecosystems. Partnerships involving cooperation between government, indigenous people, practitioners, researchers, non-government organizations and other stakeholders appear to be more effective than traditional means in creating sustainable resource management practices. Individuals and organizations with experience in bringing new products to market could prove to be an invaluable resource in terms of the economic production of non-timber forest products. Implementing the aforementioned recommendations will likely lead to a more desirable future forest plantation composition, but it is paramount that landowners understand the reasons for the actions they are taking. Through proper management, afforestation and reforestation in the tropics can benefit society locally and globally while maintaining key ecosystem components currently being threatened or degraded by anthropogenic use.

Hardwood Tree Improvement and Regeneration Center, Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907, USA; e-mail-asdavis@purdue.edu.

PLANTED FORESTS AND TREES CAN RESTORE LANDSCAPES AND ALLEVIATE POVERTY

J. B. Carle

Abstract—Planted forests and trees outside forests can contribute significantly to restoration of landscapes whilst meeting livelihoods needs in alleviating poverty and reducing hunger, particularly in developing countries.

As planted forests and trees outside forests interact with, and impact local land-uses, livelihoods and the environment, integrated planning and management approaches should be adopted within a landscape or watershed to ensure that upstream and downstream impacts are planned, managed and monitored within acceptable social, economic and environmental standards.

In the past the potential roles and values of planted forests, trees outside forests and agroforestry systems have not been fully supported by Government decision makers, partly due to a lack of information, understanding and communication, but also from conflicting policy priorities, particularly regarding development to ensure food security and poverty alleviation. This has translated into insufficient political commitment and allocation of resources to put in place the facilitating factors that are needed to encourage restoration of landscapes through afforestation and reforestation. Planting forests and trees for landscape restoration need not contradict the goal of reducing poverty and eradicating hunger, but support them.

Inter-sectoral, multi-disciplinary and multi-stakeholder participatory approaches to policy, planning and management in the restoration of landscapes are new to most developing countries. New policy, legal, regulatory and institutional frameworks, training and skills are needed if planted forests and trees are to restore landscapes whilst achieving sustainable livelihoods. The voice of the forestry sector in many developing countries has been marginalized so foresters need to be more proactive in inter-sectoral planning to ensure that forestry is considered as an important component of national development priorities, not confined to national forest programmes. In so doing, there is an opportunity to highlight the value and potential roles of natural and planted forests and trees in restoring landscapes and supporting livelihoods in both rural and urban landscapes.

It is important to integrate planted trees and forests in more holistic approaches to provide environmental services, biodiversity benefits and meet people's short and long-term needs. It is also necessary to make modern technology and traditional knowledge available in more people oriented approaches to be shared through national and international networks, and sound extension and technical support systems and demonstrations. However, there are technical and institutional challenges to meet the more diverse and flexible mixes of multiple species in mechanisms and multilevel land-uses that are more in phase with the needs of people, rather than with the engineering approaches of the past.

Examples will be given where planted forests and trees provide a valuable role in combating desertification, rehabilitation of degraded lands, watershed management and restoration of landscapes and livelihoods following catastrophic biotic and abiotic events (fire, tsunami etc).

Forestry Department, FAO of the United Nations; email-Jim.Carle@fao.org.

COULD FOREST MANAGEMENT THAT ENSURES A BALANCE OF STAND STRUCTURES ENHANCE BIODIVERSITY CONSERVATION IN NORTHEAST CHINA'S NATURAL FOREST PROTECTION PROGRAM NEED?

Xuemei Han[1], Chadwick Dearing Oliver[1], Jianping Ge[2], Qingxi Guo[3], and Xiaojun Kou[2]

Abstract—As one of the world's largest ongoing ecological rehabilitation projects, China's Natural Forest Protection Program (NFPP) is very important and has brought promising expectations to forest restoration and biodiversity conservation. The forest cover has been enhanced by the implementation of NFPP during the past years. We suggest another important element, forest stand structure, is worth attention for biodiversity conservation when restoring the forest landscape. In this article, we examine the NFPP's practices in forests in Northeastern China and Inner Mongolia with a government-independent forestry scholar's view. We hypothesize that, for the next step, some endangered species could be even better protected when the forests are managed in certain appropriate, sustainable ways. We first review the conceptual model of forest stand dynamics and explain how the stand structure changes could impact wildlife populations based on multiple cases from around the world. Second, we examine the natural forest composition in Northeastern China and Inner Mongolia where the NFPP is undertaken and predict the possible forest structure changes over time with protection. Finally, we use the Amur tiger as an example to demonstrate how proper forest management in this area could ensure an appropriate diversity of forest stand structures and further enhance maintaining the Amur tiger's population when implementing the NFPP.

China initiated its Natural Forest Protection Program (NFPP) in 1998 to prevent soil erosion, desertification, and the decline of natural forest resources. It is now implemented in 17 provinces and has become one of the world's largest ongoing ecological rehabilitation projects (NFPP Management Office and Center of State Forestry Administration 2006). The program has brought promising expectations to forest restoration and biodiversity conservation. While forest cover has been enhanced by the implementation of NFPP, we suggest another important element, forest stand structure, is worth attention for biodiversity conservation when restoring the forest landscape in the northeastern China region.

In contrast to the early "steady-state" ecological paradigm, the dynamic perspective recognizes that forest stand structures change following disturbances and forest growth (Oliver and Larson 1996). A major (stand-replacing) disturbance leads forests into an "open" structure where many trees first initiate from seeds or sprouts. With forest development, competition among trees becomes intense and the stands grow into the stem exclusion stage with very "dense" structures. As some older trees die, new trees invade but remain suppressed in understory, and forests obtain the "understory" structure. Eventually, the younger trees grow up and generate multiple canopy layers, which lead to the old growth stage that has a "complex" structure with diverse horizontal and vertical spatial patterns and relatively open canopies. Further, minor disturbances can partially eliminate trees from the dense and understory structures and quickly change them to the complex structure or the "savanna" structure with sparse trees standing (Oliver and Larson 1996, Oliver et al. 1998).

These different forest structures (i.e. open, savanna, dense, understory and complex) provide different habitat types that support different plant and animal species. For example, spotted owls (*Strix occidentalis caurina*) utilize complex structures and had declined with the shortage of old-growth forests in Northwestern United States (Gutierrez and Carey 1985); red cockaded woodpeckers (*Dendrocopos borealis*) utilize pine savannas in the Southeastern United States (U.S. Fish and Wildlife Service 1985); many butterflies have disappeared with elimination of openings (Young 1992); elk (*Cervus elaphus*) in the Northwestern United States survive best in openings which provide high quality food (Cook et al. 1998, Duncan 2000, Fisher and Wilkinson 2005); and the Florida panther (*Puma concolor coryi*), that had been believed to be a forest obligate, actually utilizes openings as well (Gross 2005, Kostyack et al. 2006).

Wildlife populations can dramatically change when the forest structure alters. The deer population in the Allegheny Plateau of the Northeastern United States had a dramatic expansion in the 1920s following the openings created by the prior heavy

[1] Yale University, School of Forestry and Environmental Studies (xuemei.han@yale.edu), New Haven, CT 06511.
[2] Beijing Normal University, Beijing, China, 100875.
[3] China Northeastern Forestry University, Harbin, Heilongjiang province, China.

forest cutting, and experienced a sharp drop in 1930s when the young secondary-growth forests grew into the stem exclusion stage with dense structures (Marquis 1975).

Forestry management with appropriate silvicultural pathways could be used to balance the stand structures and enhance biodiversity conservation (Oliver 1998), while management without maintenance of certain structures could put the dependent species in danger. We hypothesize that, for the next step, some endangered species could be even better protected when the forests are managed in certain appropriate ways during the NFPP practices.

Study area

This study focuses on the Northeastern China forest region, whose forests account for 27.8% of China's total forest resource and used to be the primary timber producing region in China. This area is inhabited by many wildlife species including endangered species such as the Amur tiger (*Panthera tigris altaica)*, Sika deer (*Cervus nippon*), and sable (*Martes zibellin*) (Hao et al. 1999).

Structures	Ungulates carrying capacity (AUM / km^2)[1]	Amur tiger carrying capacity of (number /km^2)[4]	Minimum home range of an Amur tiger (km ^{2})
Open[2]	36.5	0.061	16.4
Dense[3]	5.5	0.009	109.5
Complex[3]	12.8	0.021	46.9

1. AUM = "Animal Unit Month", an animal unit is a mother and one progeny.
2. Ungulate carrying capacity in "open" structure estimation is based on the elk study in Bighorn Creek Valley, Canada (Morgantini et al.1994).
3. Ungulate carrying capacity in Dense and Complex structure estimated by assuming forage (and AUMs) proportional to percent of sunlight reaching forest understory: assumed at 15% for dense and 35% for complex.
4. A tiger's appetite is approximately 50 ungulates per year (Karanth and Stith 2000, Karanth et al. 2004).

Table 1. Estimated carrying capacity and home range of Amur tiger in landscapes with different forest structures.

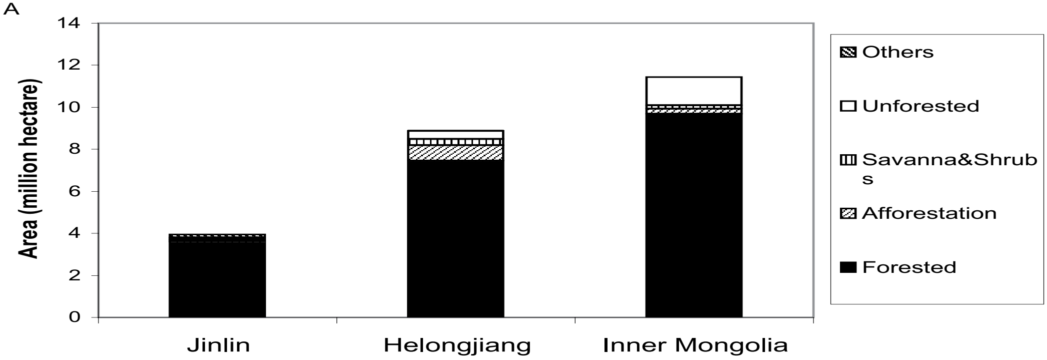
Method

The Amur tiger is discussed as an example. We interpret suitable structures for the Amur tiger by analyzing the literature and then estimating the relative amounts of suitable forest structure in Northeastern China by field observation and analysis of official data.

Results

The Amur tiger benefits from having a diversity of stand structures--The Amur tiger preys mainly on ungulates such as wild boar (*Sus scrofa*) and Cervids including elk (i.e., red deer) (*Cervus elaphus*), sika deer (*Cervus nippons*), and roe deer (*Capreolus capreolus*) (Hornocker et al. 1998, Kerley 2003). Prey is one of the determinants of the tiger's population (Karanth and Stith 1999, Miquelle et al. 1999, Karanth et al. 2004); consequently, the structures necessary for maintaining prey populations are critical. Studies in

A



B

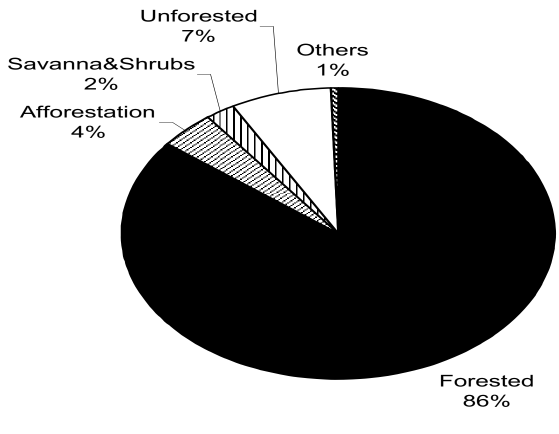


Figure 1. Forest composition in Northeastern China. A: separate for the three provinces-- Jinlin, Helongjiang, and Inner Mongolia. B: Composition for the overall northeastern China forests. (Data source: NFPP implementation scheme for Jinlin province (2002), Heilongjiang province (2001), and Inner Mongolia (2001)).

Northeastern China show that cervids inhabitated openings, riverside shrub areas, forest edges, and savanna forests (Li 2003). Wild boar prefer to live in open structures consisting of dense shrubs or wet grassland, as well as in complex and savanna structures of broadleaf forests (Song et al. 2005). These studies illustrate the importance of diverse structures, especially the open and savanna, for providing suitable habitat for the Amur tiger prey. We estimate the carrying capacity of ungulates and Amur tigers in different forest structures based on data from open-field elk studies in Canada (Morgantini et al. 1994) and tiger prey studies in India (Karanth and Sunquist 2000, Karanth et al. 2004), which also show that open structures maintain highest tiger populations (Table 1).

Northeastern China's forest is experiencing a shortage of open and savanna structures--Field observation conducted in June to August, 2006 suggest that many forests are in very dense structures. This observation is reinforced by the timber harvest history in this area. Numerous, very heavy timber harvest operations in the 1970s and 1980s (Lei 2005) led to the secondary forest regrowing into the dense structure (stem exclusion stage) at present. The official statistical data also show that less than 10% of the forest areas contain open or savanna structures (Heilongjiang Forestry Survey and Design Institute 2001, Inner Mongolia Forestry Survey and Design Institute 2001, Jilin Forestry Survey and Design Institute 2002) (Figure 1).

Conclusions

The small population of Amur tigers in Northeastern China may be caused in part by a shortage of forest stand structures that are suitable for its prey. Consequently, an additional step toward protecting this tiger and other species may be to ensure all stand structures are maintained in the forest. Forest management in this area could ensure an appropriate diversity of forest stand structures, especially ensuring open and savanna structures, and further enhance efforts to maintain the Amur tiger's population when implementing the NFPP.

Acknowlegments

This study is supported by Yale School of Forestry and Environmental Studies, Yale Institute for Biospheric Studies Center for Field Ecology Pilot Grant, the Jubitz Family Endowment for Research from United States, and the National Key Project for Cooperation Researches on key issues concerning environment and resources in China and Russia (Grant No. 2005CB724800 from China). This study received valuable encouragement from discussions with Professor Timothy G. Gregoire of Yale University and Professor Herman H. Shugart of the University of Virginia. We appreciate the help of Mr. Xuejun Chen, Vice Director of China's NFPP Office, for his discussions and for providing materials. We also thank the Hunchun National Reserve in Jilin Province for help on the Amur tiger's study.

Literature cited

Cook, J.G., Irwin, L.L., Bryant, L.D., Riggs, R.A., Thomas, J.W. 1998. Relations of forest cover and condition of elk: A test of the thermal cover hypothesis in summer and winter. *Wildlife Monographs* 5-61.

Duncan, S. 2000. Why do elk seek shelter? The case against the need for thermal cover. PNW Science Findings:1-6.

Fisher, J.T., Wilkinson, L. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. *Mammal Review* 35:51-81.

Gross, L. 2005. Why not the best? How science failed the Florida Panther. *PLoS Biology* 3:1525-1531.

Gutierrez, R.J., Carey, A.B. 1985. Ecology and management of the spotted owl in the Pacific Northwest.

Hao, Z., Wang, Q., Dai, L. 1999. The importance of the National Programme for natural forests conservation on biodiversity conservation in northeast state owned forest areas of China. Pages 21-26 in Z. Xu, editor. *China's biodiversity conservation toward the 21st century*. China Forestry Press, Beijing.

Heilongjiang Forestry Survey and Design Institute. 2001. NFPP implementation scheme for Heilongjiang province. Forestry Bureau of Heilongjiang Province.

Hornocker, M.G., Quigley, H.B., Miquelle, D.G., Goodrich, J.M., Kerley, L.L., Smirnov, E.N. 1998. Final report to the SAVE THE TIGER FUND at the National Fish and Wildlife Foundation: Ecology and Conservation of the Siberian Tiger. Hornocker Wildlife Institute, Moscow, Idaho.

Inner Mongolia Forestry Survey and Design Institute. 2001. NFPP implementation scheme for Inner Mongolia. Inner Mongolia People's Government.

Jilin Forestry Survey and Design Institute. 2002. NFPP implementation scheme for Jilin province. Jilin Provincial Forestry Department.

Karanth, K.U., Nichols, J.D., Kumar, N.S., Link, W.A., Hines, J.E. 2004. Tigers and their prey: Predicting carnivore densities from prey abundance. *Proceedings of the National Academy of Sciences of the United States of America* 101:4854-4858.

Karanth, K.U., Stith, B.M. 1999. Prey depletion as a critical determinant of tiger population viability. Pages 100-113 in J. Seidensticker, S. Christie, and P. Jackson, editors. *Riding The Tiger: Tiger Conservation In Human-Dominated Landscapes*. Cambridge University Press, Cambridge, UK.

Karanth, K.U., Sunquist, M.E. 2000. Behavioural correlates of predation by tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus*) in Nagarahole, India. *Journal of Zoology* 250:255-265.

Kerley, L. 2003. A final report to SAVE THE TIGER FUND: scent dog monitoring of Amur tiger-II. Lazovsky State Nature Zapovednik.

Kostyack, J., Hill, K., Fuller, M.K. 2006. Science behind panther decisions discredited. in N. W. Federation, editor. *News &Views.*

Lei, J. 2005. *Forest resources of China*. China Forestry Press, Beijing.

Li, W. 2003. Observation of roe deers' ecological habits and analysis of their food. *Journal of Liaoning Forestry Science and Techonology* 5:16-18.

Marquis, D.A. 1975. The Allegheny hardwood forests of Pennsylvania.

Miquelle, D.G.; Smirnov, E.N.; Merrill, T.W.; Myslenkov, A.E.; Howard B,Q.; Hornocker, M.Q., Schleyer, B. 1999. Hierarchical spatial analysis of Amur tiger relationships to habitat and prey. Pages 71-99 in J. Seidensticker, S. Christie, and P. Jackson, editors. *Riding The Tiger: Tiger Conservation In Human-Dominated Landscapes.* Cambridge University Press, Cambridge, UK.

Morgantini, L.E., Woodard, P.M., Eslinger, D. 1994. Logging and elk in the Bighorn Creek Valley in Western Alberta (1988-1991). Department of Renewable Resources in cooperation with Alberta Environmental Protection, Fish and Wildlife Service, Edmonton.

NFPP Management Office and Center of State Forestry Administration. 2006. *Natural Forest Resource Protection Program Manual*. China Forestry Press, Beijing.

Oliver, C.D. 1998. Passive versus active forest management. Pages 237-257 in J. M. Calhoun, editor. *Forest Policy: Ready for Renaissance.* Institute of Forest Resources, College of Forest Resources, University of Washington, Seattle.

Oliver, C.D., Larson, B.C. 1996. *Forest Stand Dynamics*, updated edition. John Wiley & Sons, Inc., New York.

Oliver, C.D., Osawa, A., Camp, A. 1998. Forest dynamics and resulting animal and plant population changes at the stand and landscape levels. *Journal of Sustainable Forestry* 6:281-312.

Song, J., Li, W., Zhang, H., Jiang, Y. 2005. Observation of wild boars' ecological habits and analysis of their food in Baishilazi area. *Journal of Liaoning Forestry Science and Techonology*:25-26.

U.S. Fish and Wildlife Service. 1985. Red-cockaded woodpecker recovery plan. U.S. Fish and Wildlife Service, Altlanta, Georgia, U.S.A.

Young, M. R. 1992. Conserving insect communities in mixed woodlands. Pages 277-296 in C. M. G. R., M. D. C., and R. P.A., editors. T*he Ecology Of Mixed-Species Stands Of Trees.* Blackwood Scientific Publications, London.

SPATIAL VARIATION IN AMENITY VALUE OF FOREST LANDSCAPE

Seong-Hoon Cho[1], Neelam C. Poudyal[2], Roland K. Roberts[1]

Abstract—Empirical evidence shows that amenities of different features of open space vary according to the degree of urbanization. In summary, evergreen trees, a diverse landscape with fragmented forest patches, and more complex and natural forest edges are more highly valued in Rural-Urban Interfaces. In contrast, deciduous and mixed forests, larger forest blocks, and smoothly trimmed and man-made forest patch boundaries are more highly valued in Urban Core area. As spatial variation in amenity values differs across a metropolitan area, the necessity of site-specific land use management to fit the local characteristics is recognized.

Despite the extensive use of the hedonic property method in valuing open space, few studies have valued the quality of open space. The quality of open space can be classified by composition, spatial configuration and pattern of open space. Recently, the valuation of open space with regard to its spatial configuration has become a matter of interest. Recent literature focused on the aesthetic value of land-use diversity and landscape quality in the surroundings (Geoghegan et al. 1997, Acharya and Bennett 2001, Kestens et al. 2004). Using advances in geospatial information technology, the studies attempted to measure hedonic values of spatial configurations of open space. These studies employed various spatial indices commonly used in landscape ecology research. Palmer (2004) and Geoghegan et al. (1997) found that the composition and spatial pattern of land use in the surroundings are good predictors of scenic perception and housing value. Acharya and Bennett (2001) found that housing value is influenced by the landscape structure of a neighborhood.

Previous hedonic studies on open spaces rely on few problematic assumptions. First, they assumed the exogenity of the open spaces leading to biased estimation. Since, the location of open space is largely determined by market forces, most privately owned open space are subject to market forces and will be endogenous to housing price (Irwin and Bockstael 2001, Smith et . 2002). Second, those models assumed that implicit prices are constant across a housing market. Although Geoghegan et al. (1997) detected variation in marginal effects using a spatial expansion model, the model has some limitations. First, given the complexity of the expansion equations, local level variations in the parameters are obscured. Second, the form of the expansion equations is deterministic and demands a priori knowledge (Fotheringham et al. 2002). In contrast, this research was directed toward identifying spatial variation of amenity values for both quantity and quality of open space in the housing market in a locally weighted hedonic framework that takes into account of endogeneity of open spaces in housing value.

Empirical Model and Data

Smith-Blundell Test (Wooldridge 2003, pp. 484) was conducted to check endogeneity of open space variables in the usual OLS framework of hedonic price model. As endogeneity of open space variables was detected, instrument variables approach was used to estimate a system of simultaneous equations following Irwin and Bockstael (2001). Six open space measures were treated as endogenous variables. In the first stage, the reduced forms of the housing value equation and open space equations with instrument variables were estimated using OLS regression. In the second stage, the housing value equation was estimated, first by applying OLS and then locally-weighted least squares regression, after replacing the predicted value of housing value and open space variables from the reduced form equations in the first stage (Detail discussion about the locally weighted regression is found in Fotheringham et al. 2002).

As in a typical hedonic model, the empirical model included four sets of variables including structural variables, neighborhood variables, school district variables, and open space variables. We classified the nearest open space into three categories by species composition, including evergreen, deciduous, and mixed woodlots and their proximities were included the model. In addition, we included the size and the spatial configurations of open spaces in the model. Mean forest patch size, patch density, and edge density of green open space at the census-block group level were used to analyze the effects of the size and spatial configuration of open space on house price. Mean patch size measures the general size of forest patches in the neighborhood. Patch density measures the degree of spatial heterogeneity in the open space landscape. The model is applied to the City of Knoxville and its neighboring Town of

[1]Department of Agricultural Economics, University of Tennessee, Knoxville, Tennessee, USA; email-sch09@utk.edu
[2]Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, Tennessee USA.

Farragut in Knox County, Tennessee. This research used five primary GIS data sets: individual parcel data, satellite imagery data, census-block group data, boundary data, and environmental feature data. The individual parcel data were obtained from KGIS (2006), and the County's Tax Assessor's Office (2006). Land cover information was derived from Landsat 7 imagery for 2001.

Results and Discussion

The endogeneity test rejects the hypothesis that the six open space variables are exogenous at the 1% significance level (F statistic of 14.63 and critical value of 2.80) justifying two-stage estimation of the simultaneous equations system. The higher adjusted R square, significantly lower residual sums of square and statistically insignificant spatial autocorrelation of residuals in local model suggests that it outperforms the global model.

The coefficients for five of six open space variables are statistically significant at the 5% level. Also, the null hypotheses of spatial stationarity of these variables are rejected at the 5% level suggesting their amenity effect to be spatially heterogeneous. The global model indicates that proximities to mixed forest are valued significantly more than proximities to single species forest patches. This suggests that forest species diversity is valued higher than mono-species. The negative effect of forest patch density indicates that the residents prefer spatial homogeneity of forest landscape. That means a neighborhood is valued higher if a given area of forestland is in a continuous and single forest tract compared to the one where the same forest area is in more fragmented and isolated patches. This finding seems consistent with the previous literature that the heterogeneity in fragmented landscape decreases the coherence and scenic value and homogeneous landscapes have greater amenity values (Acharya and Bennett 2001, Geoghegan et al. 1997, Nelson et al. 2004, Palmer 2004). The positive edge density indicates that larger perimeters or edges for a given woodlot are valued more in the overall area. This is consistent with Kaplan (1989) and Palmer (2004) who found that the higher edge density that captures complex shapes of landscape significantly adds the scenic value in the neighborhood. The mean size of forest patches negatively affects the housing price in the global model implying that the neighborhoods packed with bigger forest blocks are valued negatively. This finding is consistent with earlier conclusions that residents prefer neighborhood containing smaller patches (Morancho 2003, Nelson et al. 2004).

Spatial pattern analysis of local parameters revealed three consistent clusters of unique areas: the northwest of Farragut, west and south of city center, and northeast of the city center. Proximities to the three types of forest patches and forest patch density are consistently significant in the three cluster areas. The northwest of Farragut and northeast of the city center are 'Rural-Urban Interfaces' that are characterized by relatively lower housing density. The west and south of city center is 'Urban Core' area that is characterized by relatively higher housing density. The proximities to evergreen forest valued positively in the Rural-Urban Interfaces. In contrast, the proximities to deciduous forest and mixed forest are valued positively in the Urban Core area. The findings imply that the deciduous and mixed forests are valued positively in the area where green open space is relatively scarce while evergreen trees are valued positively in the area where green open space is relatively abundant. The positive effects of patch density are found in the Rural-Urban Interfaces while negative effects are found in the Urban Core area. One possible explanation for this opposite effect is that larger forest blocks are more valued in the Urban Core area where land is dominated by impervious surfaces and buildings with little vegetation. In contrast, the positive effect of forest patch density indicates that smaller and more numerous forest patches are valued more in the Rural-Urban Interfaces. This implies that fragmentation and diversity of landscape may be more highly valued when they result in the combined amenities of convenience and privacy, as is the case in the Rural-Urban Interfaces. This suggests that the amenity values of forest types vary according to the degree of urbanization.

The positive effects of edge density were found in the Rural-Urban Interfaces while negative effects were found are in the Urban Core area. This implies higher values for woodlots with rougher and more natural boundaries in the Rural-Urban Interfaces where green space is relatively abundant and higher values of smoothly trimmed and man-made forest patch boundaries in the Urban Core area where green space is relatively scarce. This suggests that city planners and urban dwellers need to invest in landscaping to fine tune the boundaries of scarce and limited green spaces to add extra aesthetic values. Positive effects of mean forest patch size are found within the perimeter of city center while negative effects are found in the northwest of the city boundary. This is not surprising because the residents in the City center may have stronger preference for bigger forest patch due to scarce and limited green spaces in the City center.

Conclusion

This study found the evidences that amenities of different features of open space vary according to the degree of urbanization. In summary, evergreen trees, e.g., conifer species, a diverse landscape with fragmented forest patches, and more complex and natural forest edges are more highly valued in Rural-Urban Interfaces. In contrast, deciduous trees, e.g., hardwood species, and mixed forests, larger forest blocks, and smoothly trimmed and man-made forest patch boundaries are more highly valued in Urban Core area. As spatial variation in amenity values differs across a metropolitan area, the necessity of site-specific land use management to fit the local characteristics is recognized. Another implication of this study is that the real estate developers and city planners can preserve or enhance housing value by considering the size, spatial configuration, and species composition of open space in residential neighborhoods.

Acknowldegement

Cho is the corresponding author. Senior authorship is shared by Seong-Hoon Cho and Neelam C. Poudyal. The authors thank Tim Kuhn and Gretchen Beal of Knoxville-Knox County Metropolitan Planning Commission and Keith G. Stump of Knoxville-Knox County-Knoxville Utilities Board Geographic Information System for providing school district, and house price data.

Literature Cited

Acharya, G., Bennett, L.L. 2001. Valuing open space and land-use patterns in urban watersheds. *Journal of Real Estate Finance and Economics* 22: 221-237.

Fotheringham, A.S., Brunsdon, C., Charlton, M.E. 2002. *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*. John Wiley and Sons Ltd.

Geoghegan, J., Wainger, L.A., Bockstael, N.E. 1997. Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. *Ecological Economics* 23: 251-264.

Irwin, E.G., Bockstael, N. E. 2001. The problem of identifying land use spillovers: measuring the effects of open space on residential property values. *American Journal of Agricultural Economics* 83(3): 698-704.

Kaplan, R., Kaplan, S. 1989. *The Experience of Natural: A Psychological Perspective.* Cambridge University Press. New York.

Kestens, Y., Theriault, M. Rosiers, F.D. 2004. The impact of surrounding land use and vegetation on single-family house prices. *Environment and Planning B: Planning and Design* 31(4): 539-567.

KGIS. 2006. Knoxville, Knox County, Knoxville Utilities Board Geographic Information System. "Knox net Where." Available at http://www.kgis.org/KnoxNetWhere.

Morancho, A.B. 2003. A hedonic valuation of urban green areas. *Landscape and Urban Planning* 66: 35-41.

Nelson, N., Kramer, E., Dorfman, J., Bumback, B. 2004. Estimating the economic benefit of landscape pattern: an hedonic analysis of spatial landscape indices and a comparison of build-out scenarios for the protection of ecosystem functions. Working paper. Institute of Ecology, University of Georgia.

Palmer, J. F. 2004. Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning* 69: 201-218.

Wooldridge, J. M. 2003. *Introductory Econometrics: A Modern Approach*. Second edition. Thompson and Southwestern.

APPALACHIAN REGIONAL REFORESTATION INITIATIVE: RESTORING FORESTS ON MINED LAND IN THE UNITED STATES

Victor M. Davis[1], Patrick N. Angel[2], James A. Burger[3], and Christopher D. Barton[4]

Abstract—More than 630,000 ha of mostly forested land have been disturbed by coal mining in the eastern United States; they are largely unproductive woody scrub. The Appalachian Regional Reforestation Initiative (ARRI) is a broad-based citizen/industry/government program working to encourage the planting of productive trees on active and abandoned coal-mined lands. Multiple benefits from this initiative include restoration of clean water and air resources, carbon sequestration, soil conservation, wildlife and endangered species habitat, recreational opportunities, and timber production. Using a combination of private and governmental resources, the program facilitates and coordinates citizen groups, university researchers, the coal industry, corporations, the environmental community, and local, state, and federal government agencies that have an interest in creating productive forestland on reclaimed mined lands. The development and execution of this multi-agency initiative may serve as an organizational model for other groups whose goal is to restore disturbed landscapes.

The majority of the Appalachian region in the eastern United States was originally covered with rich hardwood forest. Over the years, surface mining reclamation has resulted in forest fragmentation and a net loss of productive forestland. We cannot replace nature, but we can create an environment through the reclamation process that will enhance tree growth and natural succession. This is the focus of the Appalachian Regional Reforestation Initiative. With the advent of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), special efforts were made to address land stability and sedimentation caused by past mining practices. Reclamation practices including high soil compaction rates and aggressive ground covers resulted in dense hayland and pastureland. This type of reclamation may be aesthetically pleasing and desirable in some cases, but it is not conducive to productive forestland. Fortunately, researchers began to notice that tree productivity on some pre-SMCRA sites actually had superior growth rates. Most of these sites were on areas with low soil compaction rates. Forestry researchers at Southern Illinois University conducted studies during the 1970s and 1980s to examine 30-yr-old tree plantations on low-compaction spoil piles in the Midwest region (Ashby 1980). They found high survival and growth rates for many hardwood species. They also documented far greater natural succession of native forest tree species in the areas planted to trees than on adjacent unplanted areas. Research at Virginia Polytechnic Institute and State University, and the Powell River Project, confirmed that the site index, which is a measure of forest productivity, can be significantly increased by changing current reclamation practices and adopting a Forestry Reclamation Approach (FRA) (Burger et al. 1998). The FRA will increase forest productivity and timber value, increase plant diversity through natural succession, increase soil and water conservation, provide critical wildlife habitat, and carbon sequestration. It is for these reasons that the Appalachian Regional Reforestation Initiative (ARRI) was formed.

Appalachian Regional Reforestation Initiative (ARRI)

ARRI is a broad-based citizen/industry/government group working to encourage planting of productive hardwood trees on reclaimed and abandoned mine lands. Our vision is not only to plant more trees, but also to build a productive forest ecosystem that encourages natural succession of native forest plants. We will concentrate on promoting the use of the FRA technology. By using a combination of private and governmental resources, the program will facilitate and coordinate the coal industry, university researchers, the environmental community, and state and federal government agencies that have an interest in creating productive forestland on reclaimed mined lands (Angel et al. 2005). We have identified a Core Team that includes members from each Office of Surface Mining Reclamation and Enforcement (OSM) Field Office, and members from each State Regulatory Authority in the Appalachian Region. This Core Team has the responsibility to develop reforestation partnerships and promote ARRI

[1] Office of Surface Mining, United States Department of Interior, Knoxville Field Office, Knoxville, TN 37902, vdavis@osmre.gov
[2] Office of Surface Mining, United States Department of Interior, P.O. Box 1048, London, KY 40741
[3] Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060
[4] Department of Forestry, University of Kentucky, Lexington, KY 40506

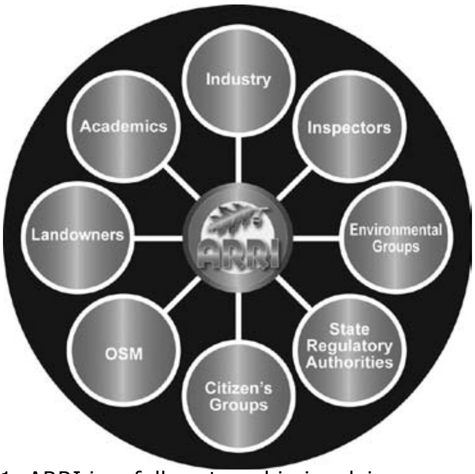


Figure 1. ARRI is a full partnership involving many government, industry, academic and private groups and individuals.

(Figure 1). ARRI has identified several cultural, technical, and regulatory barriers that must be eliminated. The goals of ARRI are to plant more high-value hardwood trees on reclaimed coal-mined lands in Appalachia, increase the survival and growth rates and productivity of planted trees, and expedite the establishment of forest habitat through natural succession.

Current forestry research conducted by the University of Kentucky and Virginia Polytechnic and State University has confirmed that highly productive forestland can be created on reclaimed mined land by using a Forestry Reclamation Approach (Burger et al. 2005). The FRA has taken lessons learned from past mining practices and modified current mining practices to create more productive forestland. The FRA discussed here is a general guideline. Each state will be encouraged to develop a FRA that fits the unique environmental conditions within that state.

Forestry Reclamation Approach

1. Create a suitable rooting medium for good tree growth that is no less than four-ft-deep and comprised of topsoil, weathered sandstone, and/or the best available material.

The selection of the best growth medium will depend on the local environmental conditions and the best available soil material. In Ohio and parts of Pennsylvania, large deposits of topsoil are available. Topsoil is a valuable resource and it should be conserved and replaced when possible. However, in the mountainous coal mining areas of the other states in the Appalachian Region, topsoil is limited and alternate growth media have been shown to support productive forestland.

During mining operations, all highly alkaline materials with excessive soluble salts and all highly acidic or toxic material should be covered with four to six ft of a suitable rooting medium that will support trees. Growth media with low to moderate levels of soluble salts, equilibrium pH of 5.0 to 7.0, low pyretic sulfur content, and textures conducive to proper drainage are preferred (Burger et al. 2005). Native hardwood diversity and productivity will be best on soils with a sandy loam texture where the pH is between 5 and 7. These types of soils can be formed from overburden materials comprised of weathered brown or unweathered gray sandstone, especially if these materials are mixed with natural soils. Shale may be used in combination with sandstone; however, high concentrations of shale and other fine-grained spoil materials should be avoided because they compact easily and have poor internal drainage. Many times these materials have higher pH values, which encourages heavy ground cover and inhibits tree growth. On remining sites, topsoil/sandstone may not be available in sufficient quantities. In these cases a combination of spoil materials will be required to create the best available growth medium.

2. Loosely grade the topsoil or topsoil substitutes established in step one to create a non-compacted soil growth medium.

The use of pans and other rubber tire equipment must be eliminated during final grading. The practice of tracking-in with dozers to create a smooth and compacted final grade is not advisable, and is an unnecessary expense. The majority of the backfill should be placed and compacted using the currently accepted practices to ensure mass stability. The difference is only during the replacement of the growth medium in the last four to six ft. In area mining, haul trucks are used to dump the growth medium in a tight arrangement, and final grading is accomplished with one or two light passes with a dozer to strike off the tops of the dump piles. Likewise, in a dragline operation, the growth medium is placed in piles and a dozer lightly grades the area leaving a rough, non-compacted growth medium (Figure 2).

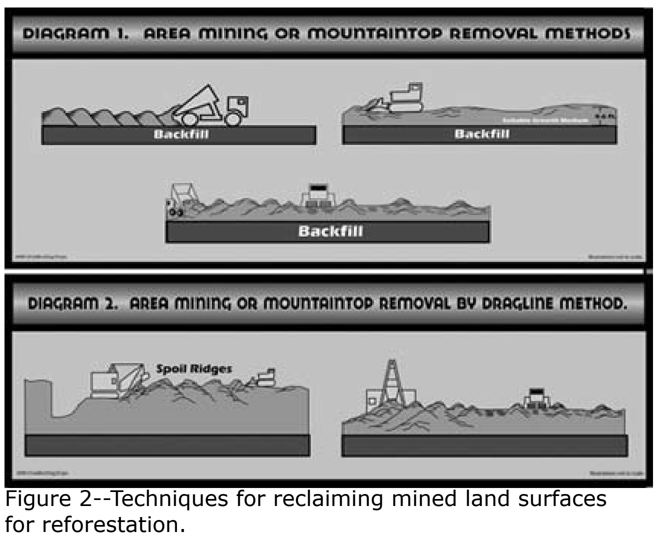


Figure 2--Techniques for reclaiming mined land surfaces for reforestation.

In steep-slope mining areas, the majority of the backfill is placed and compacted as usual, but the final four to six ft of growth medium is dumped and lightly graded to achieve the required final grade. This low compaction technique will actually reduce erosion, provide enhanced water infiltration and restore the hydrologic balance, and allow trees to achieve good root penetration. Research conducted by the University of Kentucky, at the Starfire Reforestation Project, has shown that reduced compaction rates result in superior tree survival and growth rates (Angel et al. 2006). Ripping can alleviate compaction, and research has shown that this will increase tree growth. However, this is an unnecessary expense that can be avoided by limiting compaction during final grading.

3. Use native and non-competitive ground covers that are compatible with growing trees.

Ground cover vegetation used in reforestation requires a balance between erosion control and competition for the light, water, and space required by trees. Fast-growing and competitive grasses such as Kentucky-31 tall fescue and aggressive legumes such as sericea lespedeza, and sweet clovers should not be used where trees will be planted. Seeding rates should be reduced to limit ground cover competition to planted tree seedlings. Most ground cover species under certain conditions will compete with tree seedlings. However, slower growing grasses such as red top and perennial ryegrass, and legumes include birdsfoot trefoil and white clover, are more compatible with growing trees. Using these species in a mix with other appropriate species will increase seedling survival, provide erosion control and allow development of the native forest plant community through natural succession. Fertilizer rates should be low in nitrogen to discourage heavy ground cover growth while applying sufficient rates of phosphorus and potassium for optimal tree growth (Burger et al. 2005).

4. Plant two types of trees – early successional species for wildlife and soil stability, and commercially valuable crop trees.

Early successional trees and shrubs act as nurse plants for the higher-quality hardwoods and provide wildlife food and cover. Good nurse plants include redbud and dogwood. Crop trees should be selected according to the soil and environmental conditions. Research has shown that commercially valuable hardwoods can be successfully grown, including red oak, white oak, green ash, white ash, black cherry, sugar maple, and yellow poplar (Burger et al. 2005). Conifers such as white pine and loblolly pine have also been shown to thrive on FRA sites and produce harvestable timber. By planting both early succession and late succession tree species and increasing natural succession, a shorter amount of time is required to reach a mature forest with a species composition similar to the native forest.

5. Use proper tree planting techniques.

The importance of proper tree planting cannot be overstressed. The best planting stock available should be selected and maintained in cold storage until actual planting. Tree seedling roots exposed to air for as little as 15 minutes can significantly increase the mortality rate. Care should be taken to separate seedlings and roots should never be pruned. The seedlings must be kept moist and immediately placed in the planting bag. The planting hole must be made as deep as possible to accommodate the entire root system. The planting hole must be completely closed, leaving no air pocket, and tamped in. In most cases, the extra cost of hiring professional tree planters will be well worth the investment.

Conclusion

Forestland enriches us all by providing numerous environmental and economic benefits. Forestland is also a renewable resource. By working together, state and federal government agencies, the coal industry, landowners, university researchers, and local citizens can indeed create highly productive forestland on reclaimed mined land by using the Forestry Reclamation Approach. We invite any and all interested parties to join the Appalachian Regional Reforestation Initiative and become Reforestation Champions.

Literature Cited

Angel, P.N., D.H. Graves, C. Barton, R.C. Warner, P.W. Conrad, R.J. Sweigard, C. Agouridis. 2006. Surface mine reforestation research: Evaluation of tree response to low compaction reclamation techniques. Proceeding of the 7th ICARD, (St. Louis MO. March 26-30, 2006). Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

Angel, P.,Davis, V., Burger, J., Graves, D., Zipper, C. 2005. *The Appalachian Regional Reforestation Initiative.* Forest Reclamation Advisory Number 1.

Ashby, W.C., Kolar, C.A., Rogers, N.F. 1980. Results of 30-year-old plantations on surface mines in central states. *Trees for Reclamation*. Lexington , KY.

Burger, J. A., Kelting, D.L., Zipper, C. 1998. *Maximizing the value of forests on reclaimed mined land.* Virginia Cooperative Extension Publication No. 460-139.

Burger, J., Graves, D., Angel, P., Davis, V., Zipper, C. 2005. *The Forestry Reclamation Approach.* Forest Reclamation Advisory Number 2.

SUCCESSFUL PLANT PRODUCTION FOR FOREST RESTORATION: WHAT FORESTERS SHOULD ASK NURSERY MANAGERS ABOUT THEIR CROPS (AND VICE VERSA)

R. Kasten Dumroese [1], Douglass F. Jacobs [2], and Thomas D. Landis [3]

Summary—Foresters and nursery managers must establish a rapport to ensure success in both the business and biological aspects of plant production, so that forests can be restored efficiently and effectively. Although foresters often focus on trees in forest restoration, nurseries have potential to produce a wide range of other plant types in a myriad of stocktypes. Fortunately, all plants destined for forest restoration can be produced efficiently using the Target Plant Concept, which is a framework for nursery managers and foresters to work together to produce plants specific for certain field conditions. The concept encourages both parties to communicate before, during, and after plant production to ensure the best plants are being outplanted on sites.

The Target Plant Concept has six tenets, usually posed as questions. First, what are the outplanting objectives? Is the goal forest restoration, which might include outplanting understory forbs and shrubs, or is the main emphasis simply to plant trees in order to quickly protect a degraded watershed? Second, what types of seeds will be used? Can this site be restored with genetically improved seeds from a seed orchard, or are collections from wild stands desired? Third, what factors may limit outplanting success? For example, is the site particularly harsh (hot and dry) or is competition from non-native plants extreme? Fourth, what are the outplanting windows? Can the site be planted in spring, fall, or summer? Fifth, what is the preferred tool for placing plants into the ground? Can the site be mechanically planted, or is hand-planting required? What is the optimum planting equipment or tool? Sixth, using the answers from the first five questions, what then does an ideal stocktype look like?

Once the ideal stocktype is chosen, the nursery manager and forester must work together to determine a realistic production timeline. This is the first step in specifying the responsibilities of both parties. Fortunately, business aspects are fairly straightforward and occur as specific contract provisos. Foresters and nursery managers should query each other to discern who is providing and treating seeds, when inventory numbers are needed and provided for fine-tuning outplanting contracts, responsibilities if seedling quantities lag or exceed expectations, who ensures biological quality and how, penalties for failures by either party, delivery dates for seedlings, payment terms, and other logistical, legalistic items.

From the biological side, once the target plant is defined, the characteristics of those plants can be described in the contract as well. Of the many characteristics that may be outlined, the two that must be well described are genetic quality or integrity, and seedling quality. Genetic quality is paramount – foresters should know how the nursery maintains seed source integrity from start to finish. Seedling quality should be expressed in terms of morphological and physiological criteria. Because plant morphological characteristics, such as height, stem diameter, root and shoot mass, and foliage color can vary during production, foresters should know how the nursery meets those goals, and nursery managers should know how flexible foresters are in accepting stock that may fail to meet one or more of those standards. From a physiological standpoint, foresters should know how crops will be conditioned and hardened to meet the rigors of the outplanting site; how quality will be maintained during plant production, storage, and shipment to the outplanting site; and how that quality will be quantified.

After outplanting, the professional rapport needs to continue. Nursery managers should ask foresters how the stock performed because integral feedback helps the nursery perfect cultural techniques to enhance target plant quality. Effective, honest communication throughout the entire process is essential to ensuring forest restoration success.

[1] USDA Forest Service, Southern Research Station, 1221 South Main Street, Moscow, Idaho 83843 USA; kdumroese@fs.fed.us
[2] Purdue University, Hardwood Tree Improvement and Regeneration Center, West Lafayette, Indiana USA,
[3] USDA Forest Service (retired), Medford, Oregon USA

NURSERY CULTURAL TECHNIQUES TO FACILITATE RESTORATION OF KOA (*ACACIA KOA*) COMPETING WITH EXOTIC KIKUYU GRASS IN A DRY TROPICAL FOREST IN HAWAI'I, USA

Douglass F. Jacobs[1], Anthony S. Davis[1], and R. Kasten Dumroese[2]

Summary—Koa (*Acacia koa*) is a forest tree species endemic to the islands of Hawai'i, USA, ranging in longitude from 154-160° W and latitude 19-22° N. Koa occurs across a wide range of elevations, from 90-2100 mm and rainfall patterns (up to 5100 mm). The species has long been highly prized for its valuable wood, which is used for canoes, furniture, and specialty wood working. Koa is a member of the Fabaceae family (legumes) and is able to fix atmospheric nitrogen. Thus, koa plays an important ecological role in nutrient cycling and is particularly adept at helping to restore degraded sites. Mature koa forests have been identified as critical habitat components for many of Hawai'i's endangered native bird populations. Unfortunately, Hawai'i' has experienced severe koa habitat loss associated with land clearing, indiscriminant logging, introduced animals, and exotic pests and pathogens.

Pu'u Wa'aWa'a Ranch on the dry eastern slopes of Hawai'i represents an excellent case study for examination of methods to facilitate restoration success of koa. Cattle grazing and introduced grasses have caused prominent losses of forest cover in the seasonally dry tropical forests of Hawai'i. Forest cover at Pu'u Wa'aWa'a has declined severely, largely due to sparse tree regeneration. Naturally regenerating seedlings under heavy grazing often fail due to consumption by cattle and competition from introduced exotic grasses. A major challenge to artificial reforestation of koa to Pu'u Wa'aWa'a is the introduced African kikuyu grass (*Pennisetum clandestinum*), a rapidly growing, rhizomatous plant. We examined use of varying nursery cultural techniques to facilitate establishment of koa seedlings amidst dense kikuyu grass on the Pu'u Wa'aWa'a cinder cone at 1200 m. Seedlings were grown at Waimea State Tree Nursery in three container sizes (49, 164, 656 cm^3) and with four rates (0, 10, 15, 20 kg m^{-3}) of 15-9-12 (NPK) controlled-release fertilizer incorporated into media prior to sowing. The 3 × 4 factorial experiment was established as a randomized complete block design using three replications. Seedlings were planted in March 2006 and measured for survival, height, diameter, and presence of mature leaves every 3-4 months until April 2007. Data were analyzed using analysis of variance at $p < 0.05$.

Statistically significant stocktype × fertilizer rate interactions were detected for nearly all measured parameters. After one year in the field, survival was > 85% for all treatments except the unfertilized 164 cm^3 stocktype (40%). Interestingly, some koa seedlings were able to survive for prolonged periods despite being severely suppressed underneath the grass cover. Absolute height and diameter as well as growth showed similar trends, with the 656 cm^3 stocktype always yielding greatest values. Performance among the 49 and 164 cm^3 stocktypes was relatively similar. Compared to unfertilized controls, fertilized seedlings had 100 to 500% higher values for height and diameter parameters within a given stocktype. For the 656 cm^3 stocktype, fertilizer linearly increased both absolute and growth parameters. However, for the smaller two stocktypes, fertilization effects were relatively similar among the 10, 15, and 20 kg m^{-3} rates except at the highest fertilizer rate (20 kg m^{-3}) where the 49 cm^3 containers yielded lower values. This response was probably associated with excessive media electrical conductivity values in these small containers at high fertilizer rates.

Koa is a phyllodial species that undergoes a change from true leaves (bipinnate leaflets) to sickle-shaped phyllodes (dilated petioles), which usually occurs prior to the sapling stage (i.e., < 2 m in height). Regardless of stocktype, we found that no unfertilized seedlings exhibited phyllodes. Within the fertilized 49 and 164 cm^3 stocktypes, 10-64% of seedlings exhibited phyllodes, with no clear trends according to fertilizer rate. For the fertilized 656 cm^3 stocktype, 82-93% of seedlings had phyllodes, with mean values increasing by fertilizer rate. This further reflects the rapid early development of seedlings from this stocktype treatment.

This experiment provides useful data toward evaluating the efficacy of varying nursery cultural treatments on subsequent koa seedling performance. The container-fertilizer combination used operationally at Waimea State Tree Nursery is 49 cm^3 containers fertilized at 10 kg m^{-3}. Our best container-fertilizer combination was 656 cm^3 containers fertilized at 20 kg m^{-3}, which produced relative gains of 52 and 93% in absolute height and diameter, respectively, after one year of field growth. One year after planting, trees in our optimal treatment averaged 192 cm in height and 25 mm in diameter, and were free-to-grow above the kikuyu grass. We expect that these saplings will continue to grow rapidly, develop lateral branching, and eventually close canopies, which will help shade out and eventually suppress the kikuyu grass, thereby effectively leading to site restoration.

[1]Hardwood Tree Improvement and Regeneration Center, Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907-2061, USA.; djacobs@purdue.edu
[2] USDA Forest Service, Southern Research Station, 1221 South Main Street, Moscow, ID 83843, USA.

CANOPY OPENING AND REGENERATION DYNAMICS ON YOUNG LUCIDOPHYLLOUS FORESTS RESTORED BY TREE PLANTATION IN JAPAN

Juyoung Lee and Eijiro Fujii

Abstract—Microenvironmental changes beneath forest canopy and the regeneration dynamics before and after small scale gaps were investigated in two warm temperate forests restored by tree plantations in central Japan. For the same gap sizes, the patterns of microenvironmental change and seedling occurrence were different between two stands with different forest structural diversity. These different gap responses may be related with the different abundance of understory vegetation that controls the microenvironments of forest interiors. Although ameliorated light environment after canopy opening tended to facilitate the development of the forest floor vegetation, all seedling species did not have positive correlations with increasing light intensity. Understanding different attributes of seedling responses to certain levels of light may be important for predicting the vegetation development following gap formation. Our results supported the idea that big scale gaps can not promote the replacement of canopy species in the warm temperate forests.

Since the late 1970s, afforestation through tree plantation has been vigorously carried out in Japan to restore the native forests of the region, many of which were warm-temperate or evergreen broadleaf forests. The plantation forests established in this period have great differences from earlier plantations in vegetation characteristics. However, with critical deterioration of species diversity and structural complexity in recent years, appropriate management strategies have become severely needed in the planted forests.

Gap, spatial openness in the forest canopy, has been considered inevitable for maintaining forest diversity because of the way they facilitate seedling establishment and growth (Brokaw 1985). And the current paradigm of forest dynamics emphasizes the role of small canopy gaps in the maintenance of forest dynamics (Clinton 2003). Despite of extensive studies on forest gaps for the past 20 years, many things remain unclear about gap-related ecology in planted warm-temperate forests. Therefore, surveying vegetation responses under small scale gaps is expected to provide important knowledge for the management of plantations. In this study, we investigated the characteristics of microenvironmental changes and regeneration dynamics following small size canopy opening in the planted warm-temperate forests of Japan.

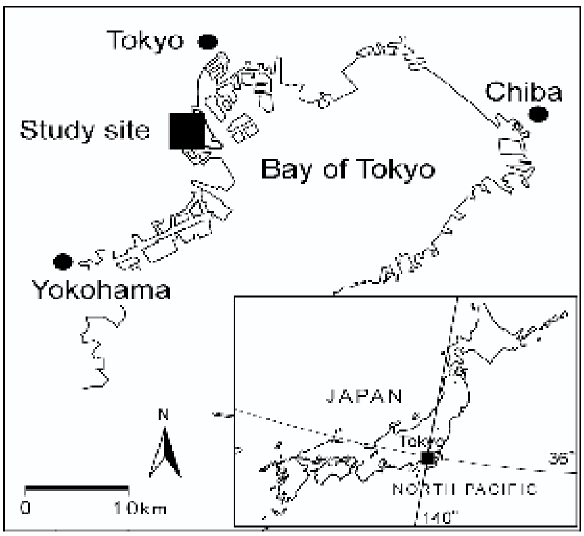


Figure 1. Location of the study site.

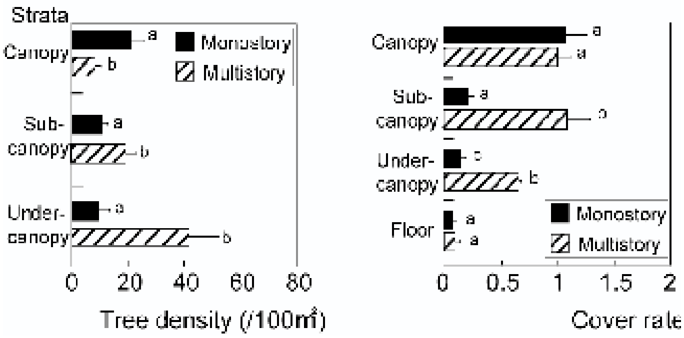


Figure 2 Mean tree density (left) and cover rate (right) of each vertical strata in two forest stands. Forest floor ≤0.8 m; Undercanopy layer≤5 m; subcanopy ≤10 m; canopy >10 m. Bars with

Materials and methods

Our study sites are located on seaside reclamation land in the northwest part of the Tokyo Bay in central Japan (Fig.1). We selected two 0.5ha evergreen broadleaved forest stands with different abundances of understory trees, which planted in 1980 and dominated mainly by *Machilus thunbergii, Castanopsis cuspidata var. sieboldii, Camellia japonica and Cinnamomum japonica*. One forest stand had only a single canopy layer with poor understory vegetation (hereafter, the monostory

Juyoung Lee, Graduate student, Graduate School of Science and Technology, Chiba University, 648 Matsudo, Matsudo-shi, Chiba, 271-8510, Japan; juyoung@graduate.chiba-a.jp
Eijiro Fujii, Professor, Faculty of Horticulture, Chiba University, 648 Matsudo, Matsudo-shi, Chiba, 271-8510, Japan

stand), whereas the other had diverse canopy layers with more abundant understory vegetation (hereafter, the multistory stand; Fig. 2). The mean annual precipitation of this region is 1388mm and mean annual temperature is 16.24 ºC (Japan Meteorological Agency, 1979–2004).

Gaps, in this experiment, means an opening in the forest canopy layer (>10m in height) created by the elimination of a tree or a few trees. We set three rectangular plots of 10×10m (four 5×5m subplots) in each homogeneous stand and cut trees to make two different sizes of gaps (30 m^2, small gap; 50 m^2, large gap) in the treatment plots of both stands in January 2004.

For each forest floor plant found in the study plots, location, species identification, individual sizes, seed-dispersal type, life form and successional category were surveyed for 4 years, 2003, 2004, 2005 and 2006. In addition to the vegetation, light regimes (relative photosynthetically active photon flux density, rPPFD), soil moisture (%), litter stock condition (mm) on the forest floor were measured in each plot. The dominance of the forest floor vegetation ($h \leq 0.8$m) was recorded by the importance value (IV) and a t-test was conducted to verify differences between the values.

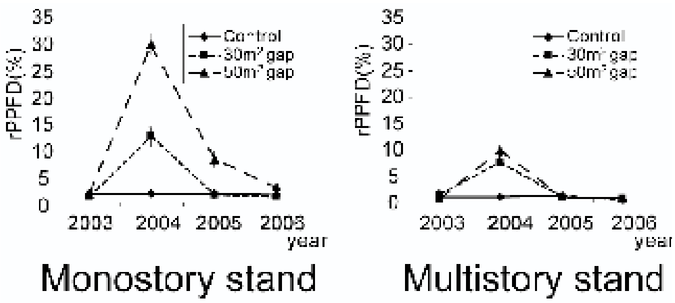


Figure 3 Changes of light intensity on the forest floor (0.5m in height) for 4 years pre- and post-gap. Mean ± SD.

Results

Microenvironmental Changes after Canopy Opening—Opening the canopy increased light intensity inside the forest (Fig. 3). The monostory stand had a higher rPPFD than the multistory stand with the same size gap. Larger gap showed higher values in rPPFD in both stands. Although canopy opening ameliorated light environments inside forest, there were no significant differences (at $p=0.05$) between the control and treatment plots, in the third year of treatment, except for the large gap in the monostory stand. It was difficult to discern a pattern in soil moisture in the multistory stand. Also for the litter stock condition, we could not find any significant characteristics caused by gap formation in either stand.

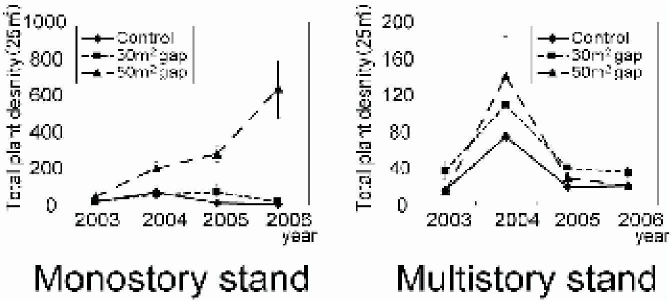


Figure 4. Mean density of total plant (top), woody seedling (middle), and climax species (bottom) on the forest floor for 4 years pre- and post-gap.

General Characteristics of Regenerations within Small Scale Gap—After canopy opening, the dynamics of the forest floor vegetation differed between the monostory and the multistory stands (Fig. 4). For the total density of floor vegetation, only the 50□gap of the monostory stand had consecutive increases after gap formation. Woody seedlings were largely increased in 2004, but there were no significant increases in 2006 compared with the control plot. But the density of woody seedling was significantly ($p<0.05$) lower than before gap. For the main climax species, including Machilus thunbergii, Castanopsis cuspidata var. sieboldii, Camellia japonica, Neolitsea sericea and Cinnamomum japonica, we could not find any significant increases in the treatment plots of either stand.

With changes in the forest floor vegetation, the dominance of different successional categories also shifted. The IV of the late-succession species decreased in 2004, due to relative acceleration of the early and general successional species, and gradually increased. Gap formation caused an increase of species richness and diversity in all plots in 2004.

Species Specific Difference of Regeneration Pattern—In the survey of the seedling occurrence with increasing light intensity for 6 frequently appearing woody species, each species had

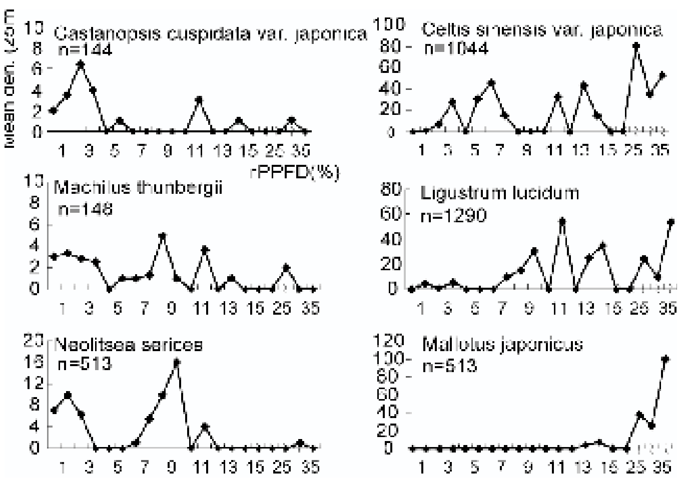


Figure 5. Patterns of seedling emergence with increasing light intensity for 6 frequently appearing

different response patterns. The main late successional species were characterized by an emergence pattern at the level of <4% and 7–12% rPPFD; General species showed an increasing pattern with increasing rPPFD, including *Ligustrum lucidum and Celtis sinensis var. japonica;* Pioneer species was mainly seen >25% rPPFD, including *Mallotus japonicus.*

Discussion

In our results, small size gaps appear to increase species richness and vegetation density on the forest floor. However, gap effects differed between two study stands, which may be caused by different abundance of understory trees that affect the environmental changes under canopy gap. Our results supported that gap effects can be determined more by the abundance of understory tree than by the gap size.

Light regime might be more critical determinant of seedling regeneration than soil water or litter stock regimes in warm temperate forests. Although amelioration of light conditions has been considered the most critical factors facilitating regeneration (Brokaw 1987), it is unlikely that light increase benefits all seedling species in our results. The main late successional species forming the forest canopy, such as *Machilus thunbergii* and *Castanopsis cuspidata* var. *sieboldii* tended to have a higher emergence rate at lower levels of light, showing a decrease of seedling density with growing rPPFD in this study. The response characteristics of the late successional species to the light may support the idea that excessive light increase by canopy opening cannot promote the replacement of canopy species in warm temperate forests.

Literature cited

Brokaw, N.V.L. 1985. Gap-phase regeneration in a tropical forest. *Ecology*. 66: 682-687.

Brokaw, N.V.L. 1987. Gap-phase regeneration of three pioneer tree species in a tropical forest. *Journal of Ecology*. 75: 9-19.

Clinton, B.D. 2003. Light, temperature, and soil moisture responses to elevation, evergreen understory, and small canopy gaps in the southern Appalachians. *Forest Ecology and Management.* 186: 243-255.

LIMING AS A METHOD TO IMPROVE NATURAL REGENERATION OF BEECH (*FAGUS SYLVATICA* L.) ON ACID SOILS IN SOUTHERN SWEDEN.

R. Övergaard

ABSTRACT—Acidification is many times a reason for changes in ecosystems and reduction of biodiversity. In Europe the atmospheric deposition of sulphur has caused the pH value in soils to decrease. In the beech distribution area of southern Sweden this has in many areas resulted in a pH level of about 4.0 – 4.4. This is in many ways an obstacle for natural regeneration of beech. A thick layer of raw humus, podzol soils, and low production characterizes these sites. In winter 1991-1992, 5 ha^{-1} tons of ground limestone was spread at 12 sites in southern Sweden, scheduled to be regenerated 10-20 years later. After mast years, though no scarification or shelterwood cutting had been done, the number of germinated seedlings was recorded. An increase in the number of seedlings and amount of earthworms has been noted on the limed areas.

Acidification is caused by emissions of mainly sulphur but also nitric oxide and ammonia contribute. In the last hundred years, this has in many regions of the world increased due to energy and food production (Galloway 2001). In Europe the most affected areas are concentrated to the north-eastern parts (www.acidrain.org) and in southern Sweden the pH value has decreased 0.3 to 1.0 unit during the last 30 years (www.naturvardsverket.se). This is in many ways an obstacle to natural regeneration of beech (Dimitri and Bressem 1988).

In Sweden natural regeneration is the most common method to regenerate beech forests. During a good mast year the ground is scarified, the beechnuts covered with soil and a shelter of trees is left (Agestam and others 2003). However, this operation is not always successful, especially not in old beech forests on poor sites with podzol soils and raw humus. A low soil pH is shown to hamper the germination of seeds (Bressem 1998), and a low pH value in the mor layer decreases the number of organisms in decomposition process, creating a thick, inactive layer of raw humus (Muys 1989). Seeds germinating at these kind of sites often die due to lack of water, since the root of the germinant must penetrate the humus layer before reaching the mineral soil where the capillary forces brings water. The decomposition process is slow in acid soils and nutrient turnover is hampered, resulting in decreased growth and a longer period of vulnerability to different calamities when the seedlings are small. Often these obstacles cause landowners to be unwilling to regenerate their beech forests, resulting in longer rotation periods, impaired timber quality, and an even worse ground condition. Nevertheless the Swedish Forestry Act states that a beech stand should be regenerated with beech (www.skogsstyrelsen.se), and a failure of natural regeneration, forcing the land owner to plant beech seedlings, would be costly.

Positive effects of liming or liming combined with fertilization on germination and early growth have been reported in studies of sowing of beech in Denmark and Europe (Haun 1958, Müller and Weis 1906). The positive results may be explained by improved ground condition caused by an increased pH value and a more rapid nutrient turnover, i.e. by earthworms loosening up the soil giving an improved germination environment (Huhta 1979). Ljungström and others (1990) did not show any positive effects of liming on natural regeneration of beech. The same results have been reported from one experiment in southern Sweden, while another showed positive effects of liming 30 years preceding the seed fall (Personal communication. Ulf Johansson. 2004. Researcher and head of the Tönnersjöheden and Skarhult Experimental Forests, P. O. Box 17, S-31038 Simlångsdalen, Sweden)

The aim of this experiment is to study the effect of liming, soil preparation and fencing on germination and early growth of natural regenerated seedlings of beech, and to develop methods of natural regeneration of beech on poor soils. The following hypotheses were studied:

- liming is positive for both germination and early growth
- best results are obtained if liming is done 10 – 20 years preceding the regeneration
- liming gives the best effect on poor sites with podzol soils and raw humus
- liming influences the ground flora and fauna
- liming influences pedogenesis and the soil texture
- liming gives the best result in combination with scarification
- liming influences the number, size and nutrient content of the beechnuts
- seedlings on limed plots will be more exposed to browsing.

Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Alnarp, Sweden;
email-rolf.overgaard@ess.slu.se

Stand no		1	2	3	4	5	6	7	8	9	10	11
Site index		F 28	F 22	F 20	F 24	F 26	F 24	F 27	F 30	F 26	F 30	F 36
pH value	Humus	4.7	4.8	4.9	5.2	4.7	4.5	4.1	4.3	4.2	4.3	4.5
(H_2O)	Mineral soil	4.4	4.5	4.5	4.6	4.4	4.5	4.3	4.2	4.4	4.4	4.4

Table 1-- Site index and pH value at control plots in eleven of the stands 1993.

Materials and methods

The field experiment is located in 12 different stands in the south of Sweden. All the stands are planned to be regenerated between the years 2005 and 2010. The sites represent a relatively wide variation of site fertilities, from the poorest site with podzol and raw humus to the richest site with brown earth. The site index, i.e. dominant height at 100 years age (Carbonnier 1971) varies from F 20 to F 36, comparable to a mean production of 3.6 to 9.2 m^3 ha^{-1} respectively (Table 1). No correlation was found between site index and pH value in the untreated areas 1993. Eleven sites were limed during the winter 1991 – 1992, and one was limed in February 1994. Five tons ha-1 of ground limestone was spread out on each site. The experiment is of block design with comparison in pairs between limed and unlimed plots. One half of each plot will be scarified and some sites will be partly fenced. One stand was regenerated in spring 1999 and three stands are planned to be

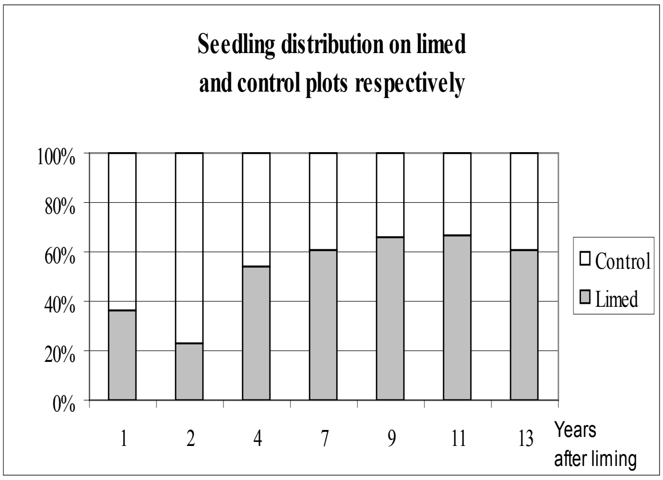


Figure 1. Distribution of germinated seedlings

regenerated in spring 2007. These three stands were scarified in autumn 2006 and shelters were cut after the seed-fall.

At every mast year the number of beechnuts, and the following spring, the number of germinants, have been counted, even though no regeneration felling or scarification has been done. Soil samples have been taken for chemical analyses. Worm-counting was done in four stands in autumn 2000. Before the regeneration felling new soil samples will be taken for analyses of nutrient content,

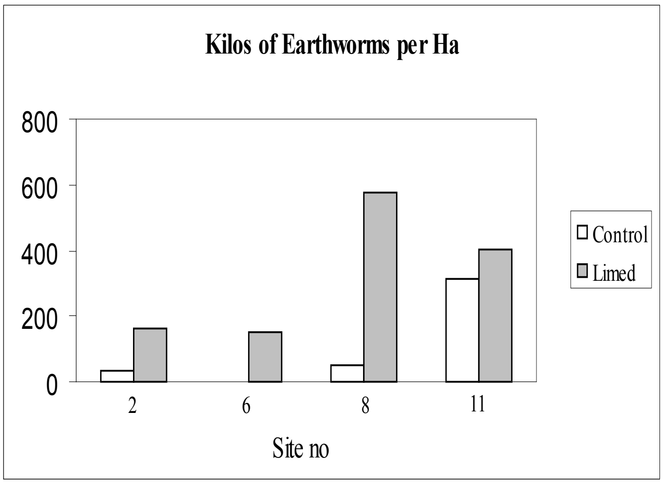


Figure 2. Kilos of earth-worms ha^{-1} at the

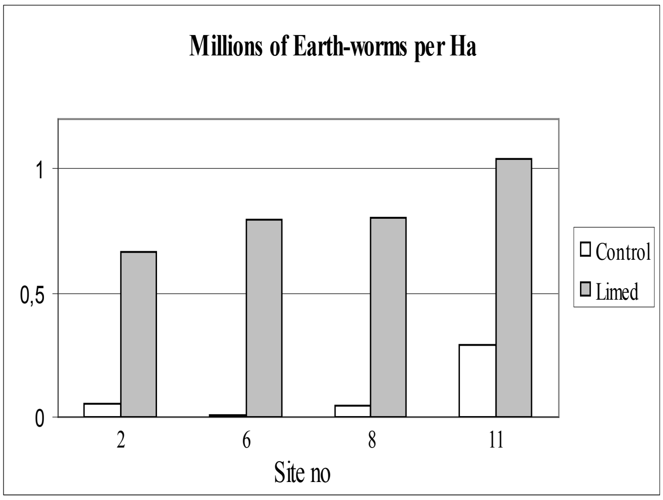


Figure 3. Millions of earth-worms ha^{-1} at the investigated sites.

soil texture and humus content. Also vegetation analyses and worm counting will be done. After the regeneration felling the number of germinated beechnuts will be registered, the development of the plants and damages will also be noted and vegetation analyses will be done.

Results and discussion

No differences in seed crop was found between limed and control plots. Because the plots are too small, 25 by 25 meters, it is possible that most trees have had their roots in both limed and unlimed areas. The seed traps, one in each plot, have been situated as far away as possible from the opposite treatment. The numbers of new seedlings have been registered after every mast year. Mostly these are relatively few in number since no soil preparation or shelter-wood cutting was done (Fig. 1). A clear trend is however shown; after the first years with lower proportions of seedlings on the limed plots, about 60 % of the seedlings are found in the limed plots seven years after the treatment. The fewer germinants on the limed plots the first years after the liming is explained by Bressem (1988) who claims that pH values above 6.0, and liming in the mast year itself, is unfavourable for the over-wintering of the seeds. Stand 11, regenerated seven years after the liming was done, is of a very high site index (Table 1). The number of seedlings on limed plots was 685 000 ha^{-1} compared to 558 000 seedlings ha^{-}1 on the control plots, but the difference is not significant. No difference in height development The thickness of the humus layer was measured at eight of the sites in autumn 2006. The humus layer on the limed plots was 80% of the thickness of the humus layer on the control plots, probably due to a more rapid turnover. Earth-worm counting was done at sites 2, 6, 8 and 11 in autumn 2000. Species were not identified. Both mass and numbers of earthworms were greater on limed areas and the difference was most obvious at sites of low site index (Fig 2 and 3). The living weight of 1 000 earth-worms was about 1 kg ha^{-}1 on control plots compared to about 0.4 kg ha^{-1} on limed plots, indicating either different species dominated at the different treatments, or enhanced fertility at limed areas caused in a high share of smaller earthworms. found between the treatments. The explanation is probably the high site index, F 36, and a rapid turnover enhancing the germination process. The ground limestone also improved the growth of the field vegetation (Bauhus and Bartsch 1996) which may be a severe competitor to the seedlings.

The thickness of the humus layer was measured at eight of the sites in autumn 2006. The humus layer on the limed plots was 80% of the thickness of the humus layer on the control plots, probably due to a more rapid turnover. Earth-worm counting was done at sites 2, 6, 8 and 11 in autumn 2000. Species were not identified. Both mass and numbers of earthworms were greater on limed areas and the difference was most obvious at sites of low site index (Fig 2 and 3). The living weight of 1 000 earth-worms was about 1 kg ha^{-1} on control plots compared to about 0.4 kg ha^{-1} on limed plots, indicating either different species dominated at the different treatments, or enhanced fertility at limed areas caused in a high share of smaller earthworms.

Conclusion

Acidification is in many ways a big menace or threat in many parts of the world. Since the problem was first identified, the emission of different air pollutants has been reduced (www.acidrain.org) but it is still considerable. Acid soils are a detriment for both fauna and flora. This presentation showed how both natural regeneration of beech and earthworm populations are affected, and how liming may improve the conditions.

Literature Cited

Agestam, E., P.M. Eko, U. Nilsson, and N.T. Welander. 2003. The effects of shelterwood density and site preparation on natural regeneration of Fagus sylvatica in southern Sweden. *Forest Ecology and Management* 176(1/3):61-73.

Acidrain, 2007. The Swedish NGO Secreteriat on Acid Rain. www.acidrain.org

Bauhus, J., and N. Bartsch. 1996. Fine-root growth in beech (*Fagus sylvatica*) forest gaps. *Canadian Journal of Forest Research* 26(12):2153-2159.

Bressem, U. 1988. Trials on promoting and preserving beech natural regeneration. P. 193 pp. in Forschungsberichte - Hessische Forstliche Versuchsanstalt.

Bressem, U. 1998. Promotion of natural regeneration of beech. *AFZ/Der Wald, Allgemeine Forst Zeitschrift fur Waldwirtschaft und Umweltvorsorge* 53(18):933-936.

Carbonnier, C. 1971. Yield of beech in southern Sweden. *Stud. for. suec. Skogshogsk.*(No. 91):89.

Dimitri, L., and U. Bressem. 1988. Some notes on the occurrence and further development of beech natural regeneration. *Forst und Holz* 43(2):32-37.

Galloway, J.N. 2001. Acidification of the world: natural and anthropogenic. *Water, Air, and Soil Pollution* 130(1/4):17-24.

Haun. 1958. Liming trial with beech sowings. *Allg. Forstzeitschr.* 13(30):424-425.

Huhta, V. 1979. Effects of liming and deciduous litter on earthworm (Lumbricidae) populations of a spruce forest, with an inoculation experiment on *Allolobophora caliginosa. Pedobiologia* 19(5):340-345.

Ljungström, M., Gyllin, M., and Nihlgård, B. 1990. Effects of liming on soil acidity and beech (*Fagus sylvatica* L.) regeneration on acid soils in south Swedish beech forests. *Scandinavian Journal of Forest Research* 5: 243-254.

Muys, B. 1989. Evaluation of conversion of tree species and liming as measures to decrease soil compaction in a beech forest on loamy soil. *Silva Gandavensis* (No. 54):13-28.

Müller, P. E., and Weis, F. 1906. Studier over skov- og hedejord. *Det forstlige forsøgsvæsen, hæfte* 3, p 266-277. In Danish.

Naturvardsverket, 2007. Swedish Environmental Protection Agency. www.naturvardsverket.se

Skogsstyrelsen 2007. The Swedish Forestry Act, 1979. www.skogsstyrelsen.se

THE DIRECT SEEDING OF BEECH (*FAGUS SYLVATICA* L.) AND OAK (*QUERCUS ROBUR* L., *QUERCUS PETRAEA* (MATT.) LIEBL.) AS A METHOD FOR FOREST RESTORATION – SOME PROBLEMS AND POSSIBILITIES

Maria Birkedal, Magnus Löf

Abstract—The direct seeding of beech (*Fagus sylvatica* L.) and oak (*Quercus robur* L., *Q. petraea* (Matt.) Liebl.) on forest land has the potential to become a cheap and appropriate method of forest regeneration, both on forest restoration areas and areas intended for commercial forest production. Direct seeding also has the advantage that it creates more heterogeneous stands than does the conventional planting of seedlings. Unfortunately direct seeding is not always a success story due to different factors, one of which is granivorous rodents. During two years we studied this problem in southern Sweden. Ways to reduce the removal of seeds were investigated, as well as the effect of rodent population size. Results from the two years show that granivorous rodents can completely destroy the direct seeding of beech and oak, and that it is better to do the direct seeding in the spring than later during the summer.

The interest in a forest today goes much further than just to the owner. Both the local and the global society have opinions about how the forest resources of the world should be utilised. That is because forests fulfil many more functions than just the production of wood. For example, forests play an important role when it comes to reducing global warming, the spread of deserts and the erosion of sensitive areas (Olschewski and others 2005). On many places in the world there is a need to restore lands that formerly were covered by trees, in order to uphold these other functions. To encourage the restoration process it is important that the establishment of trees can be achieved at a tolerable cost.

The direct seeding of beech (*Fagus sylvatica* L.) and oak (*Quercus robur* L., *Q. petraea* (Matt.) Liebl.) has the potential to provide landowners and managers with a less expensive way of regenerating these species than if conventional planting is used. The reduced costs are mainly due to the increased possibilities of mechanization (Willoughby and others 2004), and the lower cost of seeds compared to nursery grown seedlings (Bullard and others 1992, Madsen 2005). Experiments from around the world suggest that direct seeding is an appropriate method for forest restoration with other species than beech and oak as well (Engel and Parotta 2001, Johnson and Krinard 1985b, Kenk and Guehne 2001), and not only because it is cheaper than planting, but also because it creates more heterogeneous stands (Twedt and Wilson 2002). Variation is desirable both from an economical point of view, where the spreading of risks is important, and from a biodiversity point of view, where the variation gives more species a suitable habitat (Lamb and others 2005).

Unfortunately, the direct seeding of beech and oak is connected to a couple of problems, which can be more easily avoided if seeds are brought up to seedlings in a nursery before they are put out on the regeneration site. One of the most difficult problems, in natural regenerations and on direct seeded areas with beech and oak, is the removal of seeds from the sites by different kinds of animals (Watt 1919), most often by rodents (Ashby 1959, Madsen and Löf 2005).

In a series of studies in southern Sweden, we studied to which extent the acorns and beech nuts in direct seeded areas on forest land suffer from predation by rodents. We also tested the effect of seeding depth, time of seeding, and different soil scarification methods on the seed predation by rodents.

Materials and Methods

The first of the experiments were set up with four blocks (6×4.5 m^2) at two of three sites (Söderåsen 1 and Krageholm), and three blocks at one site, Söderåsen 2, in southernmost Sweden during May 2005. A randomized block design with a number of different treatments in each block was used. Two treatments were present at all three sites: direct seeding of beech in the middle of May at a soil depth of 1 cm (Treatment b) and direct seeding of beech in the middle of June at a soil dept of 1 cm (Treatment c). Treatment a was only present at Söderåsen 1 and 2 and was direct seeding of beech in the middle of May at a soil depth of 3 cm. At Krageholm two additional treatments were included by direct seeding oak nuts as well; Treatment d was direct seeding of oak in the middle of May at a soil depth of 2 cm and Treatment e direct seeding of oak (*Q. petraea* (Matt.) Liebl.) in the middle of June at a soil dept

Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Alnarp, Sweden;mariabirkedal@ess.slu.se

of 2 cm. Soil scarification was carried out manually in May using a planting spade. In the treatments there were two rows of seeds, with 30 seeding points in the rows. The beech nuts were sown two at each seeding point and the acorns were sown one and one. All seeds were sown together with a piece of white paper, to make it easier to locate the seeds at the end of the season. The distance between the seeds in the row was 15 cm.

The second experiment was set up in Asa experimental forest with four blocks (approximately 60×80 m^2), three of which were situated at Oxafällan and one at Nybygget, during June 2006. Here as well as in the previous experiment a randomized block design was used, this time with five different soil scarification treatments (harrow, patch, mound, control and bulldozed) at two times of direct seeding (June and July). All soil scarification treatments were carried out by an excavator in May. Acorns (*Q. robur* L.) were sown manually with a planting tube at 5-10 cm soil depth. In the treatments there were four or five rows of seeds, with 80 seeding points in the rows. The distance between the seeds in the row was 25 cm.

Figure 1. Birkedal & Löf.

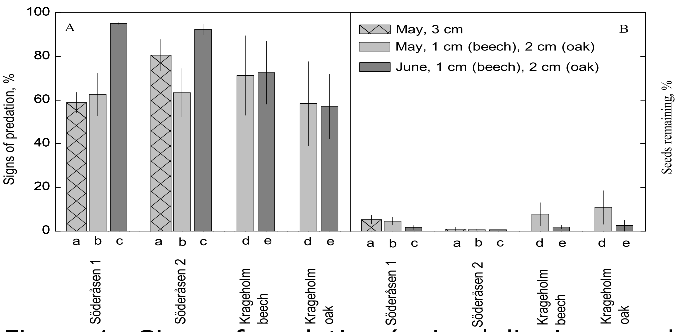


Figure 1. Signs of predation (animal digging, seed coat remains, and paper pieces on the ground) from all summer inventories added together, % of total seeding points ± SE, for five treatments at three sites in the study from 2005. B) Seeds still present at the seeding points at the final inventory in September, in % of total amount of seeds sown ± SE, for five treatments at three sites in the study from 2005.

In both experiments a number of inventories of predation signs (animal digging, seed coat remains and paper pieces on the ground) were done during the summer, as well as a final inventory where all seeding points were dug up at the end of September to determine the fate of the seeds. In the 2005 experiment all seeding points were examined, and in 2006 ten seeding points in each treatment were dug up. All sites in both years were fenced against larger herbivores.

The population sizes of rodents were estimated through live-trapping in both years. In 2005 there were two capture periods, while in 2006 there were four. Rodent live traps (type Ugglan approximately $10 \times 9 \times 25$ cm^3) were set out in grids with 15 m between the traps. In 2005, 40 to 42 traps were used per site. In 2006, 60 traps were set out over each block, and an additional 30 traps per site were set in the forest neighboring the experimental areas. The traps were baited with oats, apple and hay. On all occasions the traps were out for two nights and the rodents caught the first night were marked and counted separately from the ones caught the second night.

Results and Discussion

In 2005 large amounts of granivorous rodents (*Myodes glareolus* Schreber, *Apodemus flavicollis* Melchior, *Apodemus sylvaticus* L.) were caught in the traps (data not shown), indicating high population densities. In this year there also was high predation pressure on the direct seeded acorns and beech nuts at all sites (Figure 1A). Catches increased slightly in the June capture, and for Söderåsen 1 and 2 there also was a small increase in signs of predation in the direct seeded rows. No differences could be found between the two seeding depths of beech, which is contrary to the results obtained by Johnson (1981) for acorns. One reason for the lack of treatment effect for seeding depth could be that the difference was only two centimeters. Acorns are able to tolerate deep sowing better, making it easier to reduce predation on oak seeds by increasing seeding depth. Another reason for the non-existent treatment effect was probably that the direct seeded areas were so small that a few rodents could easily consume all the seeds available.

To be sure of the fate of the seeds there was a final inventory done, at the end of September, where all the seeding points were dug up. The results obtained from the digging (Figure 1B) support the results from the earlier inventories of predation signs. The predation was intense everywhere, but worst at Söderåsen 2 and in June at the other locations.

In 2006 there were very few rodents trapped until September, when the trapping increased markedly (data not shown). The inventories of predation signs were performed before late September and there were not many traces of predator activity to be found (Table 1). The lack of rodents during the time of seeding and most part of the summer resulted in few differences in predator activity in the different soil scarification treatments.

Fate of seed	June harrow (%)	June patch (%)	June mound (%)	June control (%)	June bulldozed (%)	July harrow (%)	July patch (%)	July mound (%)	July control (%)	July bulldozed (%)
Seedling	27.5	40	40	20	31.3	5	5	10	1.3	7.5
Viable	22.5	10	10	30	17.5	15	12.5	22.5	47.5	47.5
Dead	25	16.7	30	35	25	15	12.5	22.5	7.5	37.5
Predation	1.3	0	5	0	0	0	0	5	0	0

Table 1. Fate of acorns in five different soil scarification treatments, for two times of direct seeding, in the study from 2006, determined by

Results from the digging in September 2006 show that a rather large proportion of the seeds that have not yet formed a seedling still have the capacity to do so (Table 1); this is why it is important to be patient when dealing with the direct seeding of oak. The success or failure cannot be determined until at least two growing seasons have passed after the seeds are put into the soil. Because of this it is hard to say much about differences in seedling emergence in the different soil scarification treatments at this stage.

When the studies from the two years are analyzed together, it becomes clear that rodents are a major problem in the direct seeding of beech and oak in southern Sweden. In the first year when there were a lot of rodents, the establishment was really poor. In the second year there were hardly any rodents at all during most of the growing season and the establishment of oak was much more satisfactory. Results also indicate that it is better to do the direct seeding in May or early June than later during the summer, when the rodent populations generally have increased (Pucek and others 1993).

Conclusions

Direct seeding is an appropriate method to use for restoration of forest land, but the insecurity of the method creates problems for forest managers. One of the greatest problems is granivorous rodents which sometimes consume almost a hundred percent of the sown seeds. To make the method more reliable, ways to stop the rodents from removing the seeds need to be found.

Literature Cited

Ashby, K.R. 1959. Prevention of regeneration of woodland by field mice (*Apodemus sylvaticus* L.) and voles (*Clethrionomys glareolus* Shreber and *Microtus agrestis* L.). *Quarterly Journal of Forestry* 53: 228-236.

Bullard, S., Hodges, J.D., Johnson, R.L., Straka, T.J. 1992. Economics of direct seeding and planting for establishing oak stands on old-field sites in the South. *Southern Journal of Applied Forestry* 16: 34-40.

Engel, V.L., Parrotta, J.A. 2001. An evaluation of direct seeding for reforestation of degraded lands in central São Paolo state, Brazil. *Forest Ecology and Management* 152: 169-181.

Johnson, R.L. 1981. Oak seeding – it can work. *Southern Journal of Applied Forestry* 5: 28-33.

Johnson, R.L., Krinard, R.M. 1985. Oak seeding on an adverse field site. Research Paper SO-319. New Orleans, La: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 4p.

Kenk, G., Guehne, S. 2001. Management of transformation in central Europe. *Forest Ecology and Management* 151: 107-119.

Lamb, D., Erskine, P.D., Parrotta, J.A. 2005. Restoration of degraded tropical forest landscapes. *Science* 310: 1628-1632.

Madsen, P. 2005. Såning av skov – en dyrkningsvejledning. Svendborg: Dansk Skovforening; Kulturmanifest 2005 – såning, addition to Skoven 4. ISSN 0106-8539. 31p.

Madsen, P., Löf, M. 2005. Reforestation in southern Scandinavia using direct seeding of oak (*Quercus robur* L.). *Forestry* 78 (1): 1-10.

Olschewski, R., Benítez, P.C., de Koning, G.H.J., Schlichter, T. 2005. How attractive are forests carbon sinks? Economic insights into supply and demand of Certified Emission Reductions. *Journal of Forest Economics* 11: 77-94.

Pucek, Z., Jedrzejewski, W., Jedrzejewska, B., Pucek, M. 1993. Rodent population dynamics in a primeval deciduous forest (Bialowieza National Park) in relation to weather, seed crop, and predation. *Acta Theriologica* 38(2): 199-232.

Twedt, D.J., Wilson, R.R. 2002. Development of oak plantations established for wildlife. *Forest Ecology and Management* 162: 287–298.

Watt, A.S. 1919. On the causes of failure of natural regeneration in British oakwoods. *Journal of Ecology* 7: 173-203.

Willoughby, I., Jinks, R., Gosling, P., Kerr, G. 2004. C*reating New Broadleaved Woodland by Direct Seeding*. Edinburgh, U.K. Forestry Commission: i-iv + 1-32.

THE RELATIONSHIP BETWEEN SPATIAL DISTRIBUTION PATTERNS OF FOREST AND CHARACTERISTICS OF FOREST FIRE AT REGIONAL SCALE IN SOUTH KOREA

Jungeun Song[1], Byungdoo Lee[2] and Joosang Chung[1]

Abstract—It is worth examining the relationship between spatial distribution patterns of forest and characteristics of forest fires for effective prediction of forest fire spread and for post-fire restoration. In this study both spatial analyses and statistical techniques were applied to examine correlations between the spatial distribution patterns of forest cover and the forest fire regime at the regional level in South Korea. Nationwide we divided 751 digital forest cover-maps into 16 regional groups and used FRAGSTATS to compute a suite of landscape pattern metrics for each map. Also five variables that explained regional characteristics of forest fire regimes were obtained from the records of daily forest fires from 1991 to 2005 in South Korea, including fire occurrences and burned areas 1000 ha^{-1}, burned areas and combustion times per fire occurrence and rate of spread (ROS, ha h^{-1}). We performed Canonical Correlation Analysis in order to derive correlations between the landscape pattern metrics of each forest's cover and the five variables about forest fire characteristics. As a result of canonical correlation analysis, the first canonical correlations were very high in both whole forest (0.95) and pine forest (0.89) and statistically significant at the 0.05 level. Based on canonical loading, Shannon's diversity index of the whole forest and the patch density of the pine forests were important variables to illustrate the correlation between spatial distribution patterns of forest and forest fire characteristics. These results provide a theoretical basis to understand forest fire regime and to estimate damage of forest fire using landscape indices at the regional scale in South Korea.

Spatial distribution patterns of forest are determined by ecological processes such as forest fires and landslides, as well as by anthropogenic influences such as forest management and land use. Also, land use patterns and natural disturbance regime were affected by spatial distribution patterns of forest. That is to say, spatial distribution pattern of forest and disturbance regime have strong mutual interaction. Forest fire especially is one of the major disturbances that cause significant changes not only of ecosystems but also of human society over all. Studies about interactions between fire characteristics and natural and artificial factors that influence the fire regime are required. In this study, we used spatial analyses and statistical techniques to examine the relationship between spatial distribution patterns of forest and characteristics of forest fires.

Methods

In order to characterize spatial distribution patterns of forests nationwide, we divided 751 digital forest cover-maps into 16 regional groups including cities and provinces and computed landscape indices for two patch types (whole forest and pine forest) using FRAGSTATS 3.3. We performed a principle component analysis to reduce the number of landscape indices for each patch type and selected variables with relatively high loadings from principal components for further analysis. Also five variables that explained regional characteristics of forest fires were obtained from the records of daily forest fires from 1991 to 2005 in South Korea, including fire occurrences 1000ha^{-1}, burned areas 1000ha^{-1}, burned areas per fire, combustion times per fire, and rate of spread (ROS, ha h^{-1}). In order to model the relationship between spatial distribution patterns of forests and characteristics of forest fires, we performed a Canonical Correlation Analysis. The landscape indices surviving the variable reduction step were selected as the set of independent variables and the five variables obtained from the records of daily forest fire were selected as the set of dependent variables.

Results and Discussion

Table 1 shows the results of the canonical correlation analysis on the selected landscape indices and fire characteristics variables for whole forest. The first canonical correlations were very high in two cases, raging from 0.949 for whole forest to 0.888 for fine forest. In each case, the canonical correlations were statistically significant at the 0.05 level. Based on canonical weights and loadings, SHDI was the most important independent variable for whole forest and PD was the most important independent variable for pine forest. Also based on cross-loadings SHDI and ENN for whole forest

[1]Department of Forest Sciences, Seoul National University, San 56-1, Sillim-dong, Kwanak-gu, Seoul 151-921, South Korea; readjean@hanmail.net
[2]Division of Forest Fire, Korea Forest Research Institute, 207, Cheongyangni-2 dong, Dongdaemun-gu, Seoul 130-712, South Korea.

and PD, MPS for pine forest had high correlations with their corresponding dependent canonical variate. Canonical correlation analysis identified relationships between landscape indices and fire characteristics variables and we can use these results as a theoretical basis to understand forest fire regime using landscape indices at the regional scale in South Korea

Table 1--Results of canonical correlation analysis, showing the relationship between dependent (fire characteristics) and independent (landscape indices) variables.

Patch type	Canonical Weights	Canonical Loading	Canonical Cross-Loading
Whole forest			
Dependent variables			
Fires 1000ha^{-1}	1.6754	0.6874	0.6526
Burned areas 1000ha^{-1}	-1.5609	-0.2814	-0.2671
Burned area/fire	0.6450	-0.3794	-0.3602
Combustion times/fire	0.0573	-0.6781	-0.6437
ROS (ha min^{-1})	1.2295	-0.2499	-0.2373
Independent variables			
Contagion index (%)	-0.0363	0.4588	0.4356
Euclidian Nearest Neighbor distance (m)	0.1518	0.5861	0.5564
Interspersion and Juxtaposition index	0.6702	-0.2111	-0.2004
Shannon’s diversity index	-1.3684	-0.7837	-0.7440
Aggregation index (%)	-0.3591	0.0091	0.0086
Redundancy Index	0.5882		
Canonical correlation coefficient	0.949*(0.02)		

DEVIATION FROM REFERENCE CONDITIONS VARIES WITH SITE QUALITY IN LONGLEAF PINE WOODLANDS

Joan L. Walker[1], Greg P. Smith[2], Brian P. van Eerden[3], Vic B. Shelburne[4],
Andrea M. Silletti[1], Susan Cohen[1]

Abstract—Pine plantations occupy at least 28 million ha once occupied by the longleaf pine ecosystem, and are prime targets for restoring biodiversity. Although these stands have a common management history, they are highly variable. The purpose of our study was to examine deviations from reference conditions among stands with a common management history, and to develop a general model for framing that variation. We approached this problem by sampling ecological reference sites and plantations (≥ 20-yrs-old) at three locations in North Carolina and South Carolina. We used the Carolina Vegetation Survey methods to sample in conditions ranging from excessively to somewhat poorly drained soils. We used NMS ordination and ANOVA models to examine structure and relationships to environmental and disturbance variables. Regardless of drainage conditions, plantations had higher pine density and lower herbaceous cover than reference plots. Surprisingly, species richness at scales >100 m^2 did not differ between plantation and reference plots, though at smaller scales richness in plantations was reduced. While plantations retained many late successional species, they lost *Aristida stricta*, the dominant grass critical for maintaining the historical fire regime. The abundance of native ruderal species increased in mesic but not xeric sites. Results suggested that higher productivity sites present the greatest restoration challenges because they are naturally diverse with many species to lose, they are susceptible to invasion by and persistence of early successional species, and they show greater deviations from reference conditions. Site productivity provides a useful framework for understanding deviation from reference conditions in the longleaf pine ecosystem.

[1] Southern Research Station, USDA Forest Service, Department of Forestry and Natural Resources, Lehotsky 233,Clemson University,Clemson, SC 29634 USA, Email: joanwalker@fs.fed.us
[2] Dept. of Forestry and Natural Resources, Clemson University
[3] The Nature Conservancy
[4] Dept. of Forestry and Natural Resources, Clemson University

THE COMPARISON OF STAND STRUCTURE OF PINUS KORAIENSIS PLANTATIONS WITH ADJACENT NATURAL STANDS IN KOREA

Pil Sun Park

Abstract—Three different aged *Pinus koraiensis* plantations were compared with adjacent natural stands in species composition and stand structure. *P. koraiensis* plantations occupy the fourth-largest planted area in Korea. The three *P. koraiensis* plantations used in this study were established around in 1987 (Simwon area), 1964 (Taehwa area), and 1922 (Baekwoon area). Species importance value, diversity index, diameter distribution, height distribution, and stand volume were compared among different aged *P. koraiensis* plantations and adjacent natural stands. The importance values of *P. koraiensis* in different aged *P. koraiensis* plantations were around 60%, however, the equitability increased from 0.78 to 0.85 as the stand age increased with the introduction of species from adjacent natural stands to plantations. The importance value of most dominant species in natural stands was 18-31%.

Natural stands had a wider range of diameter distributions and height distributions than plantations in Simwon and Taehwa areas where plantations were less than 50-yrs-old; however, plantations had larger and taller trees than natural stands in Baekwoon area. Differentiation in crown layers began in *P. koraiensis plantation* established in 1964, and the stand established in around 1922 showed multi-layered *stan*d structure. Stand volumes of *P. koraiensis* plantations were 90.5 m^3 ha^{-1}, 165.9 m^3 ha^{-1}, and 316 m^3 ha^{-1} in Simwon, Taehwa, and Baekwoon, respectively. The stand volumes in plantations were less than in adjacent natural stands in Simwon and Taehwa areas. However, the plantations had more stand volume than adjacent natural stands in Baekwoon area. The annual stand growth in *P. koraiensis* plantations in Simwon, Taehwa, and Baekwoon were 4.75 m^3 ha^{-1}, 3.95 m^3 ha^{-1}, and 3.76 m^3 ha^{-1}, respectively.

The comparison of plantations with adjacent natural stands in stand structure and species composition could be helpful for establishing a management strategy and provide answers for restoration efforts.

Seoul National University, Sillim-dong, Gwanak-gu, Seoul 151-921, Korea; email-pspark@snu.ac.kr.

REGIONAL CLIMATE EFFECTS OF THE NORTHERN CHINA FOREST SHELTERBELT PROJECT

Yongqiang Liu[1], John Stanturf[1], Houquan Lu[2], Yeong Dae Park[1]

Abstract—In the past century, northern China has been facing devastating ecological and environmental problems of drying climate and diminishing forest lands, and related water shortage and severe dust storm activity. Six ecosystem projects were initiated in China during the past decades aimed at improving and conserving ecological environment in the project areas. The most magnificent one is the forest shelterbelt project in northern China, which stands along the southern edge of the sandy lands, nearly paralleling to the Great Wall. It is expected that the resultant changes in land cover, which is an important factor for climate processes, would significantly affect local and regional climate. This study was to simulate the climate effects of the northern China forest shelterbelt project with a regional climate model. Two simulations, one with the current land cover types and another simulation in which we afforested project areas and replaced the current vegetation with pine trees, were performed over East Asia from March 1987 to February 1988. The simulation resolution is 60 km. The differences between the two simulations suggest that the northern China forest shelterbelt project is likely to improve overall climate conditions by reducing prevailing westerly winds, lowering maximum as well as average air temperature, generating more rainfall, and increasing soil water storage capacity. Air water vapor content, however, is decreased in parts of the project area, probably caused by the convergence of dry air due to the reduced magnitude of prevailing winds. Changes are more significant in Spring and Summer than Fall and Winter. The climate effects are significant not only in the project areas but also in surrounding areas, featured by noticeably warmer and moister surface air conditions in East and Central China and slightly cooler and drier conditions in Inner-Mongolia and Mongolia. Changes in many water properties, e.g., evapotranspiration and soil moisture, differ between Northeast China and other project areas. This simulation assumed a case of complete plantation (100% survival) with a specific species. Actual planting information and field meteorological measurements are needed for a more realistic evaluation of the climate effects of the forest shelterbelt project.

[1] Center for Forest Disturbance Science, USDA Forest Service, Athens, Georgia, USA; yliu@fs.fed.us
[2] Division of Agri-Meteorology and Ecology, National Meteorological Center, China Meteorological Administration, Beijing, China

REDUCING POVERTY AND ENVIRONMENTAL DEGRADATION THROUGH COLLABORATIVE FOREST RESTORATION RESEARCH IN THE PHILIPPINES: THE ASEAN-KOREA ENVIRONMENTAL COOPERATION PROJECT (AKECOP)

Lucrecio L. Rebugio[1] and Don Koo Lee[2]

Summary

This paper seeks to describe the second phase of the ASEAN-Korea Environmental Cooperation Project (AKECOP) research being conducted by a multidisciplinary team of University of the Philippines Los Banos (UPLB) forestry and social scientists that addresses both the problems of poverty and environmental degradation at the ASEAN region through effective and sustainable forest ecosystems restoration strategies.

Many upland and mangrove areas in the Philippines, while considered as forest lands, are already devoid of its original forest cover and some have been totally degraded and no longer as effective in providing economic and environmental benefits. Other areas, however, are converted and developed into perennial-crop based farms that incorporate tree crops with agricultural crops, or what is now increasingly called agroforestry. Mangrove areas have also been indiscriminately converted into commercial fishponds and other inappropriate land uses resulting to their massive destruction. In an attempt to restore degraded mangrove ecosystems, community-based mangrove restoration projects have been implemented in the Philippines and several ASEAN countries.

One major cause of forest land degradation in the Philippines and other ASEAN countries is inappropriate land use or farming systems adopted by actual or *de facto* users of forest lands. Generally, this problem is very much associated with upland poverty. The upland poor generally lack the knowledge and resources to adopt appropriate land use or farming practices. Consequently, this results in soil and natural resources degradation, which in turn leads to adverse environmental impacts such as severe soil erosion and flash floods that further result in low productivity and income, thereby completing the vicious cycle of poverty and environmental degradation.

Tree plantations or reforestation projects continue to be adopted as the strategy for restoring highly degraded areas. With high poverty incidence in the uplands, however, agroforestry is emerging as a forest restoration strategy that seeks to improve

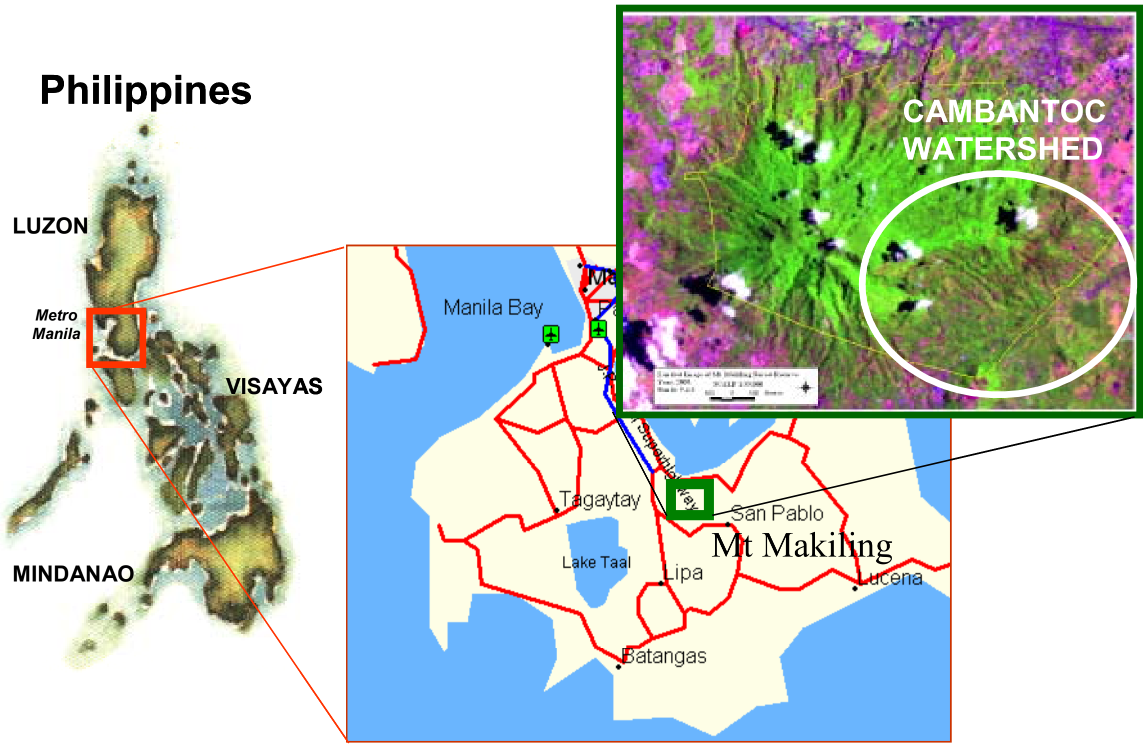


Figure 1. Forest Restoration Study in Mt. Makiling.

[1] AKECOP-Philippines Coordinator, University of the Philippines Los Banos, College, Laguna E-mail: lrebugio@yahoo.com and lrebugio@gmail.com
[2] AKECOP Project Leader, Seoul National University College of Agriculture and Life Sciences, Seoul, Korea

watershed capacity and environmental quality while providing economic benefits to upland communities.

Thus the first research activity in this collaborative project is therefore focused on the potential of agroforestry systems in alleviating poverty and enhancing environmental benefits of forests. It is being implemented in the Mt. Makiling Forest Reserve, Philippines, which has been the location of both on-site and regional research of AKECOP Phase 1 from 2000 to 2005. While focusing on agroforestry as an appropriate forest restoration strategy, the research seeks to continue in a more integrated fashion selected Phase 1 regional research efforts, such as the adoption of a Remote Sensing/Geographic Information System-based Decision Support System, environmental monitoring (e.g. rainfall and erosion), and impact assessment (carbon sequestration and socioeconomics).

In Phase 2, the regional research is being concentrated on a specific site wherein the various tools and findings can be integrated and further tested, with the aim of directly contributing to forest restoration priorities. In Mt. Makiling Forest Reserve, land uses in some of its watershed areas have changed since the mid 1960's. The Cambantoc watershed (Figure 1), located in the southeastern flank, in particular, has undergone changes in terms of deforestation, forest fragmentation, as well as transformation from open cultivated rice and corn fields (upland), to coconut-based and multi-storey agroforestry systems. This site is a good site for the conduct of research that will possibly help solve some of the country's forest restoration problems.

Specifically, this particular forest restoration research in Mt. Makiling has five components: (1) assessment of land use development in Cambantoc watershed using Remote Sensing/GIS-based Decision Support System, (2) agrobiodiversity and carbon sequestration potential of coconut-based and other multi-storey agroforestry systems; (3) soil resources and impacts of coconut-based and other multi-storey agroforestry systems, (4) water-use efficiency of plantation species in Mt Makiling, and (5) income enhancement and livelihood generation in coconut-based and other multi-storey agroforestry systems.

The second research activity on the other hand is primarily aimed at developing a tool that could improve the effectiveness and sustainability of community-based mangrove ecosystems management in the Philippines. It is being implemented in the community-based mangrove restoration sites in Quezon Province, Philippines. Its primary objective is to develop a participatory model for the assessment of socioeconomic and environmental benefits of mangrove forest ecosystems based on appropriate criteria and indicators (C & I).

DEVELOPING AND TRACKING RESTORATION SCENARIOS

Jeff Sayer

Summary
Conservation organizations became interested in Forest Landscape Restoration (FLR) partly in response to the need to restore degraded environments in many parts of the world but also because they perceived that many official government-sponsored restoration and reforestation schemes did not provide the full range of environmental and social benefits that the conservation community desired. FLR also became a rallying concept for those conservationists who did not want to operate on the basis of the "threat-based" agendas of many activist groups. FLR is attractive to those conservationists who do not want to spend their energies "opposing" threats but prefer to invest themselves in "proposing" solutions (Sayer and Maginnis 2005).

FLR is also attractive to conservationists who do not want to impose some hypothetical global conservation blueprint but rather seek to work with local stakeholders to determine the best solutions for any particular area. FLR has therefore to be based upon negotiated solutions in which the legitimate developmental needs of local people are taken into account as well as the longer-term, larger-scale environmental needs of more distant stakeholders. This requires a facilitated process of developing and exploring scenarios and seeking to optimize the trade-offs between the interests of different interested parties.

Making decisions about landscape restoration requires an analysis of the flows of developmental and environmental benefits that are sought and this leads to an understanding of how much forest is needed, what sort of forest it should be and where it should be located in the landscape. These are non-trivial questions as different interest groups will clearly favor different answers to these questions. This paper will give examples of IUCN/WWF experience at a number of sites where we have sought to work with local stakeholders to establish desirable scenarios for restoration of forest values at a landscape level.

The techniques that we have used include the study of historical trends as a means of understanding how the landscape got to be the way it is and to identify the major drivers of change. We then use visualizations techniques to allow people to identify and locate attributes of the landscape that are of actual or potential value to them. We have found it useful to encourage people to visualize worst-case and best-case scenarios. We then work with multi-stakeholder groups to identify indicators that will enable us to determine if the landscape is evolving in a positive direction – are the desired outcomes being attained? We also use simple participatory simulation models to help stakeholders to better understand the linkages within the landscape and to quantify the benefit flows from different landscape configurations (Sayer and Campbell 2004).

Our techniques draw upon the social sciences as much as the biophysical sciences and development of the social and human capital of the people living in the landscape is as important as the planting of trees to enhance the natural and built capital. We have therefore been drawn to the use of the capital assets framework as conceptual framework for assessing the outcomes of our interventions (Sayer et al. 2006). The representations of our landscapes do not take the form of conventional maps showing boundaries and segregating the landscape into mosaics. Rather they resemble the "rich pictures" used to develop scenarios for sustainable development (Morse and Bell 2003).

Literature Sited:

Bell, S., Morse, S. 2003. *Measuring Sustainability; Learning from Doing.* Earthscan, London.
Sayer, J.A., Campbell, B. 2004. *The Science of Sustainable Development; Local livelihoods and the Global Environment.* Cambridge University Press, Cambridge, UK and New York, USA.
Sayer, J.A., Maginnis, S. 2005. *Forests in Landscapes; Ecosystem Approaches to Sustainability.* Earthscan, London.
Sayer, J., Campbell, B., Petheram, L., Aldrich, M., Ruiz Pérez, M., Endamana, D., Nzooh Dongmo, Z.- L., Défo, L., Mariki, S., Doggart, N., Burgess, N. 2007. Assessing environment and development outcomes in conservation landscapes. *Biodiversity Conservation In Press* (doi 10.1007/s10531-006-9079-9.)

IUCN/WWF Gland, Switzerland; jeff.sayer@iucn.org

MULTI-STAKEHOLDER GOVERNANCE IN FOREST LANDSCAPE RESTORATION: SCALE, KNOWLEDGE AND COLLECTIVE ACTION

Doris Capistrano

Summary—Increasing public attention to climate change and the need to reduce carbon emissions from deforestation and forest degradation have brought forest-related issues back into the limelight. The protection, rehabilitation, and restoration of degraded land and forests at landscape levels (FLR) are also being viewed with greater urgency. Increased government and donor attention to this agenda is expected to pave the way for greater investment in FLR and related interventions in the foreseeable future. It is important to build on the experience and lessons from previous FLR efforts in order to amplify previous successes and avoid making the same mistakes.

One clear lesson from the past is that rehabilitating and restoring degraded lands and forests is not just a technical-ecological problem. The thorniest issues that spell the difference between success and failure often pertain to issues of institutions and governance.

Driven by different motivations, a range of actors and stakeholders – individuals, households, communities, collectives, civil society organizations, companies, governments – have engaged in diverse efforts to protect, restore or rehabilitate degraded lands and forests. Operating alone or in partnership with others, these actors and stakeholders have undertaken FLR on privately owned, communally owned or managed, and state-owned lands and forests. Where two or more stakeholders are involved, invariably the long-term viability of FLR efforts hinge on successful negotiation and balancing of multiple, in most cases competing, goals and interests. Some leveling of disparities in capacities, information and influence among partners and stakeholder groups are often necessary. The scale and degree of organization, the types of knowledge that are brought to bear and the manner by which these are mobilized to pursue common interests are among the institutional features of FLR efforts.

How decisions are made, who are responsible, how they wield and share power, and how they are held to account fundamentally affect how FLR benefits and burdens, risks and rewards are distributed, and who in the end gains and who loses. The extent to which FLR efforts and agreements serve the needs and interests of different stakeholders determines the long-term sustainability of these efforts and the imprint they eventually leave on the landscape.

Director, Forests and Governance Programme, Center for International Forestry Research (CIFOR), Bogor, Indonesia; d.capistrano@cgiar.org

UNDERSTANDING LANDSCAPES THROUGH SPATIAL MODELING

Michael C. Wimberly

Introduction

Spatial simulation models play an important role in furthering our understanding of forest landscapes. Forest landscapes encompass heterogeneous mosaics of physical environments, community types, disturbance histories, and land ownerships distributed over areas ranging from thousands to millions of hectares. Hierarchy theory posits that spatial and temporal scales are correlated in ecological systems (Urban et al. 1987). Therefore, forest landscapes must be studied over time periods ranging from decades to centuries. These broad spatial and temporal scales limit our ability to apply traditional experimental and observational methods in landscape ecology. In some cases, retrospective datasets are available and allow the study of historical landscape changes. However, simply extrapolating past trends into the future is problematic because future landscape changes are likely to occur in the context of climates, species assemblages, and socio-economic conditions that have no historical analog. Despite our limited knowledge of landscape dynamics, land managers must still make decisions that will influence forest landscapes for decades to centuries into the future. For these reasons, landscape simulation models are being increasingly applied in scientific research in the field of landscape ecology, and as decision support tools to help in the practice of landscape management and restoration.

Most forest landscape simulation models currently in use are spatially explicit; with discrete landscape units represented as geographic information system (GIS) data structures such as raster cells or vector polygons. The forest vegetation within each landscape unit is characterized by one or more variables including dominant species, stand age, successional stage, or specific stand structure measurements such as tree size and density. Mathematical or rule-based models are applied to model successional changes in forest vegetation. Disturbance processes such as fire, windstorms, insects, and timber harvesting initiate vegetation change, and are also constrained by the spatial pattern of forest vegetation. Spatial relationships are explicitly modeled, and include both vertical interactions between climate, topography, soils, and vegetation with a particular landscape unit, and horizontal interactions such as fire spread between landscape units and adjacency constraints on timber harvests. Given an initial landscape condition, landscape simulation models generate projections of landscape change that reflect the

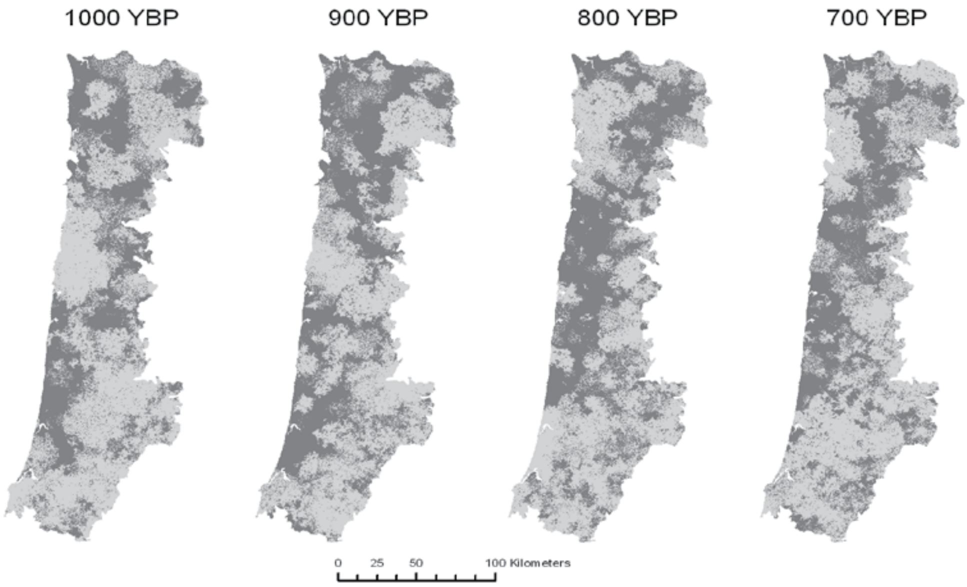


Figure 1. LADS simulation of one hypothetical time series of historical landscape patterns in the Oregon Coast Range. Dark gray patches represent closed-canopy old-growth forests. Light gray patches represent other forest structure classes (including early-successional, young, and mature forests).

Geographic Information Science Center of Excellence South Dakota State University Brookings, SD 57006 michael.wimberly@sdstate.edu

underlying data and assumptions used to develop model structure and calibrate parameters.

Several papers have reviewed different types of landscape models, focusing on conceptual and technical aspects of model design (Baker 1989, Gardner et al. 1999, Keane et al. 2004, Perry and Enright 2006). This presentation will explore how landscape models are applied in science and management, and will examine three specific examples of how landscape simulation models can enhance our understanding of forest landscapes. The first approach uses a landscape model to reconstruct historical landscape structure and dynamics using data on historical disturbance regimes. The second approach uses simulation to project forest landscape change into the future to compare alternative scenarios of forest management and landscape change. The third approach applies a landscape model in an experimental framework to develop general hypotheses about the influences of landscape dynamics on forest ecosystem function.

Simulating Historical Landscapes

Forest landscape restoration depends on our ability to define reference conditions that serve as a baseline for restoration. Because most forest landscapes are dynamic, disturbance-driven mosaics, static reference conditions are often inappropriate. Therefore, the concept of a natural or historical range of variability (HRV) has emerged as a framework for land management and forest restoration (Hunter 1993, Landres et al. 1999). Prior to Euro-American settlement, the Oregon Coast Range was characterized by a gradient of disturbance regimes, ranging from large, infrequent, stand-replacement wildfires in the north and along the coast to smaller, more frequent, mixed-severity wildfires to the south and in the interior. Data on historical fire regimes was gleaned from dendroecological (Impara 1997), paleoecological (Long et al. 1998, Long and Whitlock 2002), and historical (Teensma et al. 1991) studies. The LAndscape Dynamics Simulator (LADS) was developed to link data on historical fire regimes with our knowledge of forest succession to estimate the range of historical variability in the amount and spatial pattern of old-growth forests (Wimberly et al. 2000, Wimberly 2002). Simulations of pre-settlement landscapes demonstrated that old-growth forests occupied an average of ~ 45% of the landscape, but were highly variable in both space and time (Figure 1). Even after accounting for disturbance-driven temporal variability, current amounts of old growth are much lower than would be expected under the pre-settlement disturbance regime (Wimberly et al. 2004).

Projecting Future Landscapes

Landscape models can also be applied to project future landscape conditions under alternative scenarios of future land management policy. These alternative scenarios may be chosen to reflect specific land management strategies, or to span a wide range of management options and outline the range of our uncertainty about possible future landscapes. Nonaka and Spies (2005) used landscape simulation models to examine whether restoration of historical disturbance processes would be an effective strategy for restoring pre-settlement landscape patterns. Starting with the landscape condition in 1996, two scenarios were simulated: one based on a continuation of current forest management practices was simulated using the LAMPS model (Bettinger et al. 2005), and another in which no management or fire suppression and a return to the pre-settlement fire regime was simulated using the LADS model. Continuation of current land management practices for 100 years restored some, but not all, of the spatial patterns characteristic of pre-settlement landscapes. Restoration of the historical disturbance regime initially increased the departure of landscape patterns from pre-settlement conditions, and required several centuries to create patterns falling within the HRV.

Exploring Landscape Hypotheses

Current forest management policies in the Oregon Coast Range are based on static reserve-based strategies. Late-successional reserves on public lands are projected to be eventually dominated by old forests, whereas private landscapes are expected to remain dominated by younger managed forests. In contrast, pre-settlement fire regimes created a continuously-shifting mosaic of forest age classes (Figure 1). To explore the ecological implications of changes in the rates and patterns of landscape dynamics, the LADS model was modified to incorporate a simple species occupancy model. Experimental model runs were conducted for several hypothetical species with a range of dispersal distances, colonization rates, and extinction rates (Wimberly 2006). Experiments were designed to compare dynamic and static landscapes with similar landscape patterns and habitat amounts. Species in dynamic landscapes typically exhibited a more rapid decline to extinction with habitat loss in dynamic landscapes than in static landscapes. However, in some cases species occupancy was actually higher in dynamic landscape mosaics than in static landscapes with similar habitat amount and pattern. In these situations, habitat dynamics actually increased habitat connectivity over space and time, even though the habitat pattern at any single point in time was highly fragmented.

Summary and Conclusions

The application of landscape simulation models to study historical landscapes and future landscapes in the Oregon Coast Range, along with hypothetical landscapes in the framework of simulation experiments, has contributed to several novel insights about the landscape ecology of disturbance-driven forest mosaics. First, historical evidence of large, catastrophic wildfires is not inconsistent with the existence of a landscape dominated by old-growth forests. However, the locations of old growth forests were dynamic at time scales ranging from centuries to millennia. Second, there is a strong inertia to human-induced forest landscape change, and the pathways of change are not time-reversible. For these reasons, the restoration of historical processes (e.g., a disturbance regime dominated by large, infrequent wildfires) is not necessarily the most effective way to manage for historical landscape patterns in a landscape already heavily altered by humans. Finally, restoration strategies aimed at recreating historical landscape patterns (e.g., management for old-growth forests in a system of static reserves) will not necessarily restore the ecosystem function of dynamic landscapes. In particular, disturbance-driven landscape dynamics may create habitat patterns that are temporally connected, even if they are fragmented at any single point in time.

Literature cited

Baker, W.L. 1989. A review of models of landscape change. *Landscape Ecology* 2:111-133.

Bettinger, P., M. Lennette, K.N. Johnson, and T.A. Spies. 2005. A hierarchical spatial framework for forest landscape planning. *Ecological Modelling* 182:25-48.

Gardner, R.H., W.H. Romme, and M.G. Turner. 1999. Predicting forest fire effects at landscape scales. in D.J. Mladenoff and W.L. Baker, editors. *Spatial Modeling of Forest Landscape Change*. Cambridge University Press, London.

Hunter, M.L. 1993. Natural fire regimes as spatial models for managing boreal forests. *Biological Conservation* 65:115-120.

Impara, P.C. 1997. Spatial and temporal patterns of fire in the forests of the Central Oregon Coast Range. Oregon State University, Corvallis, OR.

Keane, R.E., G.J. Cary, I.D. Davies, M.D. Flannigan, R.H. Gardner, S. Lavorel, J.M. Lenihan, C. Li, and T.S. Rupp. 2004. A classification of landscape fire succession models: spatial simulations of fire and vegetation dynamics. *Ecological Modelling* 179:3-27.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9:1179-1188.

Long, C.J. and C.Whitlock. 2002. Fire and vegetation history from the coastal rain forest of the western Oregon coast range. *Quaternary Research* 58:215-225.

Long, C.J., C. Whitlock, P.J. Bartlien, and S.H. Millspaugh. 1998. A 9,000-year fire history from the Oregon Coast Range, based on a high-resolution charcoal study. *Canadian Journal of Forest Research* 28:774-787.

Nonaka, E. and T.A. Spies. 2005. Historical range of variability in landscape structure: A simulation study in Oregon, USA. *Ecological Applications* 15:1727-1746.

Perry, G.L. W. and N.J. Enright. 2006. Spatial modelling of vegetation change in dynamic landscapes: a review of methods and applications. *Progress in Physical Geography* 30:47-72.

Teensma, P.D., J.T. Rienstra, and M.A. Yeiter. 1991. Preliminary reconstruction and analysis of change in forest stand age class of the Oregon Coast Range from 1850 to 1940. T/N OR-9, U.S. Bureau of Land Management, Portland, OR.

Urban, D.L., R.V. O'Neill, and H.H. Shugart. 1987. Landscape ecology: A hierarchical perspective can help scientists understand spatial patterns. *Bioscience* 37:119-127.

Wimberly, M.C. 2002. Spatial simulation of historical landscape patterns in coastal forests of the Pacific Northwest. *Canadian Journal of Forest Research* 32:1316-1328.

Wimberly, M.C. 2006. Species dynamics in disturbed landscapes: When does a shifting habitat mosaic enhance connectivity? *Landscape Ecology* 21:35-46.

Wimberly, M.C., T.A. Spies, C.J. Long, and C. Whitlock. 2000. Simulating historical variability in the amount of old forests in the Oregon Coast Range. *Conservation Biology* 14:167-180.

Wimberly, M.C., T.A. Spies, and E. Nonaka. 2004. Using criteria based on the natural fire regime to evaluate forest

SUPPORTING LANDSCAPE ECOLOGICAL DECISIONS USING THE LANDIS-II FOREST DYNAMICS SIMULATOR

Eric J. Gustafson[1], Brian R. Sturtevant[1], Anatoly Z. Shvidenko[2], Robert M. Scheller[3]

Introduction

Many ecological problems can only be understood and managed at landscape scales, including ecological restoration problems. Examples include incorporating natural disturbance into management plans, understanding how disturbances interact to produce the ecological mosaic, assessing restoration plans in light of global change and understanding the range of natural variability. Furthermore, landscapes are characterized by a mosaic of diverse ecological conditions, multiple disturbance regimes, anthropogenic use and management and complex interactions among all these factors. Given these complexities, it is difficult for managers to understand the effects of proposed management actions in the presence of these complex interactions, to assess the range of natural variability of ecosystem properties and objectively predict the consequences of management alternatives. Consequently, there is a need for landscape-scale ecological decision support tools.

LANDIS is a landscape forest succession and disturbance model that independently simulates multiple ecological and disturbance processes (Mladenoff 2004). LANDIS represents landscapes as a raster grid, with each cell containing age cohorts of tree species rather than individual trees. It accounts for complex interactions, predicts forest species, age classes and biomass and produces mapped output of simulated forest landscapes. LANDIS simulates the ecological processes that establish and remove cohorts of tree species by using the vital attributes of tree species and the spatial and temporal distributions of disturbance events. These processes may vary by ecological zones, and are simulated with a high degree of spatial dynamism. The model produces mapped projections of forest conditions (tree species and biomass by age class) over large areas (>106 ha) and long time periods (centuries). LANDIS-II is a second generation version that offers users an unusually high level of confidence in its results because it was designed and constructed using modern software engineering practices (Iterative, Agile Development), which reduce errors in translating the conceptual model into computer code Scheller et al. 2007). Its freely available source code makes the model transparent, and it is relatively easy to modify modules to meet user needs. Furthermore, LANDIS-II includes biomass productivity processes that can respond to climate change.

LANDIS outputs can provide useful insights into the response of landscapes to future conditions and to management treatments including restoration activities. Of particular value are maps of the landscape through time, with cell values representing some forest attribute. These attributes include forest composition (forest types or community associations), maximum age of each species or all species, amount of living biomass by species, total living biomass or total dead biomass. Maps of the intensity of disturbance events are also produced, and tabular information on disturbance events is automatically generated.

LANDIS is a powerful decision support tool because it projects the interaction of initial conditions, natural disturbances and proposed human actions, predicting their effect on forest dynamics and future states. Examples of the types of decision support problems LANDIS can address include cumulative effects of vegetation management (including restoration plans), ecological effects of changes in disturbance regimes (including climate change), predictions of range of natural variability under specific disturbance regimes, and studies of interactions among disturbances, such as wildfire and land use change.

We present two case studies in this talk of the use of LANDIS in forest management. The first explores the effect of global changes on forest composition and spatial pattern in Siberia, to provide insight into the interacting effects of climate change and opening an area to timber harvest activity. In the second case study, LANDIS provided decision support for reducing wildfire risk in the face of increasing human population density.

Case Study I: Siberia and Climate Change

Many Siberian forests face increasing timber harvest activity and climate change. It is not clear how these previously unexploited forests will respond to these novel pressures, and there is interest in managing such forests to maintain their ecological integrity. LANDIS-II provides a tool to increase our insight into the future of these forests under different management and disturbance scenarios.

[1] USDA Forest Service, Northern Research Station, Rhinelander, Wisconsin USA; egustafson@fs.fed.us
[2] International Institute for Applied Systems Analysis, Laxenburg, Austria
[3] Department of Forest Ecology and Management, University of Wisconsin, Madison, Wisconsin USA

The study area is north of Ust-ilimsk, Russia, centered at 58.9° N, 103.0° E. The age structure of the boreal forest there has been formed primarily by the fire regime, which is the dominant natural disturbance (Vaschuk and Shvidenko 2006). Fires are mostly of human origin, and because access is poor, most fires are not suppressed and the size of fires can be quite large. Most fires are ground fires, but crown fires do occur (primarily in pine stands), and are responsible for 17% of the total burned area. There are currently no major insect pests that kill trees in the study area. However, a major tree-killing insect, the Siberian silkworm (*Dendrolimus sibiricus superanse*), occurs just south of the study area. It is expected that a warming climate will allow this defoliator to exploit resources north of its current distribution by reducing the frequency of extreme cold events that kill over-wintering individuals. Much of the study area has never been harvested because of its remoteness. It was recently opened for timber production and will be intensively harvested in the future.

We used LANDIS-II to describe the range of historic variability by simulating forest dynamics under recent climate (1981-2001) and recent fire regime, but without harvesting and silk moth. Initial conditions reflect the current landscape as represented in the Siberia-II dataset used to estimate carbon dynamics for central Siberia (Schumillius et al. 2004). We simulated 300 years under this scenario with multiple replicates and quantified the range of natural variability by documenting the variability through time of proportion of each species, total woody biomass, edge density of age classes and species groups, and mean distance to edge.

To assess the effects of climate change on forest composition, we estimated altered species productivity rates using the PnET-II model (Aber et al. 1995) by assuming a 2° C warming and 5% less precipitation. We also simulated climate effects on fire by estimating the relationship between temperature, precipitation and fire event duration, which has an effect on the area burned during each simulated fire event. Fire ignitions are primarily anthropogenic, and were held constant. The simulated range of variability under future climate was compared to the historic range of variability.

We also added the Siberian silk moth to the landscape under the future climate parameters. Insect disturbance parameters were chosen based on the characteristic of outbreaks in nearby regions to the south. The effect of silk moth was compared to the historic range of variability. Finally, we added timber harvest to the landscape, along with future climate and the silk moth and compared the combined effects of these three future disturbances on the range of variability.

The simulated natural variability shows that the current landscape is not near the center of the simulated range of natural variability, with more aspen and birch, and less larch than the average. These results also show that the proportion of each species varies through time. Under a warming climate, the composition of the landscape is projected to shift to a greater abundance of larch, aspen and birch, primarily caused by the introduction of the Siberian silk moth. Increased harvesting in the area is predicted to increase the abundance of Scot's pine at the expense of other conifer species. Taken together, LANDIS provides a visual and quantitative projection of significant changes in forest composition and spatial pattern caused by interacting global changes.

Case Study II: Chequamegon-Nicolet National Forest

Another example of the use of LANDIS for decision support is the evaluation of four wildfire risk mitigation strategies on part of the Chequamegon-Nicolet National Forest in Wisconsin, USA. The Lakewood Unit of the Forest (45.2° N, 88.3° W) contains fire-prone ecosystems dominated by red pine and jack pine. The area contains a high proportion of privately-owned inholdings with rapid human population growth. It is known that the probability of forest fire ignitions is primarily a function of housing density, and the size of the resulting fires is dependent on ecosystem properties that control fire spread such as soil water retention and flammability of vegetation types. Most fires are actively suppressed. The managers of the Forest wanted to explore forest management options to reduce the risk of wildfire damage to timber and private property resources while restoring fire-dependent ecosystems. The options considered were 1) eliminate debris burning permits, 2) roadside fuel treatments where roadside buffers on Forest Service lands (where ignition rates are high) are cleared of fuels, 3) strategic fire breaks and 4) fire protection zones where "risky" forest prescriptions (conifer species) are moved away from areas of high human population density.

We used LANDIS to simulate each of these options and constructed a fire risk map based on the results of 50 replicate simulations. We found that ignition prevention (fire education and enforcement) had the largest impact on the likelihood of fire. Fire protection zones (management of the spatial location of conifers) were also effective because a simple redistribution of forest types can reduce fire likelihood with little impact on ecological and timber goals. Roadside treatments were only effective outside of areas with relatively high human population density. Strategic fire breaks had local but not landscape effects.

Conclusions

LANDIS is a powerful decision support tool because it projects the interaction of initial conditions, succession, natural disturbances and proposed human actions, predicting their effect on forest dynamics and future states. Because these interactions are not defined a priori, their effects are an emergent property of the simulations. This compelling feature of LANDIS is possible because LANDIS is a process-based model. Rather than defining successional pathways and the effect of disturbance on those pathways, LANDIS encapsulates each ecological process as an independent module, each operating to establish or remove age cohorts of tree species on individual cells. The succession dynamics are based on vital attribute theory (Roberts 1996). Disturbance effects are based on empirical observations. Accordingly, LANDIS can make testable predictions of the response of a forested ecosystem to combinations of conditions that have never existed before. For example, one does not need empirical estimates of the effects of Siberian silk moth and harvesting in Ust-Ilimsk (which has never been observed), because the ecological processes driving each disturbance have been empirically estimated in nearby ecosystems.

The LANDIS design provides great flexibility. Because it is process-based, the combinations of ecological disturbances and environmental conditions can be completely novel. Furthermore, the research and decision support questions it can be called upon to address can also be novel. In ecological restoration projects the primary question typically is – "How likely is it that the restoration actions will produce the desired result?" Because the number of previously implemented, similar restoration actions is usually zero, there is no empirical way to estimate this likelihood. Such estimates are therefore based on a theoretical understanding of ecological processes and their interactions. LANDIS is a tool to formalize such an approach in a spatially dynamic computational model, incorporating the vast complexity of interacting ecological phenomena with a sophistication and detail that is not possible with human mental capacity alone. The greatest danger in such an approach is to impute more accuracy to the forecasts than is warranted by any such model. The value of LANDIS results lies in their ability to heuristically show the interactions of complex spatial and temporal processes that may not otherwise be intuitive.

Because the process modules of LANDIS are independent, it is relatively easy to update them to reflect new ecological knowledge or to modify them to meet special needs. LANDIS-II has open-source software code, making the model more transparent than most landscape models. Furthermore, LANDIS-II was developed using state-of-the-art software engineering techniques that feature extensive and repeated unit testing. This makes the model very robust. The LANDIS lineage of models has been widely used and tested for over a decade. The traits provide a high level of credibility and provide decision support capabilities that are not readily available elsewhere.

Literature cited

Aber, J.D., Ollinger, S.V., Federer, C.A., Reich, P.B., Goulden, M.L., Kicklighter, D.W., Mellilo, J.M., Lathrop, R.G. 1995. Predicting the effects of climate change on water yield and forest production in the northeastern US. *Climate Change Research* 5:207-222.

Mladenoff, D.J. 2004. LANDIS and forest landscape models. *Ecological Modelling* 180:7-19.

Roberts, D. W. 1996. Modeling forest dynamics with vital attributes and fuzzy systems theory. *Ecological Modelling*. 90: 161-173.

Scheller, R.M., J.B. Domingo, B.R. Sturtevant, J.S. Williams, A. Rudy, E.J. Gustafson, and D.J. Mladenoff. 2007. Design, development, and application of LANDIS-II, a spatial landscape simulation model with flexible temporal and spatial resolution. *Ecological Modelling* 201:409-419.

Schmullius, C., Santoro, M., and SIBERIA-II Team. 2004. SIBERIA-II Operational Multi-Sensor Products for Greenhouse Gas Accounting of Northern Eurasia. Proceedings of IGARSS'04, Anchorage, 20-24 September.

Vaschuk, L.N. and A.Z. Shvidenko. 2006. *Dynamics of Forests of the Irkutsk Region.* Irkutsk, Russia: Irkutsk Printing House No. 1. 392 pp. (*in Russian*)

RESTORING FOREST ECOSYSTEM SERVICES IN RURAL LANDSCAPES OF LATIN AMERICA: EXPERIENCES FROM MODEL FORESTS, WATERSHEDS AND BIOLOGICAL CORRIDORS

José J. Campos, A. Olga Corrales, Róger Villalobos, Milka Barriga and Fabrice Le Clerck

Abstract—Preliminary evidence has shown that landscape-scale management increases the likelihood for an intervention to conserve and restore the provision of ecosystem services for the human well being in a sustainable manner. This might also result in enhancing the resilience of landscapes and the human populations to climate change pressures. Preliminary evidence has also shown that a fluid scaling-up to the landscape-scale is about multi-sector networks of change agents. Our experience demonstrates that in rural areas of the Latin American region, improving the provisioning of ecosystem services starts by facilitating an enabling environment for dialogue and negotiation amongst stakeholders. CATIE, as a knowledge manager and facilitator of technical solutions has developed a constructive niche as a neutral partner to decision-makers. Dialogue amongst sectors with conflicting interests in rural landscapes, has leveraged a capacity to construct a shared vision of the landscape and innovative solutions to improve ecosystem services. Partnering with a knowledge manager perceived as a neutral facilitator, allows landscape stakeholders to monitor the effect of their decisions on the landscape and the resilience of ecosystem services amidst change. In this way it is expected that stakeholders become systems thinkers of their own landscape. CATIE´s people-based approach to improving the provision of ecosystem services at the landscape-scale is being called ***"adaptive collaborative landscape management."*** This approach is based on five components: (i) effective environmental governance; (ii) participatory planning; (iii) sustainable financial mechanisms; (iv) adaptive management and learning; and (iv) public-private partnerships. Additionally, evidence-based decision making is an important component of this approach. This is particularly important when market-based mechanisms such as compensation for ecosystem services are part of the strategies. In these cases CATIE proposes that those mechanisms be based on a "dose-response" function, which would require the support of science (Campos et al. 2006).

This paper summarizes the main concepts adopted by CATIE in its work on landscape restoration in Latin America, its historical evolution, and the experience and practices emerging from the field application of these concepts in different countries and conditions. This experience is the basis of a proposal that we need to facilitate the enabling environment for sustainable interventions at the landscape scale, provide technical support and capacity building, and to document successes so that rigorous evidence can support policy innovations on improving ecosystem services in landscapes.

Key Dimensions to Successful Landscape-Scale Approaches

The most recent global environmental policy and guiding documents have been framed in a comprehensive agenda that addresses social, economic and environmental scenarios. The agreed Millennium Development Goals, the results of the Millennium Ecosystem Assessment, the guiding principles of the Convention on Biological Diversity, and the UNCCD all integrate human needs and opportunities as part of the recovery, health and improvement of land and nature. The basic concepts adopted by CATIE in this area are consistent with this vision. These concepts are preliminarily described in the remainder of this document.

People-Centered Landscape

First, the agreed concept of landscape is a broad one: a territory shared by several communities. Moreover, the CATIE experience indicates better results when the boundaries of the territory are defined by the local stakeholders, or take into account their cultural, political, social and economic priorities.

Landscape management is not a purely ecological concept. On the contrary, CATIE approaches it as a systems approach that includes the necessary ecological aspects (e.g., ecosystems, species, ecosystem processes, ecosystem goods and services, interactions between ecosystems, ecological connectivity and others) as well as the human dimensions such as economic issues, cultural aspects, organization, policy at different levels, land uses (agriculture, husbandry, forestry) and non-consumptive uses (tourism, research,

Tropical Agricultural Research and Higher Education Center and Latin American Network of Model Forests, Turrialba, Costa Rica; jcampos@catie.ac.cr

spiritual values and others).

CATIE´s approach is people-centered, meaning that the rationale for an effective and sustainable management of the landscapes is as essential to human wellbeing, as it is for biodiversity conservation and other related environmental aspects. Therefore, landscape restoration should not only achieve an improvement of the environmental aspects but its ultimate goal is the improvement of the livelihoods of the people inhabiting, depending on, or influencing those landscapes. Our concept of landscape restoration means managing the different components in the landscape with the aim of conserving or improving its capacity to provide ecosystem services for sustainable livelihoods.

Degradation-Restoration-Improvement

The notion of restoration implies a notion that there has been a previous degradation of the landscape. CATIE´s approach understands degradation as the reduction in the capacity of the landscape and its natural resources to maintain basic ecological processes and the subsequent reduction of its capacity to generate goods and services that are vital to improve, or at least maintain, human wellbeing. Degradation may be the result of natural phenomena and/or the result of unsustainable land use practices by agricultural, livestock and forestry activities.

Therefore, the restoration concept is about recovering the landscape's capacity to generate goods and services through the collaborative action of local and national stakeholders at different scales (farm, community, landscape). Usually these processes require a catalytic external intervention or facilitator to ignite the process, carefully designating interventions in a way that ensures that the external catalytic agent can be removed in time without stopping the process.

Empowering Change Agents for Improving the Provision of Ecosystem Services in Landscapes in Latin America

While interventions at the crop, farm, and community levels are relatively known and managed, the work at the landscape scale poses new challenges. The experience gathered by CATIE has resulted in a proposed approach that we have called "adaptive collaborative landscape management." The purpose of the approach is to conserve, restore or improve the capacity of rural landscapes for their sustainable provision of ecosystem services for the human well-being. This approach comprises the following five critical components (Campos et al. In Press): (i) effective environmental governance; (ii) participatory planning; (iii) sustainable financial mechanisms; (iv) adaptive management and learning; and (iv) public-private partnerships.

Effective Environmental Governance

Effective environmental governance at the landscape-scale is an enabling condition. We define governance in a broad sense, focusing on the dialogue, trust and interaction amongst stakeholders that allows an intervention to be effective. Platforms or groupings of stakeholders, voluntary or formalized, are a tangible first step towards effective environmental governance. The networks that CATIE facilitates (model forest boards, watershed committees, and corridor commissions) has paved the road for representatives of different stakeholder sectors and organizations to develop trust, initiate a solution seeking dialogue and create a common vision. These are platforms for negotiation, conflict management, opportunity discovering, synergies, etc.

Participatory planning

Constructing a shared vision for the landscape through a process of multi-stakeholder partnerships, dialogue and collaborative planning is a key for enabling a multi-stakeholder vision of the future. As the planning process is owned by the stakeholders with our facilitation, the improvement of quality of life of the inhabitants on the landscape takes priority. Equitable and sustainable activities tend to be main targets of stakeholder platforms in the landscapes. Income generation and income improvement activities such as engaging in market and process chains, tourism and ecotourism, and certification (organic, fair, solidarity, niche and others) are commonly considered by local stakeholders. Usually these activities also include strengthening of the capacities of the local organizations active in marketing, processing and other local activities.

Innovative and Sustainable Financial Mechanisms

The previous two components require the necessary funding to be implemented; in this respect CATIE is helping local actors implementing sustainable funding mechanisms such as environmental funds, payment or compensation for ecosystem services, sustainable management contracts, seed funds, coordination of externally funded activities, national lobbying to attract governmental spending and investment, etc.

CATIE assists with local adoption of sustainable mechanisms such as participatory joint planning, administration, recovery and replenishment of seed funds, development of links with existing incentive mechanisms, and practices for landscape restoration and management.

Adaptive Management and Learning
Landscapes are complex and often uncertainty exists about interventions and outcomes. Therefore management has to be adaptive, building on collective learning. With participatory construction of realistic and cost-effective criteria and indicators around the joint vision, effective and locally -led monitoring and evaluation tools are feasible. Technological improvements through capacity building and demonstration of better land management practices, better management of common resources, introduction of better crop varieties, organic or low-input agriculture, etc. have to be monitored to assess their impact on soils, water, biodiversity, and ecosystem services in general.

Knowledge generation and sharing is implemented through the articulated use of local, national and international resources, ranging from graduate research theses to volunteers, projects, attraction of activities from national universities and research centers, etc. The information and knowledge generated in these ways is shared locally, across sites, organization and countries through networks, websites, email lists, conferences and other means.

The livelihoods approach is promoted as an integrated way to map a baseline and as a tool for monitoring and evaluating interventions in the landscape. This is another area in which there are improvements as this approach is being adapted and tested to be used as the organizing framework for situation analysis, planning, monitoring, and evaluation. It is important to stress the importance of providing evidence in support of, or critiquing the outcomes, of these initiatives.

Public-private partnerships
This component seeks to involve socially responsible enterprises interested in the provisioning of ecosystem services, human well-being and a public sector facilitating an enabling environment for effective landscape management. This approach is consistent with the conclusions of the various regional and global forums on how to achieve the Millennium Development Goals. Though we believe that this component could significantly contribute to landscape restoration, the experiences are currently less developed.

From Crops to the Landscapes: CATIE´S Experience
Over the last two decades, CATIE has developed and tested a number of ideas and approaches for landscape-scale work, using watersheds, model forests, and biological corridors as the units of study. Its research findings, though fruitful, are far from complete.

CATIE started its work on landscape management in the early eighties. The starting point was through watershed management approaches followed by several forestry projects implemented in the late 1980s and 1990s such as Olafo, TRANSFORMA, and Natural Forests Management. These project interventions dealt with rural development, sustainable management of natural resources, forest management, non-timber forest products (NTFP), and other topics in a multi-actor, multi-disciplinary approach at the landscape scale. The rationale for this approach was the need to address and to scale-up our analysis and intervention from the plot, farm, and community levels. We began to focus on scales that at times were even larger than watersheds in order to incorporate the actors, interests and components that interact in the rural landscapes where CATIE promotes sustainable development.

Applied Science and Solution Seeking: CATIE's Approach
At the landscape scale, several of these projects are showing progress towards improving the management of natural resources (forests, mangroves). Moreover, this strengthening of the natural capital seems consistent with improvements on several other capitals (e.g., social, political, financial, and human) of rural sustainable livelihoods (community organization, increased income, capacity to leverage support from governmental institutions on issues such as water, health, roads, processing and marketing of local products, etc.). Therefore the need for scaling-up was obvious and the following step was chosen to work at a larger geographical scale, encompassing several communities: the landscape. However, this scaling-up was about people, their interests and their vision of their landscape. To enable an environment for a more successful intervention, CATIE found value in the strong network of alumni and CATIE-trained change agents that had an increased capacity in being receptive and willing to enter into a constructive dialogue with the diverse stakeholders of the landscape. In addition, CATIE served as a neutral facilitator. Experience has shown that an effective way to scale-up capacity creation for improved land use is based on landscape stakeholder driven interventions. The broad and diverse network of CATIE leaders permitted initial dialogues. These experiences were consistent with those of CATIE scientists working on watershed management and biodiversity conservation whom also were finding great value in scaling-up their approaches. Later, these ideas permeated to other areas and technical groups in CATIE, emerging as one of the most important areas for the Center these days.

In this last cycle of institutional appropriation of the concepts, the situation of highly degraded lands emerged quite strongly from other projects such as degraded pasturelands, FRAGMENT (biodiversity conservation in agricultural landscapes), and watershed management. SEBSA, the environmental socio-economic thematic group at CATIE, has advocated multi-stakeholder approach to innovative interventions such as payment for local ecosystem services. Additionally, the Global Change thematic group has proposed the need to restore Latin American landscapes as a strategy for adaptation to climate change.

A Timely Approach to the Region: CATIE's Clients

This emphasis on degraded lands is not surprising in Latin America, where land degradation processes are affected by underlying causes such as uncertainty of land and water property rights. This degradation has impacted several of the rural economies, and the capacity for the provision of ecosystem services where CATIE provides knowledge management services.

Hosting Landscape Networks: CATIE as Landscape Partner

The concepts presented in the previous section are the construction and learning from the experience gained by CATIE through its projects implemented in the Latin American region, and involving several means of landscape management. These experiences can be organized into three main approaches:

1. Water, soil and agricultural productivity
2. Conservation of biological diversity
3. Environmental governance, partnerships and participation.

These emphases are being implemented in three focal landscape delineations: model forests, watersheds, and biological corridors. The local expression for this is the Mesoamerican Biological Corridor, which is an ecoregional priority for the Central American Commission on Environment and Development.

Model Forests

CATIE plays a key role leading the Network of Model Forest for the Latin America and Caribbean Region (Model Forests). Model Forest is a stakeholder-centered innovative approach for managing the ecosystem services at the landscape scale. Model Forest's foundation is a platform of multiple partnerships and governance initiatives. The partnership between these model landscapes and CATIE is an ideal one, where the platform of solution-seeking stakeholders demands knowledge and capacity creation. Innovative solutions such as payment for ecosystem services are more likely to be successful if all the parties of a potential ecosystem service market are already parties of a common vision.

Besides hosting the Secretariat of the Latin American and Caribbean Network of Model Forests, CATIE is actively involved in research and training related to conceptualization and development of management strategies for model forests in Latin America. To have first-hand research results and experience about these processes and mechanisms, CATIE is directly involved in development of the Reventazón Model Forest (Costa Rica) and the Chiquitano Model Forest in Bolivia. We have also started specific research activities in Alto Malleco Model Forest in Chile, the Sabana Yegua Model Forest in the Dominican Republic, and in Pereira, Colombia.

Watersheds

CATIE is working since 2004 in four pilot processes of watershed management under the principles described in the previous section. These sites are located in Honduras (Copan watershed and the La Soledad watershed in Valle de Angeles, a key source of water for the capital) and Nicaragua (Aguas Calientes watershed and the Jucuapa watershed, both of which are very dry and degraded regions).

Biological Corridors

CATIE is involved in a direct way in the development of two biological corridors in Costa Rica: San Juan – La Selva, and Volcánica Central – Talamanca. In both cases CATIE is producing significant results and information on social, economic, agricultural and biological issues related with the performance of these corridors. CATIE is also carrying out strategic research for a third biological corridor in the Osa region of Costa Rica). Such research is building a theoretical and practical framework to guide the management of other biological corridors, mainly in the context of the Mesoamerican Biological Corridor. While all these processes are approached with the same conceptual model described above, the mechanisms adopted in each location depend on the specific characteristics of the landscape. The activities implemented activities also depend on the characteristics of the site and on the interests and needs of the local stakeholders.

The adoption and gradual improvement of appreciative inquiry, participatory action-research methods and the regular use of reflection and systematization of lessons learned processes are helping CATIE to distil its experiences and feed the lessons into other processes within CATIE and its partner organizations.

Literature Cited

Campos, J., Corrales, O., Barriga, M. In Press. El paisaje como eslabón para la política ambiental: Experiencias en cuencas, corredores biológicos y bosques modelo. *In* De Camino, R. Políticas Ambientales en América Latina. United Nations University for Peace.

ECOSYSTEM SERVICES OF BIBOSOOP IN THE KOREAN AGRICULTURAL LANDSCAPE: MICROCLIMATE AND SOIL FERTILITY

Insu Koh[1], Dowon Lee[1], Chan-Ryul Park[2], Myoung-Sub Choi[2]

Abstract—Bibosoops are a unique type of Korean village grove that is mostly found at the mouth of a watershed. This research focuses on the microclimate stability and soil fertility of ecosystem services that a Bibosoop provides in a Korean agricultural landscape. We found that mountain and valley breezes prevailed over the study site. The Bibosoop reduced the speed of valley winds, predominantly southern wind, by 30 % on average. As a result of wind speed reduction, sensible temperature increased from 1 to 5 ^{0}C in the leeward side in winter. During November 2006, the amount of leaf litter in the Bibosoop was 331.95 g m^{-2} and that of leaf litter in the leeward side of the Bibosoop was 76.18 g m^{-2}. These results suggest that the Bibosoop may play an important role in regulating microclimate in the village and enhancing soil fertility in the adjacent rice paddies.

Bibosoop is a unique type of Korean village grove that complements a weak part of the landscape as can be seen. Bibosoops used to be nurtured at the mouth of the watershed where a village was located, but have been removed or degrading during the last several decades. Recently, many Korean researchers have become interested in various ecological functions of Bibosoops as shelterbelts, vegetation filter strips, and wildlife habitat (Lee 2003). Yet experimental data rarely have been reported to show what and how much ecosystem services Bibosoops provide for humans. In this research, we investigated the effects of microclimate stability and soil fertility that an adjacent Bibosoop had on village and paddy field.

Material and Methods

The study area includes Songmal Bibosoop and adjacent lands, lying in Songmal-Ri Beaksa-Myun Icheon, Kyonggido province. The 80 m long and 40 m wide Bibosoop, which is currently dominated by approximately 20 m high trees of *Zelkova serrata*, has been managed by local inhabitants for approximately 400 years. The landform of the area slopes from forest down to the village, an inner paddy field, the Bibosoop, and an outer paddy field. To understand ecosystem services of the Bibosoop, air temperature, relative humidity, solar radiation, wind speed, wind direction, and litter fall were measured at the windward, leeward side and inside of the Songmal Bibosoop from November 2004 to November 2006.

Results and Discussion

We found that mountain and valley breeze prevailed over the study site. Songmal Bibosoop reduced the speed of valley wind, predominantly southern wind, by 30 % on average. This result shows that the Bibosoop has a typical windbreak function (Zhang and others 1995). As a result of wind speed reduction by the Bibosoop, sensible temperature increased from 1 to 5ºC in the leeward side in the winter, which shelters a major residential area lying inside the watershed. Hence, villagers say that they have a milder winter environment in their village than on the windward side of the Bibosoop. During November 2006, the amount of leaf litter collected was 331.95 g m^{-2} in the Bibosoop and 76.18 g m^{-2} in the leeward side of the Bibosoop. Valley wind might blow the leaf litter from the Bibosoop within 50 m distance to the leeward side. The result suggests that the Bibosoop is a source of organic matter to the adjacent agricultural area.

Conclusions

Our research suggests that the Bibosoop plays an important role in regulating microclimate in the village and enhancing soil fertility in the adjacent rice paddies. Under mountain and valley wind systems, Songmal Bibosoop has an ecological function of windbreak. The Bibosoop reduced valley wind by 30% on average. As a result, sensible temperature increased from 1 to 5ºC in the leeward side in the winter. The amount of the litter fall in the leeward side was considerable, indicating that the Bibosoop may contribute to enhancing soil fertility. Thus the findings of this research provide practical interpretation for understanding ecosystem services of Bibosoop in Korean agricultural landscape.

Acknowledgements

We thank Youngryel Ryu and Yongil Kim for help to instruct automatic weather station. We also thank the head of village and villagers in Songmal Ri Beaksa-Myun Icheon, Kyonggido province. This research was supported by Institute of Korean Studies, Seoul National University 04-03-211-38 and Korean Forest Research Institute.

[1] Graduate School of Environmental Studies, Seoul National University, Seoul, South Korea; kohis01@shu.ac.kr
[2] Korea Forest Research Institute, Seoul, South Korea.

Literature Cited

Lee, D. 2003. *Ecological Knowledge Embedded in Traditional Korean Landscapes*. Seoul, Seoul National University Press. 102p (in Korean with English abstract).

Zhang, H., Brandle, J., Meyer, G., Hodges, L. 1995. The relationship between open windspeed and windspeed reduction in shelter. *Agroforestry Systems* 32: 297-311.

SYMBIOTIC SERVICE IN MANAGED FORESTED LANDSCAPES – DOES ARBUSCULAR MYCORRHIZAL INOCULATION POTENTIAL ALLOW RESTORATION OF NATURAL VEGETATION?

Martin Zobel[1], Mari Moora[1], Maarja Öpik[1,2], Tim Daniell[2]

Abstract—Ecosystems provide a variety of benefits and services to people. Service providing units (SPU) are populations of one or several species responsible for providing a particular service. We studied the arbuscular mycorrhizal (AM) fungi, providing 'symbiotic service' for understorey plant species and some deciduous trees, which were responsible for multiple of ecosystem services for humans (provisioning, regulating, cultural). We studied the diversity of AM fungal communities in intensively managed forest stands and old growth stands within fragmented landscapes of central Estonia and asked whether the intensively managed stands have retained their ability to provide 'symbiotic service'? We concluded that although the composition of AM fungal communities in intensively managed stands differed from that in old stands, the ecosystem can still offer 'symbiotic service,' necessary for restoration of characteristic old growth understorey plant community.

Ecosystems provide a variety of benefits and services to people. A term 'ecosystem services' has been suggested to denote those benefits. Millennium Ecosystem Assessment (Hassan et al. 2005) suggested distinguishing between four major group of services – provisioning, regulating, cultural, and supporting, with different categories and subcategories. Populations of one or multiple species responsible for provisioning a particular ecosystem service are called Service Providing Units (terminology by Luck et al. 2003). For instance, a provisioning service 'fibre', subcategory 'timber', may be provided by SPU - a community of several predominating tree species. At the same time, the functioning of this SPU is supported by other functional units, e.g. by communities of symbiotic organisms, which represent secondary SPUs. In this way, one may distinguish between primary ecosystem services and primary SPUs, directly responsible for benefits to people, and secondary services and SPUs, responsible for the functioning of primary SPUs.

In the case of forest ecosystems, several services are of importance – provisioning services like fibre (timber, wood fuel), regulating services like erosion regulation, cultural services like educational and aesthetic values and recreation. SPUs provisioning these services are either populations of trees or multiple understorey species, or both. Both tree and understorey plant populations are supported by secondary SPUs, providing secondary 'symbiotic service.' These SPUs include communities of ectomycorrhizal and arbuscular mycorrhizal (AM) fungal communities largely responsible for nutrient uptake.

We address the question whether intensive forest management in human-impacted landscapes influence symbiotic service and whether one may expect restoration of service after the management intensity has been relaxed and we aim to restore natural forest stands. We begun with studying the symbiotic service provided by AM fungi in forest soil. Here we report the first results of a larger study project.

Results and Discussion

The area of natural old growth herb rich mixed coniferous stands within a forested landscape in Central Estonia has decreased tremendously. Forests are managed intensively; clear-cut areas are planted with dense monocultures of *Picea abies*. The field layer vegetation in these stands is characterized by several early successional species, as well as by a lack or low abundance of species characteristic to old stands. The great majority of field layer species, but also some broadleaved tree species, are arbuscular-mycorrhizal (AM). We were interested whether these stands maintain their 'symbiotic service' – the ability to inoculate disturbed forest understorey communities with AM fungi? We studied AM fungal communities within a 5x5 km area in the roots of five plant species (*Fragaria vesca, Galeobdolon luteum, Hepatica nobilis, Oxalis acetoselal* and *Trifolium pretense*). Three sampling sites were located in young stands, planted in former clearcut areas, and three sites in less intensively managed old stands. Altogether 30 fungal taxa (SSU rDNA sequence types) were discovered from 91 plant samples (912 clones sequenced) of which 3 taxa were recorded for the first time. The AM fungal taxon richness discovered is remarkably high. The global comparison of AM fungal community taxon composition showed that fungal communities in Koeru coniferous forest are relatively distinct from other known communities. On average, 3.2 AM fungal taxa were recorded per individual plant root sample. AM fungal taxon richness per plant individual was significantly dependent on the identity of plant species. DCA ordination showed that the AM fungal community composition is primarily determined by forest

[1] Institute of Botany and Ecology, University of Tartu, Lai St.40, Tartu 51005, Estonia; martin.zobel@ut.ee
[2] Environment Plant Interactions, Scottish Crop Research Institute, Dundee, DD2 5DA. UK

management intensity, while, additionally, soil nitrate content had a slight impact on AMF community composition.

We concluded that although the composition of AM fungal communities in intensively managed stands differed from that in old stands, the ecosystem has still retained its ability to offer 'symbiotic service,' provided by AM fungi. Since the presence of an appropriate AM fungal community significantly enhances establishment and growth of natural plant species (Moora et al. 2004), one may expect that in intensively managed stands there is still a SPU available necessary for restoration of a characteristic old growth understorey community. Further experimental study should clarify the functional characteristics (e.g. enhancement of plant growth) provided by 'symbiotic services.' In collaboration with another research group, we also plan to start with studying ectomycorrhizal 'symbiotic service.'

Literature Cited

Hassan,R., Scholes, R., Ash, N. (editors) 2005. *Millennium Ecosystem Assessment. Volume 1. Ecosystems and Human Well-being*. Island Press, Washington. 917 p.

Luck, G. W., Daily, G.C., Ehrlich, P.R. 2003. Population diversity and ecosystem services. *Trends in Ecology & Evolution*. 18:331-336.

Moora, M., Öpik, M., Sen, R., Zobel, M. 2004. Native arbuscular mycorrhizal fungal communities differentially influence the seedling performance of rare and common *Pulsatilla* species. *Functional Ecology* 18:554-562.

LOCATIONS AND TOPOGRAPHICAL CHARACTER OF THE MAEULSOOP (KOREAN VILLAGE GROVES) AND A ROLE FOR THE COMMUNITY

Jino Kwon[1], Dong Hyun Kim[2], Jeong-Hak Oh[1], Myoung-Sub Choi[1], Young-Kul Kim[2], and Myoung-Bo Lee[2]

Abstract—The MAEULSOOP, man-made village groves in Korea were established since the 7th Century to serve the nearby villages, and many of them have survived. To explore the roles for the village community, spatial character of locations of MAEULSOOPs and the related village were analyzed by using GIS. One of the characters of the Korean peninsula based on topography could be a mountainous landscape. It can be represented as the eastern-hilly region and southwestern-flat region. The MAEULSOOPs in good condition from two regions were sub-categorized according to spatial characteristics. Representative sites were tested to explore their roles for the community; for example, simulation for a wind-tunnel test or shapes of groves against a prime corridor. According to the spatial characteristics, the MAEULSOOPs are categorized into 9 groups. It seems that the location-difference determines the key role of MAEULSOOP, such as protection from wind, maintaining water-ways, screening from harmful events, and defining field boundaries, etc.

Introduction

In general, the Korean landscape can be described as a forested-mountainous landscape because of the portion of mountains, which comprise more than 65% of the land area. Historically, villages located in the corridor between mountains. Therefore the MAEULSOOP, Korean village groves, could be the result of this prevailing condition. Nine types of illustrated landscapes from previous research (Kwon 2002, illustrations after Higuchi 1983) were used to classify the location of the MAEULSOOP. Aerial photographs, DEM, the ArcScene with a modified AML (after Zimmermann 2000) and Computational Fluid Dynamics (CFD) were applied for classification, and produced their overview in landscape as illustrations (Kwon and others 2006).

Locations, Spatial Distribution and Roles of the MAEULSOOP

The locations of MAEULSOOP could be understood based on 'How is the village community exposed against its prime corridor and territory?' Pinpoint location could be determined according to the nearby water-way, wind-way etc. within the corridor where the MAEULSOOP is located. The size in both width and length might be influenced by the size of the prime corridor and territory. One of the major roles for the village community is shifting the direction of harsh winds, which could be considered for the restoration of historical MAEULSOOPs and installation of new MAEULSOOP for a future Korean landscape.

Literature Cited

Higuchi, T. 1983. *The Visual And Spatial Structure Of Landscape.* Cambridge, Mass; London: The MIT Press and Cambridge Mass: 94-185.

Kwon, J. 2002. Sense of place – A concept of Korean prototype landscape with reference to a new policy of urban fringe forest. England. Sheffield: Sheffield University. pp174-186. PhD. Thesis.

Kwon, J., Shin, J.H., Kim, Y.K., Choi, M.S., Oh, J.H. 2006. Geographical characteristics of the MAEULSOOP (Korean Village groves) between southwestern flat region and eastern hilly region [Abstract]. In: The 2nd Scientific Congress of East Asian Federation of Ecological Societies. [Niigata, Japan]: East Asian Federation of Ecological Societies: 463.

Zimmermann N. E. 2000. Topographic position mapping routines. http://www.wsl. ch/staff/niklaus.zimmermann/ programs/aml.html#4. [Data accessed: August 1, 2006].

[1] Div. of Forest Ecology, Korea Forest Research Institute, 207, Cheongyangni-2 dong dongdaemun-gu, Seoul, 130-712 Korea; alp96jk@foa.go.kr
[2] Div. of Forest Fire, Korea Forest Research Institute, Seoul, Korea

PRESERVATION AND RESTORATION OF FORESTS ASSOCIATED WITH NEW TOWN DEVELOPMENT IN HONG KONG

C.Y. Jim

Abstract—The new town program in Hong Kong initiated in the early 1970s has thus far shifted about two million people from the old city core to previous rural and countryside areas. Such massive urban sprawl, resulting in the creation of seven new towns, has brought extensive intrusion into farmlands and natural hill slopes, and imposed widespread influence on pre-urbanization natural and cultural vegetation. This study aimed at understanding the following aspects of the urban forests associated with new town development: the nature and magnitude of the positive and negative changes, the geometric pattern of forest cover changes, the present forest condition and performance, and the factors and processes leading to the vegetation modifications and restoration. The management implications of the findings will be explored.

This study focused on the Tai Po new town in the largely rural New Territories of Hong Kong. Developed since 1979, it has a current population of about 300,000 and area of 3,500 ha. It began as a small old market town established in 1672 and an adjacent new market town founded in 1893. They were surrounded by village settlements and farmlands in the lowlands, which in turn were surrounded by undeveloped hills lying beyond. It offers an exemplary of achieving a reasonable balance between high-density urban growth and nature conservation, and which provides a more livable and green environment. Efforts were made by the development agency to preserve and enhance vegetation, with an emphasis on the tree life forms. As an integral part of the development process, the government identified and preserved existing woodland pockets of high ecological value, planted urban trees along streets and other incidental and remnant undeveloped areas, created two new town parks and a number of neighborhood green spaces, and afforested the extensive fringe hill slopes.

Results and Discussion

Human impacts on vegetation in Tai Po were traced since its inception with the help of large scale sequential color aerial photographs, topographic and land use maps, field surveys and government documents. The data collection aimed at two scales. The first was a macro-level characterization of canopy cover changes of the intra-urban and urban-fringe forests, divided into three pre-urbanization and three post-urbanization phases. The boundaries of the tree covers were mapped to detect their expansion or contraction, and to assess their geometric attributes such as size, shape, connectivity and fragmentation. The second was a micro-level evaluation of individual urban trees in terms of species composition, site condition, tree quantities, tree dimensions, and tree performance, with data collected from a sample of the trees lying in the contiguous built-up areas. A stratified sampling approach based on major land use types was adopted to determine the sample. The study then evaluated the factors that might mold these tree attributes, such as antecedent and present land use, development age, urban form, human impacts, planting objectives, and management regime.

After nearly 30 years of development, the physical fabric of the town and its constituent greenery has begun to mature. Its urban forests have experienced a significant restoration in total canopy coverage, biomass volume, vegetation structure, and species diversity. The townscape is now well endowed with a sylvan landscape, with trees liberally and often closely planted to cover lands within and around the town. The rich species diversity in built-up areas has a notable exotic component. There is a tendency in recent years to shift from small to medium final dimensions and notable physical constraints to tree growth. Significant spatial variations in tree performance and tree stocking rate occur between districts, land uses and development age. Most urban trees especially the better quality ones are concentrated in several land uses, including open space, roadside, residential, and government, institutional and community.

On previous farmlands and village lands, a small number of large specimen trees of outstanding structure, stature and performance have been engulfed and preserved in built-up areas. They denote natural and cultural relicts of the community with historical and sentimental values. The site design for such heritage trees, however, is beset by excessive concrete and impervious covers and sometimes intrusion of rooting room and crown growth space by underground utilities

Department of Geography, University of Hong Kong, Pokfulam Road, Hong Kong; hragjcy@hkucc.hku.hk

and buildings. Otherwise, the trees were newly planted after new town development. On the reclaimed lands, all trees were newly planted. The two town parks with generous tree cover are situated entirely on reclaimed lands; hence all the trees were nurtured from scratch.

The lower slopes with relatively gentle gradient, situated adjacent to the lowlands, had been encroached by urban expansion. The topography has been transformed by cut and fill into terraces or platforms for building and road development, thus all the vegetation there had been eradicated. Some urban trees mainly at roadsides have since been planted on the engineered surfaces, but the tree cover remains rather sparse and scattered. The upper slopes with steep gradient have been designated as conservation areas with green belt zoning. Pre-urbanization forests at such remaining hilly fringe have been partly preserved and subsequently enhanced. They contain the bulk of the town's forest stock and associated natural ingredients.

The pre-urbanization forest in the 1950s was characterized by limited cover, isolated and mainly small patches, and high degree of fragmentation. Most wooded patches had sparse tree cover and were found on slopes. Individual forest pockets were separated by degraded grasslands. The disparate forest enclaves denoted secondary growths after the complete destruction of the original natural tropical forest. The migration of sedentary farmers into the territory about a thousand years ago brought rapid forest decimation. The small but compact market town and its surrounding farmlands and villages had scant and piecemeal tree presence. They contain mainly scattered and solitary trees. The forest pattern indicated the resultant of natural process of regeneration interacting with continual human disturbance. The less stressful and more sheltered sites such as valleys and gentle slopes favored spontaneous recovery of woody vegetation and more resistance against human perturbation especially frequent hill fires. No sign of systematic forest plantation could be detected. The 1960s aerial photographs indicated an increase in forest cover accompanied by pronounced coalescence of previously discrete pockets. The forest acreage expanded from 3.7 km^2 in 1956 to 8.5 km^2 in 1969, mainly due to government afforestation. The merging process generated a more extensive and continuous tree canopy with more connectivity and less edges. Meanwhile, the developed lands continued to have meager tree cover.

In the 1970s, shortly before declaration of new town status, the forest area increased merely by 5.9%. It indicated that better sites for voluntary forest recovery had been exhausted, and the process had encountered difficulty extending into stressful sites. Human inroads in the interim had brought forest degeneration, breaking up of some large wooded patches, and forest regression. Intensive new town development in the 1980s witnessed massive earth borrowing activities on the hills to obtain fill materials, which wiped out some forest plantations and reduced forest acreage by 14.4%. In the 1990s, the new town began to take shape and assiduous afforestation was resumed, ushering a very significant 101.3% rise in forest cover. Most hill slopes lying beyond the built-up areas were completely clothed by a continuous wooded mantle that permits habitat connectivity to foster wildlife recovery. The new town is almost completely enveloped by forests except on the coastal side. In the urbanized lands, long linear roadside tree belts and green patches in urban parks and other green spaces began to mature. The extensive forest restoration work was able to drastically overhaul within several decades a badly degraded landscape into a lush sylvan one to wrap and penetrate the new town.

To tackle the harsh site conditions, a two-stage species choice and planting approach was adopted in the reforestation program. Due to the harsh soil and microclimatic conditions and especially the barren and erosion-prone slopes, fast growing exotic species were initially preferred to permit fast revegetation. The initial planting focused on creating promptly a continuous vegetation cover on the denuded land to arrest soil erosion, which could otherwise proceed at a rapid rate under the heavy tropical rains and hence further reduce the life-supporting capacity of the land. They served as very effective pioneers and nursing plants to trigger gradual improvements in habitat conditions. Recent replacement and enrichment planting on the enhanced land has adopted mainly native species for ecological enhancement. The new comers have helped to transform the exotic forests gradually into native forests by triggering a self-sustaining ecosystem succession process.

This extensive circum-urban forest girdle envelops the built-up areas to furnish valuable ecosystem services to the new town and to contribute to environmental quality and quality of life. The key natural functions include floral and faunal conservation, soil and water conservation, flood abatement, air quality improvement, microclimatic amelioration, and dampening of the urban heat island effect. Moreover, it offers a high quality and salubrious outdoor recreational venue for town folks to explore. Situated right next to developed areas and equipped with a footpath system, the forest is highly accessible. It plays the role of an urban fringe park or even a surrogate urban park to meet passive leisure demands. With continued increase in biomass content, biotic diversity and cover continuity, the ecological and amenity values are expected to rise further in due course.

The present level of 1550 ha of forests represents a mosaic of both pre-urbanization secondary forest patches and recently planted ones. The increase in forest acreage has been accompanied by improvement in continuity and connectivity, thus raising their ecological and environmental benefits. The new town thus has 44% of its land covered by extensive forests, denoting an exceptionally rich natural endowment that is much better than the old city core and other new towns. The opportunities and trigger effect of new urban growth on vegetation in Tai Po exemplified the co-existence of densely-populated cities and nature. It could serve as a model to restore forests in the course of urban expansion in other cities especially those of the compact mode in the developing world. It provides a pointer that urbanization does not need to be unfriendly to forests.

DESIGNING AND PLANNING URBAN FOREST LANDSCAPES BY MEANS OF FOREST DEVELOPMENT TYPES

J. Bo Larsen[1] and Anders Busse Nielsen[1]

Introduction

The world is getting increasingly urbanized! This year the proportion of urban dwellers passed 50% across the globe and is expected to reach 60% by 2030. In Europe, the percentage of the population living in urban areas is expected to rise from 73% in 2000 to 80% in 2030. Therefore, the identification of forest landscape restoration strategies focusing upon forests and trees in an urban and peri-urban context is crucial (Larsen 2005): We have to restore forests and develop nature where people live.

The importance of urban forests has from a forestry perspective been widely overlooked and, as a result, undervalued. The various environmental and social benefits and potentials of forests and trees in populated areas to limit energy use, improve air quality, reduce noise, increase water storage, maintain fragmented ecosystems, and positively affect the societal sense of well-being are, however, increasingly being accepted (Konijnendijk et al. 2005).

Most urban forests have developed from "commercial" forests seeking to incorporate societal functions in a basic wood production oriented management system thereby focussing upon the stand as the functional unit. When dealing with urban forests the higher functional level - the forest landscape - much more is in focus in order to develop the intended recreational and ecological functionality. Hence, long-term goals that not only (Larsen and Nielsen 2007) consider stands but also the forest landscape have to be developed when managing urban forests.

The Forest Restoration Perspective – Planning With Nature

From a forest restoration viewpoint, silvicultural strategies are required in order to develop forests with a high potential for biodiversity protection and contributions to environmental and social values. This can be achieved by incorporating structural and functional features of natural forest ecosystems. This approach can be summarised by the term "nature-based silviculture." Nature-based forestry is based upon the principle of supporting natural processes of the forest ecosystem by facilitating site-adapted species mixtures through natural regeneration and making use of natural self-differentiation (Schütz 2006). Hence, the complex nature of near-natural forest structures and dynamics and their management arrangements requires integrative and flexible management frameworks and tools.

The concept "Forest Development Type" (FDT) provides one such adequate framework for advancing and describing ideas about long-term goals for stand structures and dynamics in stands subjected to nature-based forest management. FDT describes long-term goals for forest development in a given locality (climate and soil conditions) in order to accomplish specific long-term aims of functionality (ecological-protection, economic-production, and social-cultural functions) (Larsen and Nielsen 2007). The concept comprises a broader understanding of natural disturbance regimes and successional processes. The disturbances and processes in natural forest ecosystems, which cause structural heterogeneity at both large- and small-scale are linked to regional characteristics of climate, soil, and species compositions. It is expressed as for example, infrequent, large-scale storm disturbances, small- and large-scale fire-driven disturbances in boreal ecosystems, and frequent, small-scale disturbances in Central-European forests. Hence, models describing the region-specific disturbance patterns in such natural ecosystems should be used in the development of applied silvicultural methods (Hahn et al. 2005).

A major object of FDT scenarios is to describe the practical impact of the general policies for nature-based silviculture on the stand level. For each FDT stand structure, species composition and regeneration dynamics are described both qualitatively (verbal descriptions) and quantitatively (numeric descriptions) for their mutual supportiveness, 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 is illustrated by means of profile diagrams (Larsen and Nielsen 2007).

The Landscape Restoration Perspective – Planning With Design

From a landscape restoration viewpoint diverse forest ecosystems can be introduced as an integral part of the urban landscape, bringing the special qualities of nature into peoples' daily lives. A key element in the provision of these new forests is the

[1] Forest and Landscape, University of Copenhagen, Frederiksberg, Denmark; jbl@life.ku.dk

integration of forested areas, openings and other nature types into spatially and visually diverse forest landscapes. This implies the incorporation of silvicultural, ecological and landscape architectural expertise in a design-led approach that integrates functional efficiency, economics, ecology and visual attractiveness (Lucas 1999, Bell et al. 2005). Additionally, as urban landscapes and society are changing and developing with relentless speed, urban forests design must be flexible and inextricably linked to management, so that the developing forest landscape can evolve and adapt to changing pressures and challenges. In this context, keeping as close to nature as possible and using natural processes as the base for design and management is generally claimed to be one of the most promising approaches in the development of the urban forest resource for human use and environmental services (Bell et al. 2005).

Combining the strengths of both forestry and landscape architecture around the concept of forest development types (FDT) a useful tool in designing and planning urban forest landscapes along natural principles can be developed and adapted across urban zones and functionalities. Combining different FDTs with other nature types i.e. meadows, wetlands, and water bodies, the urban forest landscape can be designed with a range of site-adapted rich ecosystems and recreational experiences.

The Urban Perspective – Planning With People

From an urban viewpoint, the debate about changing silvicultural practices and developing functional landscapes covers more than silviculture and landscape architecture. It is also linked to an ongoing discussion within urbanized societies, implying that at the socio-political level urban woodland landscapes must be developed in a transparent and participatory process. In this context, FDT scenarios and their illustration by means of profile diagrams have proven to be integrative, flexible and easy to comprehend. They are efficient tools for developing and communicating long-term goals for stand and landscape development in nature-based forest management between scientists, professional and laypersons (Larsen and Nielsen 2007, Nielsen et al. 2007). The concept enables the participatory approach and a sense of ownership among the beneficiaries and creates close links between planning, design and management by defining and agreeing upon long term goals not just for stands but especially for landscape development.

Literature Cited

Bell, S., Blom, D., Rautamäki, M., Castel-Branco, C., Simson, A., Olsen, I.A. 2005. Design of Urban Forests. In: Konijnendijk, C.C., Nilsson, K., Randrup, T.B., Schipperijn, J. (eds). *Urban Forests and Trees*. Springer, 149-186.

Hahn, K., Emborg, J., Larsen J.B., Madsen, P. 2005. Forest rehabilitation in Denmark using nature-based forestry. In Stanturf J.A., and Madsen P. (eds.), *Restoration of Boreal and Temperate Forests*. CRC Press, 299-317.

Konijnendijk, C.C., Nilsson K., Randrup, T.B., Schipperijn, J., eds. 2005. *Urban Forests and Trees*. Springer, Berlin.

Larsen, J.B. 2005. Functional forests in multifunctional landscapes - Restoring the adaptive capacity of landscapes with forests and trees. EFI-Proceedings 53: 97-102.

Larsen, J.B., Nielsen, A.B. 2007. Nature-based forest management – where are we going? – Elaboration forest development types in and with practice. *Forest Ecology and Management* 238: 107-117.

Lucas, O.W.R. 1999. *The Design of Forest Landscape*. Oxford University Press, Oxford.

Nielsen, A.B., Olsen, S.B., Lundhede, T. 2007. An economic valuation of the recreational benefits associated with nature-based forest management practices. *Landscape and Urban Planning* 80: 63-71.

Schütz, J.-P. 2006. Opportunities and strategies of bio rationalisation of forests tending within nature-based management. *Studia Forestalia Slovenica* 126: 39-46.

DESIGNATION OF THE BAEKDUDAEGAN MOUNTAIN SYSTEM PROTECTED AREAS AND ITS MANAGEMENT STRATEGIES

Young Kul Kim, Im Kyun Lee, Jong Hwan Lim, Jung Hwa Chun, Joon Hwan Shin

Abstract—The Baekdudaegan Mountain System (BDMS) is the longest series (1,400km) of mountain ranges that forms the backbone of the Korean peninsula's topography. The BDMS is critical to the maintenance of ecosystem stability and a hot-spot of Korea's biological diversity. In order to protect Korea's forest ecosystems from further deterioration, the Act on the Protection of the BDMS was legislated in 2003 and went into effect in 2005. To date, a total of 263,427ha of forests have been designated as protected areas, covering 2.6% of the land area and 4% of the forested area. In 2005, Korea established the strategies for an effective management of the BDMS protected areas. The strategies include 1) ecological management and sustainable utilization of the natural resources; 2) establishment of conservation framework; 3) active participation of the public in the protecting activities and 4) strengthening of international cooperation.

Korea is a mountainous country. As of the year of 2006, 64% of land area is covered with mountains. In Korea, the term of mountains is, frequently, regarded as the same as forests because almost all the forests are distributed in the mountains. The Baekdudaegan Mountain System (BDMS) is the longest series of mountain ranges stretching from Mt. Baekdu in North Korea all the way down to Mt. Jiri in the southern part of South Korea (Hyun 2000). The Baekdudaegan means a great mountain range originated from Mt. Baekdu. Actually the BDMS is a hot-spot of Korea's biological diversity and the rise source of Korea's 4 major rivers. Meanwhile, Koreans traditionally view the lands as the human body. As the backbone of Korea peninsula, the BDMS is composed of one main artery and several minor arteries. The main artery is called "Jeong-gan" and minor arteries are called "Jung-maek" in Korean (Hyun 2000). Unfortunately, for the past half a century, the BDMS has been damaged mainly by land use changes which are caused by rapid industrialization and urbanization. Thus, the KFS established the Act on Protection of the BDMS on December 31 in 2003, and designated the BDMS protected areas on September 9 in 2005 for more systematic protection of the BDMS and restoration of degraded forest ecosystems (Korea Forest Service 2006). The major objectives of this study are 1) to introduce the current status of the BDMS protected area and 2) to suggest the strategy for more efficient and systematic management of the BDMS protected area.

About the Baekdudaegan Mountain System

The first detailed mention of the BDMS in literature is found in "Sankyeongpyeo" which was written in the early 19th century (Hyun 2000). The BDMS consists of one mountain system (dae-gan in Korean) and one primary chain of mountains (Jeong-gan) and 13 secondary chains of mountains (13 Jeong-maek). "Jeong-gan" and "Jeong-maek" literally means the main stem and the branch of a mountain range, respectively. Based on the traditional philosophy, they can be interpreted as the main artery (or main vein) and the minor arteries (or minor veins), respectively.

From an ecological point of view, the BDMS plays an important role as an eco-passage. Various kinds of animals and plants have flowed into our lands through the BDMS and migrated along the BDMS. It is reported that a total of 1,248 plant species are distributed in the BDMS, which amount to 33% of the total floras in Korea. Of these, 108 species are endemic species (Lim 2003; Lim and others 2003). As well, the BDMS is a symbol of national spirits of constantly striving to guard freedom, support equality and fight for justice. The BDMS also provides us with recreational, eco-touristic and educational places.

Designation Of Protected Areas In The BDMS

The protection of the BDMS is very important for the future generation because of its economic, environmental, ecological, and aesthetic values. However, development-oriented policies during the past decades have caused fragmentation and devastation of forests and transformation of landscapes of the BDMS. Accordingly, measures to protect the BDMS from reckless development and to restore the damaged ecosystems are urgently needed. In 2004, the KFS set the criteria for designating protected areas within the BDMS areas through a public hearing process. Finally, the Act on Protection of the Baekdudaegan Mountain System went into effect on Januaey 1, 2005 and the BDMS protected areas were designated on September 9, 2005. A total of 263,427ha (Core zone: 169,950ha, Buffer zone: 93,477ha) have

Dept. of Forest Environment, Korea Forest Research Institute, Seoul 130-712, Korea; youngkul@foa.go.kr

been designated as protected areas, covering 6 provinces, 32 cities or counties, and 108 districts or regions (KFS 2005).

Management strategy of the BDMS Protected Areas

Criteria and indexes for avoiding a large, destroyed landscape should be developed. No more quarrying and mining should be permitted in the BDMS protected areas. Abandoned mine sites and roads should be rehabilitated. It is also proposed that gardens of wild flowers will be established along the forest roads to recover landscape (Shin 2004). In an attempt to improve the environment of the BDMS region, we need to recommend farmers to adopt organic farming practices as ecologically sustainable and ecologically friendly agriculture practices. The government should also induce the farmers who are running large-scale ranches to install livestock waste treatment facilities. In addition, as an attraction, the government needs to find a market for the farmers who are running small-scale ranches on condition that they take any kinds of measures for reducing livestock waste. On top of it, the government needs to induce the residents in the BDMS areas to participate in the development of cultures for the conservation of the BDMS (Shin 2004). Forests in the BDMS areas should be managed by adopting environment friendly forest practices such as selective cutting. Additionally the KFS needs to develop a forest management plan which is appropriate for the conservation of the BDMS (Shin 2004).

Conclusion

The BDMS is a living nature as well as a source of life. Accordingly, it should be well-preserved and managed for future generations. In this regard, the enforcement of the Act on Protection of the Baekdudaegan Mountain System is timely and very significant to recover the health and historic meaning of the BDMS. The designation of protected areas in the BDMS is not to encroach on the resident's rights and lives. Instead, legally protected areas can contribute to enhancing the quality of life and become an income source for the resident because protected forests, landscapes and cultures can be used as resources of tourism and recreation. In addition, the government should develop a program for the resident to voluntarily join the activities for the conservation of the BDMS. At the same time, the government should make an effort to establish a cooperative relationship with North Korea. South and North Korea have a mutual obligation to protect the BDMS - a natural heritage of Korea peninsula.

Literature cited

Hyun, J.S. 2000. SanGyungPyo- *Korea has a genealogical table even though mountain.* Pulbit press, Seoul. 347p.

Korea Forest Service. 2005. Designation Status of Protected Areas of Baekdudaegan Mountain System. 228p.

Korea Forest Service. 2006. *Baekdudaegan Mountain system White Paper.* 625p.

Korea Meterorological Administration. 2005. Data provided by internet. http://www.kma.go.kr/new/index.html.

Lim, D.O. 2003. Vascular plants of mountain ridge from Cheonwangbong- Hyangjeokbong section in the Baekdedaegan. *Korean Society of Environment and Ecology.* 16(4): 359-386.

Lim, D.O.; Kim Y.S.; Park Y.K.; Ryu Y.M. 2003. Vascular plants of Manbokdae, Goribong and Sujeongbong in the Baekdedaegan. *Korean Society of Environment and Ecology.* 16(4): 387-403.

Shin, J.H. 2004. Management area and management strategy of Baekdudaegan. *Korean Society of Environment and Ecology.* 18(2): 197-204.

LANDSCAPE MODELING FOR FOREST RESTORATION: CONCEPTS AND APPLICATIONS

Weimin Xi[1], John D. Waldron[2], Robert N. Coulson[1], Maria D. Tchakerian[1], David M. Cairns[3], Charles W. Lafon[3], Andrew G. Birt[1], Kier D. Klepzig[4]

Abstract—Ecosystems provide a variety of benefits and services to people. Service providing units (SPU) are populations of one or several species responsible for providing a particular service. We studied the arbuscular mycorrhizal (AM) fungi, providing 'symbiotic service' for understorey plant species and some deciduous trees, which were responsible for multiple of ecosystem services for humans (provisioning, regulating, cultural). We studied the diversity of AM fungal communities in intensively managed forest stands and old growth stands within fragmented landscapes of central Estonia and asked whether the intensively managed stands have retained their ability to provide 'symbiotic service'? We concluded that although the composition of AM fungal communities in intensively managed stands differed from that in old stands, the ecosystem can still offer 'symbiotic service,' necessary for restoration of characteristic old growth understorey plant community.

Restoration planning, evaluation, and implementation are of paramount importance in forested areas of the United States and in many other regions of the world. In the United States, forest restoration has become an urgent task for forest health and sustainable development (The United States Congress 2003, Stanturf 2005). Using landscape models to investigate forest restoration provides a promising opportunity for planning and evaluating restoration strategies in forest areas damaged by insects and diseases, fire, hurricanes, invasive species, and other forest environmental threats. In this paper, we provide a framework for using landscape simulation model to restore forests; present a case study using this approach to explore the effects of forest restoration strategies of the Southern Pine Beetle (SPB; *Dendroctonus frontalis* Zimmermann) damaged forests in the southern Appalachians, USA; and use SPB as an example to illustrate, in a broader context, how landscape models can be used to support restoration planning and evaluation.

A Framework of Landscape Modeling For Forest Restoration

Landscape models simulate change throughout time using spatially referenced data across a broad spatial scale (ca. 1~1,000s km^2). They have been used to explore the reciprocal interactions between forest structure and a variety of natural disturbance agents including wildland fires (He and Mladenoff 1999, Shang and others 2004, Scheller and others 2005), pests and disease (Sturtevant and others 2004) characteristic to a geographical area. These models have also been used to simulate the effects of a variety of human-made disturbances such as harvesting, thinning, and planting (Gustafson and others 2000, Shifley and others 2000).

A general framework of landscape modeling for forest restoration is to integrate natural disturbance agents and restoration strategies into a landscape model capable of simulating vegetation dynamics through space and time. Using auxiliary models, these forest patterns and restoration strategies, described as simulation scenarios, can be evaluated according to various criteria including the cost of the management strategy versus the utility of the simulated landscape.

The desired goal of a restoration strategy may be known and well defined a priori. In these cases, a modeling approach can be used to determine the management strategy that leads to the landscape structure that best fits this ideal. However, determining restoration goals a priori is difficult owing to limitations of historical data; the long term horizons of forest dynamics; unprecedented human impacts on forest landscapes and the fact that effective management involves the optimal allocation of limited economic resources.

Where restoration goals cannot be defined a priori, an iterative modeling approach can be used to explore various management strategies and their consequences for landscape structure. This process leads to the identification of appropriate and practical restoration goals. Clearly, the success of this iterative approach depends upon having a model that is flexible enough to represent a variety of disturbance agents and management practices.

A Case Study Using LANDIS to Model Restoration of Appalachian Pine Forests Damaged by SPB

SPB is the most destructive native insect affecting

[1] Knowledge Engineering Laboratory, Texas A&M University, College Station, TX, USA; email-xi@tamu.edu
[2] Department of Environmental Studies, University of West Florida, Ft. Walton Beach, FL, USA.
[3] Department of Geography, Texas A&M University.
[4] USDA Forest Service Southern Research Station, Pineville, LA, USA.

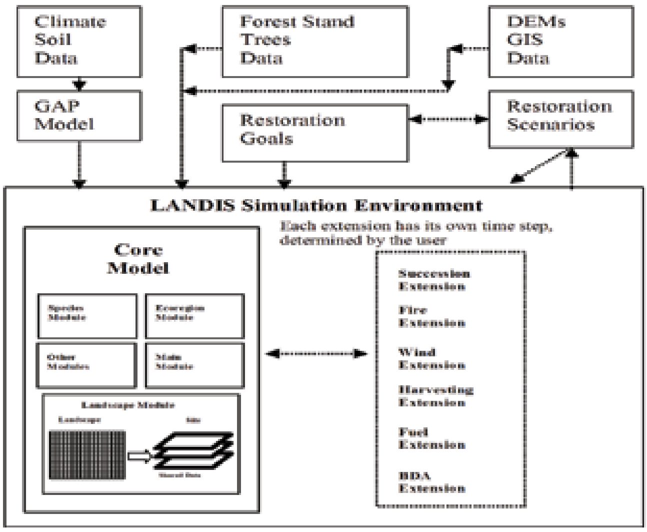


Figure 1. The working flow using LANDIS model for SPB restoration planning and evaluation. BDA in this figure refers to Biological Disturbance Agent

the southern US forests. In the southern US, there is currently a substantial program, administered through the USDA Forest Service, entirely dedicated to restoring public and private forests damaged by SPB (USDA Forest Health Protection 2005). In the years of 2000-2003, SPB caused catastrophic damage in the southern Appalachian Mountains. Restoring yellow pine forests is an important and challenging task for forest owners and managers in this region.

We used landscape modeling to evaluate and plan management strategies for forests damaged by SPB in the southern Appalachians (Coulson and others 2004, Waldron and others 2005, 2007, Lafon and others 2007 in press). Our goal was to develop a procedure to facilitate restoration planning and evaluation for SPB-damaged pine forests in the southern Appalachians. Our specific objectives were to: 1) Facilitate the use of landscape models in forest pest and pathogen damage restoration planning and evaluation, and, 2) Develop model-informed restoration plans that can be implemented in a sustainable forest management context.

We chose LANDIS (LANdscape DIsturbance and Succession, both LANDIS 4.0 and LANDIS-II) as our primary modeling tool for forest restoration because it provides a framework for determining the effects of disturbances such as fire regimes, insect outbreaks, harvesting and planting on changes in forest structure (Mladenoff 2004, Waldron and others 2005). LANDIS is a spatially explicit landscape-scale simulation model that incorporates natural processes, ecological succession, seed dispersal, and forest management practices. We parameterized LANDIS for the southern Appalachian forests. Existing forest stand conditions and land types were used as the starting point for landscape simulation (Figure 1). Site specific Forest Management Plans based on Forest Service practices were then used to determine the desired future forest conditions and the specific restoration goals (Table 1).

Our modeling projections suggest that a combination of fire and SPB disturbance creates sustainable yellow pine forests, and the regime of multiple interacting disturbances have important implications for succession in yellow pine forests of the southern Appalachians (Waldron and others 2005, 2007). Our results also suggest that Table Mountain pine could be a species of particular interest for restoration efforts on low- to mid-elevation ridges and southeast-west facing open slopes in the southern Appalachians. Table Mountain pine, a southern Appalachian endemic, contributes to the high biodiversity of the region. In addition, the model projections imply that reintroducing fire would help maintain open pine stands in southern Appalachians similar to those thought to have occupied dry sites on Appalachian landscapes in the past (Lafon and others 2007 in press). Our findings are currently in review by the USDA Forest Service.

Overall, our research suggests that LANDIS is a useful management tool and a valuable aid in the forest restoration decision-making process. The LANDIS model we used incorporates ecological succession, natural disturbance (e.g., wildfire, windstorms, and insect outbreaks), seed dispersal, and forest management practices. It has the

1. Control (No action alternative)	
	No harvest/fire exclusion
	Fire exclusion plus current management levels of harvest
	Current SPB outbreak rate and intensity
2. The minor action alternative	
	Natural Regeneration with burning (prescribed fires)
	Use of wildfire plus thinning, common size harvestings
	Current SPB outbreak rate and intensity
3. High action alternative	
	Use of fires to restore Table Mountain pitch pine forests
	Combinations of larger harvest/thinning, planting & fires
	Current or higher SPB outbreak rate and intensity

Table 1--Using LANDIS model under different forest management and restoration scenarios

appropriate spatial scales and details needed to represent forest change over time, and therefore can be used for forest restoration efforts.

Broader Applications of Landscape Modeling for Forest Restoration

LANDIS provides a proven framework for investigating the interaction between abiotic and biotic disturbances, forest management practices, and forest structure and composition over broad landscapes (He and others 1999, Mladenoff and others 2004). Many of the forest landscape restoration and management problems are represented by the spatial and temporal scales of the LANDIS approach (ca. 1 to 1,000 km^2). As a result, the methods outlined here are best described as a multi-tiered approach where the LANDIS model integrates detailed knowledge of vegetation dynamics and provides a quantitative output amenable to the evaluation of restoration goals. In the context of forest restoration, such an approach is important because, while vegetation dynamics may operate over relatively long time scales, the costs of restoration practices are high, and the demands for effective research are often immediate.

While we can justify the large spatial and temporal scales of the LANDIS approach, it is also important to note that our approach does not preclude the use of modeling at a finer scale. In fact, the success of the LANDIS approach requires a proper understanding of the dynamics of vegetation at much smaller spatial scales for it is an overview of these relationships that are used to parameterize the broader scale model. Some of the critical parameters can be calculated by using certain finer-scale forest gap models (e.g., Linkages). Additionally, the outputs from LANDIS may require knowledge-based interpretation to make assessments of the utility of a particular management strategy.

In all cases, we find that a modeling approach provides a valuable tool for decision makers for a number of reasons: (1) The relationships between landscape function, human-made impacts and desired forest conditions are too complex to formulate and explore without quantitative modeling tools, (2) Quantitative outputs are a common requirement for decisions that involve federal agencies and multiple stakeholders, (3) Forest landscapes operate on spatial and temporal scales that prohibit in situ experiments, and (4) Modeling encourages the collection and organization of data and knowledge and the formulation of well defined restoration goals.

Moreover, our use of LANDIS suggests that these functions can be performed efficiently and procedurally. LANDIS can be parameterized effectively for many forest landscape restoration problems and in doing so researchers and forest managers gain the benefit of using a model that has been well studied, has a significant user base, and produces comparable quantitative outputs. This is especially true in the United States, where publicly available data allows models to be run on 'real' landscapes (i.e., landscapes that incorporate details of the current distribution and composition of forests), and where there is considerable data detailing the life-history of relevant species, allowing effective parameterization of broader scale interactions.

In summary, there are many advantages of the landscape modeling approach for forest restoration. Forest landscape models simulate change through time due to the interactions between succession and external drivers (e.g., disturbances or climate change) across a spatially extensive forest landscape. The models provide projections of long-term and broad-scale forest change and allow experimentation and comparisons between scenarios. They are useful tools for synthesizing data and models of smaller-scale processes. They also can be used in conjunction with restoration scenarios to examine management consequences over time.

Conclusion and Future Directions

The work presented here is part of a larger effort to investigate the utility of landscape models as a decision-making tool for pre-damage impact analysis and post-damage restoration of forest landscapes threatened by a variety of invasive pest species. Our research suggests that landscape models are a useful management tool and a valuable aid in the forest restoration decision-making process. This landscape modeling approach allows forest managers to determine the effects of changes in forest structure and tree composition on biodiversity and habitats. The result is the identification of the best strategies for restoring key forest landscapes that may be significantly impacted by multiple threat interactions.

Our goals for future research are to: (1) Test the capability of the LANDIS approach to evaluate changes in composition and structure of eastern US forests undergoing multiple interacting environmental threats and global warming in forest management decision-making, (2) Develop methods that make the parameterization of the model and the interpretation of its results more efficient and available to a wider scientific audience, and (3) Test the results of LANDIS by implementing recommendations based on the modeling scenarios in test locations and then monitoring those areas to determine the effectiveness of using the model as a management tool.

Acknowledgements

This research was supported through USDA Forest Service, Southern Research Station cooperative agreement SRS03-CA-11330129-168. We thank Ms. Audrey Bunting and Dr. Lei Wang for their assistance during the project. We thank John Nowak, Coleman Doggett, Henry McNab, James Guldin, and Eric Gustafson for their input at various stages of this project. We also are grateful to Drs. David Mladenoff, Hong He, Robert Scheller, Brian Sturtevant, Zongbo Shang, and Jian Yang for providing LANDIS and LANDIS-II programs and aiding in LANDIS use.

Literature Cited

Coulson, R. N., K. D. Klepzig, T. E. Nebeker, F. L. Oliveria, S. M. Salom, F. M. Stephen, and H. J. Meyer, editors. 2004. The research, development, and applications agenda for a Southern Pine Beetle integrated pest management program. Proceedings of a Facilitated Workshop, August 11-14, 2003, Mountain Lake, VA, USA.

Gustafson, E. J., P. A Zollner, B. R. Sturtevant, H. S. He, and D. J. Mladenoff. 2004. Influence of forest management alternatives and land type on susceptibility to fire in northern Wisconsin, USA. *Landscape Ecology* 19: 327-341.

He, H. S. and D. J. Mladenoff. 1999. Spatially explicit and stochastic simulation of forest landscape fire disturbance and succession. *Ecology* 80: 81-99.

The United States Congress. 2003. The Healthy Forests Restoration Act of 2003 (HFRA). URL http://www.healthyforests.gov/initiative/legislation.html

Lafon, C. W., J. D. Waldron, D. M. Cairns, M. D. Tchakerian, R. N. Coulson, and K. D. Klepzig. 2007. Modeling the effects of fire on the long-term dynamics and restoration of yellow pine and oak forests in the southern Appalachian Mountains. *Restoration Ecology* In press.

Mladenoff, D. J. 2004. LANDIS and forest landscape models. *Ecological Modelling* 180: 7-19.

Scheller, R. M., D. J. Mladenoff, T. R. Crow, and T. S. Sickley. 2005. Simulating the effects of fire reintroduction versus continued suppression on forest composition and landscape structure in the Boundary Waters Canoe Area, northern Minnesota (USA). *Ecosystems* 8: 396-411.

Shang, Z. B., H. S. He, T. R. Crow, and S. R. Shifley. 2004. Fuel load reductions and fire risk in Central Hardwood Forests of the United States: a spatial simulation study. *Ecological Modelling* 180: 89-102.

Shifley, S. R., F. R. Thompson III, D. R. Larsen, and W. D. Kijak. 2000. Modeling forest landscape change in the Missouri Ozarks under alternative management practices. *Computers and Electronics in Agriculture* 27: 7-24.

Stanturf, J. A. 2005. What is forest restoration? In J. A. Stanturf and P. Madsen, editors. *Restoration of Boreal and Temperate Forests.* CRC Press, Boca Raton, FL, USA, 3-11.

Sturtevant, B. R., E. J. Gustafson, W. Li, and H. S. He. 2004. Modeling biological disturbances in LANDIS: a module description and demonstration using spruce budworm. *Ecological Modelling* 80: 153-174.

USDA Forest Health Protection. 2005. Southern Pine Beetle Prevention and Restoration Program. URL http://www.stateforesters.org/positions/2002.SPB.html

Waldron, J. D., R. N. Coulson, M. D. Tchakerian, C. W. Lafon, D. M. Cairns, and K. D. Klepzig. 2005. Utilizing a landscape scale model of forest disturbance and succession for forest decision-making in the southern Appalachians. *Papers and Proceedings of the Applied Geography Conferences* 28: 160-169.

Waldron, J. D., C. W. Lafon, R. N. Coulson, D. M. Cairns, M. D. Tchakerian, A. G. Birt, and K. D. Klepzig. 2007. Simulating the impacts of Southern Pine Beetle and fire on pine dynamics on xeric southern Appalachian landscapes. *Applied Vegetation Science* 10:53-64.

Waldron, J. D., R.N. Coulson, D. M. Cairns, C. W. Lafon, M. D. Tchakerian, W. Xi, K. D. Klepzig, and A. G. Birt. 2007. Evaluating the impact of invasive species in forest landscapes: the Southern Pine Beetle and the Hemlock Woolly Adelgid. USDA Forest Service. *Encyclopedia of Forest Environmental Threats.* (In press.)

PRIORITIZING THE LOCATIONS OF FOREST RESTORATION TO IMPROVE LANDSCAPE FUNCTION USING GIS SCENARIO MODELLING: AN EXAMPLE FOR LINKAGE RESTORATION

David V. Pullar and David Lamb

Abstract—Regional conservation programmes have as a goal the integration of Protected Areas into broader ecological frameworks. Creating landscape corridors and buffers within a land mosaic by restoring forest cover is one way of supporting the functional viability of ecosystems. Implementing these programmes on the ground is problematic however, especially in areas with a mix of land uses and fragmented natural forests. In such cases it is necessary to prioritise restoration decisions to balance ecological benefits against the cost of restoration efforts. A tool has been developed whereby scenarios based upon spatial landscape designs may be used to evaluate opportunities and costs for different restoration options. The paper describes a methodology and GIS application for prioritizing restoration efforts. Using a case study for linkage restoration in a tropical region in Australia we demonstrate how our approach can assess different options for vegetation corridors using spatial indicators. The spatial indicators and their evaluation in scenarios quantify structural aspects of designs in a way that relates to the provision of landscape functions.

Ecological networks are seen as an important pillar for Econservation and sustainable use of biological diversity (WSSD 2002). An ecological network provides a link to connect and buffer an assemblage of core areas. They are particularly relevant for species that require very large habitat areas. For instance in the wet tropics of Australia, some marsupials utilise multiple parts of the landscape for foraging and mating. In the short-term, species need to move to avoid periodic natural disturbances, such as floods; and longer-term survival may require moving large distances away from a threat and recolonising more favourable habitat areas (Jorgman et al. 2004). A number of operational models for ecological networks are applied by countries; namely biosphere reserves, reserve networks, bioregional planning, biological or conservation corridors and ecoregion-based conservation. Despite the differences in terminology, these approaches share a core vision on how best to integrate the conservation of biodiversity with sustainable development (Bennett 2004).

Establishing ecological networks across broad landscapes will inevitably require lands outside the boundaries of national parks and reserves. The challenge is to gain support from local communities to: i) reverse the trends of land clearing and environmental degradation, and ii) adopt principles for sustainable land use. Enlisting the support of local people by demonstrating the benefits of conservation and sustainable development is recognised as critical (WSSD 2002). Local communities may be engaged in a number of ways; for instance by involvement in ecological network planning and projects, local associations, education and economic incentives (Bennett 2004). After the initial phase of awareness-raising, communities will want to see where, how, and what ecological benefits are possible. Feasible options are needed that match the local capacity to undertake conservation and restoration work. This paper describes methods and tools to evaluate options for choosing linkage restoration plans. Scenarios provide a useful way to explore how well options meet objectives and varying requirements. Scenarios showing alternate options are given and analysed to quantify their performance to achieve benefits. The indicators are spatially explicit and based upon principles for landscape ecology (Forman 1995).

A key aim of the paper is to explore intelligent indicators to evaluate landscape scenarios. That is, the indicators should provide an aggregate measure that relates landscape structure to landscape

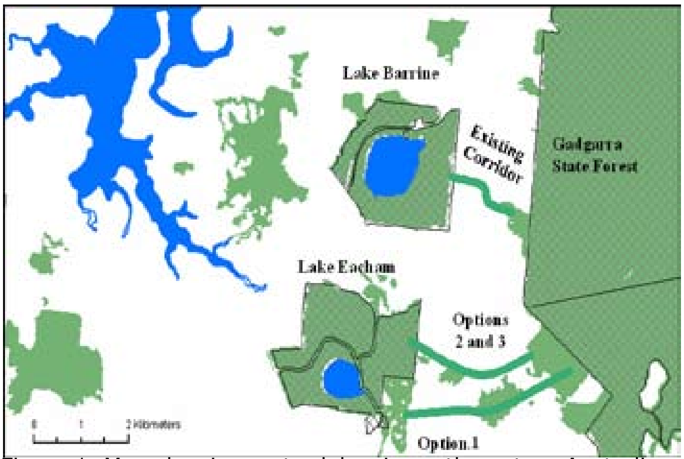


Figure 1. Map showing crater lakes in north-eastern Australia. A restoration corridor created a link between Lake Barrine and the Gadgarra State Forest in 1995. Three alternative options for a restoration linkage corridor for Lake Eacham are illustrated.

The University of Queensland, Australia 4072; d.pullar@uq.edu.au

functioning and the provision of ecosystem services. At a broad landscape scale it may be possible to quantify the provision of ecosystem services in socio-economic and monetary terms (de Groot 2006). However, for restoration planning you need to zoom into a landscape and enumerate the worth of individual site elements and establish their role in landscape functioning. The focus of this paper is to use spatial analysis to assess landscape functions within a landscape context at a site planning scale. We apply land assessment methods as indicative rules that represent the best science and practice for restoring landscape function. Our scenarios evaluate specific spatial configurations that support ecological processes and sustainable conditions (Opdam et al. 2006). Forman (1995) provides simple guidelines for sustainable planning organised around concepts of: i) landscapes and regions, ii) patches and corridors, iii) mosaics, and iv) efficient landscape patterns. Scenarios that follow these guidelines may assess the effectiveness of specific patch-corridor-matrix options. Our focus is on comparing scenarios on the basis of providing support for landscape functions (Botequilha Leitão et al. 2006). The hypothesis is that different spatial structures-configurations make a difference for management choices and for supporting landscape functions. We test this by analysing scenarios with a GIS tool for an example restoration problem.

The outline of the paper is as follows. The next section describes the study area and the indicative rules used to assess the biodiversity benefit for linkage options. A subsequent section explains how these rules are quantified in a GIS and evaluates scenarios for linkage options. The conclusion discusses results, and the use of scenario analysis using indicator rules for assessing landscape functions.

Linkage Restoration Study Area

Resilience_Cleared	Resilience_Soils	Resilience_Veg	Classification Code
Recent	Unmodified	Native_dominate	High
Recent	Unmodified	Exotic_dominate	Moderate
Recent	Modified	Native_dominate	Low
Recent	Modified	Exotic_dominate	VeryLow
Historical	Unmodified	Native_dominate	Moderate
Historical	Unmodified	Exotic_dominate	Low
Historical	Modified	Native_dominate	VeryLow
Historical	Modified	Exotic_dominate	VeryLow

Table 1. Decision classification table for the recovery capacity of degraded site.

The study area for the paper is in the wet tropics region of north-eastern Australia. The motivation for linkage restoration follows a previous project at Lake Barrine (Tucker 2000). Figure 1 shows two lakes, called crater lakes, formed from eroded volcanic craters. The areas surrounding these lakes are richly vegetated with rainforest, but are isolated within the landscape due to agriculture. They are, however, located close to a large state forest. In 1995 a restoration project was undertaken to link the northern lake, Lake Barrine, to the State Forest in the east. A 70-120 m wide and 1 km long corridor was restored along a creek to link the forests. Details of the project, issues and restoration concepts are discussed in Tucker (2000). There is another crater lake with a fragmented rainforest to the south, namely Lake Eacham. As an exercise we investigated three options for linking the Lake Eacham fragment to the main State Forest. These are explained in the next section, and the remainder of this section develops indicator rules to assess the best option.

Table 2. Nominal values of a biodiversity index depending on the type of forest, its size, age and composition .(0 low; 1.0 high)

Size of forest area	Natural forest			Planted forest			
	Undisturbed	Regrowth		Monocultures		Mixtures	
		Young	Old	Young	Old	Young	Old
Small (<10 ha)	0.4	0.2	0.4	0.0	0.1	0.1	0.3
Large (>10 ha)	1.0	0.6	0.9	0.0	0.3	0.2	0.5

A landscape ecology approach to restoration focuses on landscape structure and function. Structure describes the composition and configuration of natural elements to support landscape functions, and function encompasses broad ecological services provided by the landscape, i.e. regulation, protection and production. Modelling structure-function relationships may be applied within landscape planning at the design stage to explore scenarios for proposed changes and later monitoring to validate the assumptions (Botequilha Leitão et al. 2006). While landscape planning approaches vary somewhat between countries (Hawkens and Selman 2002), ideally some general principles emerge that are transferable

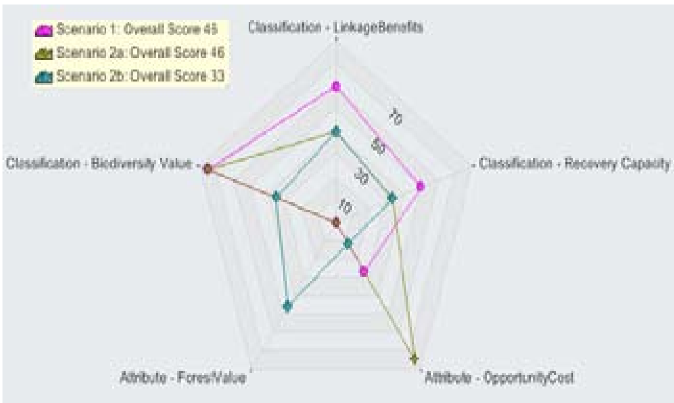


Figure 2. Result of scenario analysis displayed as radar chart for the three options using five indicator rules.

between similar landscapes. The paper identifies a number of generic rules for structure-function relationships that assess restoration objectives for alternate restoration plans in terms of: i) the capacity of degraded sites to recover without the need of external intervention, ii) the value of the restored area for biodiversity conservation, and iii) the biodiversity value of a linkage corridor. While a number of studies have identified the ecological importance of shape-configuration metrics in landscape planning (Turner et al. 2001, Bennet et al. 2006), the challenge remains to make more ecological meaningful interpretations of combinations of metrics. We develop indicative rules for each of the landscape restoration objectives identified above. While a more comprehensive review is required, the rules we identify are sufficient to distinguish between restoration choices on the basis of how well they support landscape functioning. The following three sub-sections describe several of the indicator rules.

Indicator Rule 1 - Recovery Capacity—Gibbons and Freudenberger (2006) review a number of conceptual frameworks to assess vegetation condition. They observe a common aim among the approaches is to combine data from multiple landscape attributes into a single index. The use of criteria and scoring procedures are described. We favour procedures based on decision trees as they allow a more meaningful combination of attributes. Gibbons and Freudenberger (2006) describe a decision tree to assess how well a disturbed site is expected to recover to a natural state with restoration treatment. Decision criteria on past disturbance (clearing and soils modified by cultivation) and type of vegetation are used to derive a recovery capacity. This is shown in Table 1 as a decision classification table, which is exactly the way it appears in the scenario GIS tool described in the next section.

Indicator Rule 2 – Biodiversity Value—Supporting biodiversity in landscape restoration focuses on identifying priority sites. A number of general principles apply for prioritizing restoration activities to protect resources and enhance productivity across the landscape (Lamb 2005). These principles assume a good understanding of the current landscape mosaic, including knowledge of the spatial patterns of current land uses and forest types. The principles may be assessed as part of a landscape characterisation using simple indicative rules. Table 2 illustrates a decision classification using a number of landscape criteria to create a biodiversity index; the values in the table may be changed to suit local circumstances.

Indicator Rule 3 - Specific Linkage Qualities—Tucker (2000) outlines issues relevant to the study area in north-eastern Australia, but they are broadly applicable to other tropical and subtropical areas. The issues relate to threats from disturbances and viable linkage configurations. Many of the restoration issues are related to landscape forest shape-configuration. A high edge-area ratio of a corridor increases the susceptibility of the area to weed establishment. Wildlife in thin corridors is likely to be more prone to predation than those in broad corridors. However, the disadvantages of narrow corridors with large edge-area ratios can sometimes be reduced if species with dense canopies that persist to ground level are used to "seal" the boundary. In the case of the Lake Barrine corridor this was done using *Araucaria cunninghamii.* The next section explains how these indicative rules are encoded using a decision classification table in GIS.

GIS Scenario Analysis Tool

GIS is known for data maintenance, analysis and visualisation of geographic information. We extend the functionality of a GIS with scenarios analysis. A scenario analysis tool was developed to evaluate planning options based on user defined rules, including the ability to build a user defined decision classification table. A full description of the Scenario Analysis tool is available at www.gpa.uq.edu.au/CRSSIS/tools/.

Table 1 shows the Rule 1 encoded using a decision classification table in the Scenario Analysis extension; the other rules for general forest quality (Rule 2) and specific linkage qualities (Rule 3) are similarly encoded. Additional rules are set to compute the opportunity cost for lost agriculture production (Rule 4) and affected land values for the corridor (Rule 5). The last point is relevant to the third scenario that includes improved land values from agroforestry at the corridor margins. Each of the indicator rules are generic, but are applied to the data for the three scenarios to generate different performance results. Figure 2 shows these results graphically as a star chart with the degree of satisfaction of a rule expressed as a percentage. The rules are represented by the radial axes and the scenarios as the charted lines showing the results for satisfying the rules. The best scenarios show a charted line to the outside, and the worst show a charted line shrunk to the centre. The purpose of the visualisation is to make explicit the trade-offs between the scenario options.

Conclusion

The results of scenario analysis showed that Option 1 had the highest score for the recovery capacity, general forest quality and linkage quality for a moderate loss of agricultural production. In the absence of any compensation to private land owners, the third option may be favoured despite having a sub-optimal result for restoration qualities as it had a low opportunity cost and provided the land owner with a long term benefit for land value. The indicator rules and scenario analysis make these trade-offs explicit. Whatever the outcome would be, we have demonstrated through this example that location and spatial structure influence the decisions and that indicative rules are sufficient to quantify the changes to landscape function for the restoration options. Being able to understand trade-off landscape qualities for site restoration

Literature Cited

Bennett, A.F., Radford, J.Q., Haslem, A. 2006. Properties of land mosaics: Implications for nature conservation in agricultural environments. *Biological Conservation* 133(2): 250–264.

Bennett, G. 2004. *Integrating Biodiversity Conservation and Sustainable Use: Lessons Learned From Ecological Networks.* Cambridge: IUCN. 66p.

Botequilha Leitão, A., Miller, J., Ahern, J., McGarigal, K. 2006. *Measuring Landscapes: A Planner's Handbook.* Washington: Island Press. 245p.

de Groot, R. 2006. Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning* 75(3-4): 175-186.

Forman, R.T. 1995. Some general principles of landscape and regional ecology. *Landscape Ecology* 10(3): 133-142.

Gibbons, P., Freudenberger, D. 2006. An overview of methods used to assess vegetation condition at the scale of the site. *Ecological Management and Restoration* 7(1): 10-17.

Hawkins, V., Selman, P. 2002. Landscape scale planning: exploring alternative land use scenarios. *Landscape and Urban Planning* 60(4): 211-224.

Lamb, D. 2005. Scenario modelling to optimize outcomes. In: *Restoring Forest Landscapes*. International Tropical Timber Organization Technical Series No 23: 117-124.

Jongman, R., Külvik, M., Kristiansen, I. 2004. European ecological networks and greenways. *Landscape and Urban Planning* 68: 305–319.

Opdam, P., Steingröver, E., van Rooij, S. 2006. Ecological networks: A spatial concept for multi-actor planning of sustainable landscapes. *Landscape and Urban Planning* 75: 322–332.

Turner, M.G., Gardner R.H., O'Neill, R.V. 2001. *Landscape Ecology in Theory and Practice: Pattern and Process.* New York: Springer. 401p.

WSSD 2002. Report of the World Summit on Sustainable Development Johannesburg, South Africa, August, 2002, New York: United Nations.

THE COMMUNITY-BASED FOREST MANAGEMENT PROGRAM AS A STRATEGY FOR FOREST LANDSCAPE RESTORATION IN THE PHILIPPINES

Romulo T. Aggangan[1], Faustina C. Baradas[1] and Nelly S. Aggangan[2]

Summary—In 1995, through Executive Order number 263, the Community-Based Forest Management (CBFM) program was the strategy adopted by the Philippine government to ensure the sustainable development of forest resources while promoting people empowerment and social justice. The underlying principles of CBFM are social equity, sustainability, and the involvement of communities in forest management and biodiversity conservation. The CBFM aims to improve the well-being of forest-dependent communities, both indigenous and migrant groups, and to ensure the sustainable management, rehabilitation, and protection of the country's forestlands and forest resources. As an integrated approach, CBFM offers a better alternative where corporate path have led to forest depletion and socio-economic deprivation of upland communities. As of 2004, there were 5,503 CBFM projects. These covered an area of 5.97 million ha, however, only 4.904 million ha (82.16%) were covered by a specific tenure instrument called Community-Based Forest Management Agreement (CBFMA). A total of 2,877 People's Organizations (POs) were involved in these projects, while 690,691 households benefited from it. Recent policy research revealed that CBFM makes a positive contribution to the biophysical conditions of the sites and general improvement of the socio-economic well-being of the program participants. Moreover, the program enhances understanding by the people about the dynamics of environmental degradation, wise use of scarce natural resources, and forest conservation practices. Also, the experience and lessons learned from various CBFM sites show that more and more stakeholders are coming out in the open and expressing willingness to support the program. Local government units are becoming active partners in the program while non-governmental organizations and legislators are also responding to the expressed needs of the people. The private sectors are enthusiastic in the provision of livelihood opportunities to the upland communities. This paper also addresses some key issues and concerns as well as provides some recommendations for its successful and sustained implementation.

[1]Forestry and Environment Research Division, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), 4030 Los Baños, Laguna, Philippines. E-mail: r.aggangan@pcarrd.dost.gov.ph or raggangan@yahoo.com.
[2]Mycorrhiza Laboratory, National Institute for Molecular Biology and Biotechnology (BIOTECH), University of the Philippines Los Baños, 4031 College, Laguna, Philippines.

FUTURE FOREST LANDSCAPES: WILDING & SUSTAINABILITY

Ian Convery, Tom Dutson & Kevin Scott

Abstract—This paper describes a wilding project in Ennerdale, a valley in the Lake District National Park in the northwest England. The Forestry Commission is a major landowner and partner in the Wild Ennerdale initiative and the valley has been managed as plantation forest since the 1930s. The vision of Wild Ennerdale is 'to allow the evolution of Ennerdale as a wild valley for the benefit of people, relying more on natural processes to shape its landscape and ecology'. The vision is qualified with an assertion that the valley will sustain the livelihoods of local people in keeping and enhancing the valley's special qualities and that a broader section of local people will have a greater sense of involvement in its future. This action research study aims to contribute to the achievement of the vision.

Ennerdale valley has a long history of management; some members of the farming community have ties to the land spanning several generations. In contrast, the extensive conifer plantations are relatively recent, yet form the starting point for the Wild Ennerdale initiative. This study highlights the need for a more integrated, holistic approach to landscape management. The data reveal a wide and interrelated set of themes and issues that interweave wilding with issues of cultural landscape, social capital and farming/landscape lineages.

The study has highlighted the importance of social capital in remote upland rural locations, in particular the importance of social networks, both formal and informal. The research also emphasises the need for stronger links between the Wild Ennerdale and the Ennerdale community. In particular, there needs to be much greater appreciation of the role the rural community have played, and continue to play, in shaping the landscape of Ennerdale. Recognition of this role is important in terms of delivering a sustainable future for the valley.

National School of Forestry, University of Central Lancashire, Penrith, CA10 0AH, e-mail: iconvery@uclan.ac.uk;

RESTORATION OF DECIDUOUS FOREST IN SÖDERÅSEN NATIONAL PARK, SWEDEN

Oddvar Fiskesjö

Abstract—Founded partly due to its valuable broadleaved forest, Söderåsen National Park also contained semi-naturally dispersed and plantations of Norway spruce (*Picea abies*) and large areas of old clearcuts where spruce had been invaded by grasses or silver birch (*Betula pendula*). In order to preserve and enlarge the deciduous forest, especially the broadleaves, the County Administrative Board in Skåne has between 2002 and 2006 run a forest restoration project comprising more than 1000 ha. Spruce forests were thinned, and shall be successively phased-out while used as shelterwoods for regeneration of deciduous trees. Young spruce stands and dispersed spruce were felled. More than 500 000 broadleaved trees have been planted, mostly pedunculate oak (*Quercus robur*) and beech (*Fagus sylvatica*). Grass-dominated areas were scarified to enhance plant survival. Unique experiments with machine sowing of beechnuts were performed. All regeneration areas were fenced to prevent game browsing. Monitoring showed a plant survival rate of more 80% and good plant growth in most areas.

No environment in Sweden is so diverse and accommodates so many endangered species as the southern Swedish deciduous forest, in particular the species-rich broadleaved forest with beech *Fagus sylvatica*, pedunculate oak *Quercus robur* and sessile oak *Q. petraea*, Wych elm *Ulmus glabra*, hornbeam *Carpinus betulus*, European ash *Fraxinus excelsior*, small-leaved lime *Tilia cordata*, Norway maple *Acer platanoides* and wild cherry *Prunus avium*. Large areas of broadleaved forest in Sweden have been replaced by Norway spruce *Picea abies* and other tree-species foreign to this region. The larger part is managed leaving roughly only 5% that is protected and can develop naturally. Consequently, naturally developing broadleaved forest with a large proportion of dead trees is nowadays in very short supply. It is therefore essential to protect the mature deciduous forest that remains and increase the area of semi-natural deciduous forest habitats.

Söderåsen National Park in southern Sweden was founded in 2001 and is, with its 1625 ha, one of the largest continuous areas of broadleaved forest and other deciduous forest in northern Europe. However, when the national park was founded, large areas consisted of stands with spruce, and former spruce areas that were clearcut housing dense populations of wavy hair grass *Deschampsia flexuosa* or silver birch *Betula pendula*. These areas have, partly due to the surrounding deciduous forest, the conditions to develop into a deciduous forest habitat. The protection and management of as large an area as possible means that those habitats favoured by the free development of broadleaved forest and related species will have a better chance of surviving and developing in the future.

The County Administrative Board of Skåne, Sweden initiated a project the 1st June 2002, in order to start the conversion of spruce forests and clearcut areas to deciduous forest, especially broadleaved. The project, comprising 1070 ha, is one of the largest nature conservation projects in

Figure 1. The Norway spruce will be successively phased-out in order to prevent it from dominating the next tree-generation.

Sweden and had a budget of more than 1.7 million euro (approx 2.35 million USD). It was financed by the EC environmental fund LIFE-Nature, Swedish Environmental Protection Agency and the County Administrative Board in Skåne, and ended the 31st December 2006.

Phasing Out Foreign Tree Species

Norway Spruce Phase-Out—Older, homogenous stands comprising about 76 ha were thinned during the project. These stands will be successively phased out over 15 years through the gradual process of more thinning and cutting off forest edges, gaps and corridors. In 45 ha, mostly young spruce was felled where remaining deciduous trees, mostly birch, form the new stand. The

National park manager, County Administration Board of Skåne, Söderåsen National Park, Ljungbyhed, Sweden;oddvar.fiskesjo@m.lst.se

intention is that remaining deciduous trees and spruce, during the extensive cutting period, should act as shelterwood for naturally regenerated and planted deciduous trees. More widely scattered spruce that had spread into the deciduous forest were manually cut and left to decay in more than 700 ha. This action also promotes the long-term survival of other forest habitats and tree-species than broadleaved, including swamp woods with alder *Alnus glutinosa*.

Most of the spruce has been cut with average-sized machinery, but we also have used horses for extracting wood and a small eight-wheeled tool carrier to crosscut and trim trees. From an environmental point of view, there are special cases where extracting with horses is superior and consequently are economically defendable, but the capacity is very low. The tool carrier showed to be very useful in sensitive areas and in areas with ancient remains mainly because of its low ground impact and good maneuverability.

Other Foreign Tree-species Phase-out—Many small areas were planted with sycamore maple *Acer pseudoplatanus*, northern red oak *Quercus rubra*, European larch *Larix decidua*, yew *Thuja occidentalis*, Douglas-fir *Pseudotsuga menziesii* and others. Except for cutting most of these stands, experiments were carried out with other controlling methods, especially when treating sycamore, such as ring-barking of trees, salting stumps, and cutting high stumps.

Figure 2. The eight-wheeled tool carrier was rebuilt as an innovative forest land sowing machine.


Figure 3. The game fences have denser mesh near the ground to stop hares, and a stripe above to prevent animals from jumping over.

Establishment of New Broad-Leaved Forest

Soil Scarification—The clearcut areas that were dominated by wavy hair grass were soil scarified to accomodate planting or sowing of broadleaves. In 14 ha, old-breed pigs were roaming, and in 66 ha we used the tool carrier, that can carry both tree-cutting and scarification devices. The experiment with the pigs was interesting but the effect on the dry and hard clearcuts was uncertain. Pigs are probably more efficient on better soils under a shelter wood of older deciduous trees. The tool carrier was a good and environmental friendly alternative to larger machinery.

Planting—More than 512 000 broadleaves have been planted in 230 ha. The dominant species are pedunculate oak (290 000), beech (170 000), hornbeam (25 500) and Norway maple (17 000), but also smaller amounts of sessile oak, ash, wild cherry and small-leaved lime have been planted. The plants seeds were harvested in and around the national park. Aiming at mixed future forests, beech was planted in shelterwoods and oak in more open areas. Competing vegetation such as grass, herbs and birch is regularly cleared in order to enhance plant survival. The goal is that at least 500 trees/ha shall survive and in 8-10 years grow higher than game browsing height, about 3 m.

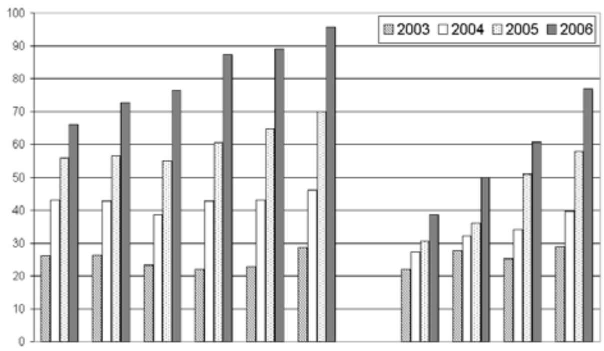


Figure 4. Average height in cm of plants in ten planted areas 2003-2006; six areas with oak (left) and four with beech (right).

Sowing—A unique experiment with machine sowing of beechnuts in forest land was performed for the first time in Sweden. A new sowing machine prototype, built on the tool carrier scarification device, was developed by a subcontractor and has been functioning well. About 100 000 beechnuts were sown per ha in about 14 ha. Many of the sowed plants show surprisingly good growth.

Game Fencing—Hunting is not permitted in the national park. In order to protect new plants from growing populations of browsing animals as moose *Alces alces*, fallow deer *Dama dama*, roe deer *Capreolus capreolus* and hare *Lepus europaeus,* almost all plantations and sowings were fenced with more than 50 km of 2-m-high fence, which should stand for about 10 years. The fence was made from as environmentally friendly material as possible, and several gates were mounted in each fence to allow hikers to pass. Supervision and repair is carried out continuously. When game sometimes gets inside, primarily they are driven out. Some problems have arisen with wild boar *Sus scrofa*, not because they damage plants, but they do rather great harm to the fences.

Monitoring

Monitoring was performed by scientists from a forest research centre. In different action areas, 12 transect lines were established. Along these lines, circular inventory plots were established, in which plant survival and height was examined as well as forest habitat regeneration. Planted trees that have been measured are oak, beech and hornbeam. Natural tree regeneration was also noted. The aim is that monitoring should continue until plants are established and have reached proper height. The results show a survival rate of 75% in a few areas but over 90 % in most areas. Especially oak and hornbeam have established beyond expectations; mean height of oak and beech in 2003-2006 in eight plantations on clearcuts is shown in Figure 4. We also carried out an over-all follow-up by photographing all areas before and after measures were undertaken.

Information and Experience Exchange

In contrast to our expectations, the external interest for the project has been very great with many visiting groups. The DVD-film "From needles to leaves – LIFE-project in Söderåsen national park," which can be ordered, summarizes the project. By experience exchanges in Sweden and abroad we have shared knowledge about conversion of conifer forests. A booklet about the project was published. The project website can be visited at www.nationalpark-soderasen.lst.se/life/eindex.html

STRATEGIES FOR SUCCESSFUL ECOLOGICAL RESTORATION OF DEGRADED FOREST ECOSYSTEM IN MONGOLIA

Yeong Dae Park [1], Don Koo Lee [2], J. Tsogtbaatar [3], John A. Stanturf [1],
Nyam-Osor Batkhuu [2], Dongkyun Park [4]

Abstract—Mongolia is a country with serious forest degradation problems. Although numerous restoration activities have been conducted in Mongolia, they have shown mostly poor results due to natural reasons such as the harsh climate but also from a lack of understanding of ecological and physiological characteristics of the country. This research aimed to suggest strategies to promote successful ecological restoration in Mongolia based on improved understanding of ecological conditions.

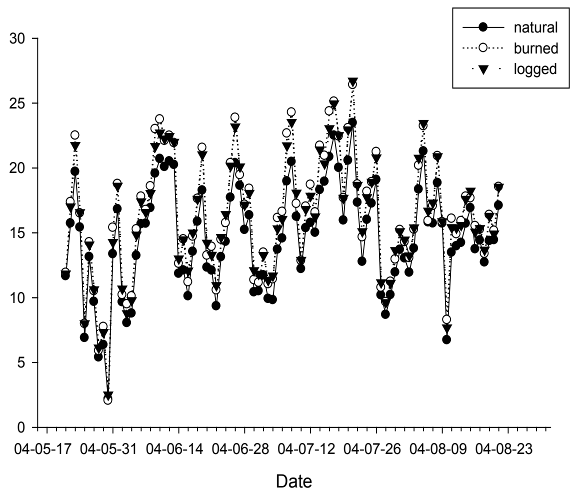
Forests in Mongolia have been severely degraded by forest fire, illegal logging, and inadequate management. During the last decade, Mongolia has lost approximately four million ha of forests, averaging 40,000 ha annually, but between 1990 and 2000 the rate of deforestation increased to 60,000 ha per year. One result of this ongoing loss and degradation has been the negative affect on the environment of neighboring countries such as Korea, as well as the environment of Mongolia.

Rehabilitation activity in Mongolia started in 1971. Although positive results were shown in response to these activities, rehabilitated areas have been reduced due to harsh climate conditions (low precipitation and relatively long winters), inefficient working system (increased cost of products and use of outdated equipment/facilities, etc.), lack of professional experts in the field and no silvicultural treatments and monitoring after rehabilitation. Consequently, the total area that has been successfully replanted represents only 5% of the total forest lost, mostly due to low survival rates of the planted seedlings. Restoration activities encounter numerous challenges and soil moisture is one of the most limiting environmental factors for tree survival and growth in Mongolia. Therefore, a thorough understanding of ecological and physiological aspects is critical to successful conduct of ecological restoration in Mongolia. Such understanding, supported by science, will assist decision making for utilization of specific techniques such as natural regeneration, artificial plantation, and appropriate silvicultural treatments to promote the success of ecological restoration in Mongolia.

The objectives of this research were 1) to investigate the ecological changes in vegetation and soil properties after forest degradation by fire or logging, 2) to identify drought-resistant species to utilize for rehabilitation of degraded forests, and 3) to suggest the strategies to promote success of ecological restoration in Mongolia based on understanding of ecological and physiological characteristics.

Materials and Methods

The field study was conducted in the southern area of Khenti in Mongolia. This area lies between the southern fringe of the Siberian boreal forest (taiga) and Mid-Asia Steppe zone. Therefore, this area is very sensitive and vulnerable to external disturbances such as forest fire and logging. A total of 17 study sites were selected



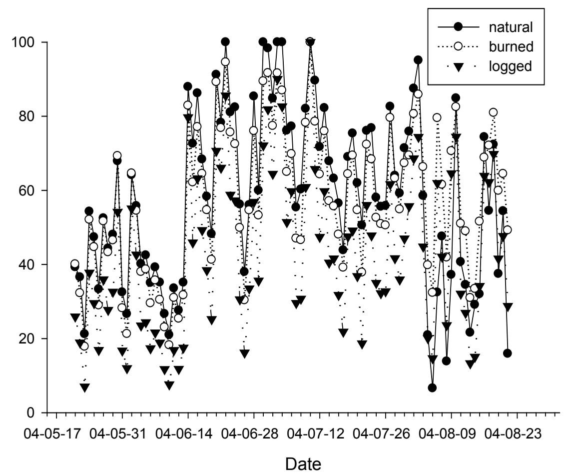


Figure 1. Daily mean temperature and relative humidity (RH) at study sites

[1] Center for Forest Disturbance Science, USDA Forest Service, 320 Green Street, Athens, GA 30602, U.S.A.; email-parkyd70@gmail.com
[2] Dept. of Forest Sciences, Seoul National University, Seoul 151-921, Republic of Korea
[3] Institute of Geoecology, Mongolian; Academy of Sciences, Ulaanbaatar 211238, Mongolia
[4] Korea Forest Research Institute, Seoul 130-712, Republic of Korea

with different degradation factors and land use history. In each site, three 30m by 30m square plots were randomly established to investigate the composition of overstory species. In each main sample plot, three 5m by 5m square subplots were inset to investigate natural regeneration and five 2m by 2m square subplots were included to investigate the composition of understory vegetation. Importance value, species diversity, and similarity of all identified vegetation were calculated to examine the changes in vegetation after forest fire or logging. In each study plot, soil samples were collected using a soil auger at three soil depths: the forest floor (O) and mineral horizons (A and B), with four replications each. All samples were air-dried after collection and physical and chemical properties analyzed. This study used five native species comprised of two conifers, one hardwood, and two shrubs of two-year-old seedlings growing in a field nursery to identify drought-resistance, and also used four local populations of *Larix sibirica* from contrasting habitats in Mongolia to investigate the population variation in drought-resistance.

Results and Discussion

Changes In Vegetation Composition After Forest Fire Or Logging—Development of the *Larix sibirica* stand mainly progressed into four stages after fire or logging: 1) secondary larch stand, 2) hardwood stand mainly composed of birch and willow species, 3) bush stand, and 4) grassland (steppe). Stand development strongly depended on the intensity of degradation and the potential for natural regeneration. The intensity of degradation in secondary larch and hardwood forests was slight and these forests progressed easily into a natural restoration stage. However, bush stand and steppe were affected by heavy degradation intensity and progressed only slowly into, or did not reach, the natural restoration stage. Thus, artificial rehabilitation may be more suitable than natural restoration in the environmental conditions of these sites in Mongolia. Microclimate variables such as temperature and relative humidity (RH) sharply changed after forest fire or logging. Temperature increased by an average of 1.6-1.7°C, but RH decreased up to 15.7% after logging (Figure 1). It was mainly affected to changes in the composition of understory vegetation. Species composition of the taiga community in the natural stand decreased from 30.6% to 11.4% after fire and disappeared after logging. However, that of forest meadow and steppe communities increased. This suggests that the taiga community was very sensitive to anthropogenic disturbances and a very important factor for evaluation for the status of degradation or restoration in Mongolia.

Changes In Soil Properties After Forest Fire Or Logging—Soil moisture significantly decreased after forest fire or logging, and the extent of decrease was more severe in the logged stand. These results indicate that changes in physical soil properties such as water content and bulk density were more affected by logging than forest fire. Reduced infiltration rates led to increased overland flow and accelerated soil erosion. The chemical properties of the soil organic layer were significantly affected by forest fire or logging but the mineral soil horizons were unaffected. Forest fire stimulated the increase of pH while organic matter (OM) content significantly decreased. This was caused by ash deposition on the soil surface and nutrient losses through leaching. Logging stimulated the decrease of inorganic N (NH_4^+-N, NO_3^--N). Inorganic nitrogen of the forest floor (O horizon) significantly decreased in the logged stand compared to that of the natural and burned stands. This indicated that logging activity more negatively changed species composition and soil properties than did forest fire.

Selection for Drought-Resistant Species—Native Mongolian species showed various responses and strategies for drought conditions. *Ulmus pumila* showed superior morphological response such as more biomass and nitrogen accumulation in roots compared to above ground. *L. sibirica* and *Pinus sylvestris* showed a higher physiological response such as lower transpiration rates relative to photosynthesis. Shrubs such as *Caragana arborescene* and *Hippophae rhamnoides* exhibited higher carbon isotope composition (δ13C) which is used as a tool for estimating genetic potential for drought resistance. The carbon isotope composition varied significantly ($p=0.04$) among four different seed sources of *L. sibirica*. Seedlings with seed sources originating under low precipitation conditions showed higher δ13C than those with seed sources from high precipitation. Population variation in carbon isotope composition was negatively correlated with precipitation ($r = 0.82$). This suggests that population variation should be considered when deciding where to establish a seed orchard or field nursery to produce drought-resistant seedlings.

Conclusions

Bush stand and steppe, which were affected by heavy degradation, progressed slowly into or did not reach the natural restoration condition for a long time. Thus, artificial plantations are urgently needed in these sites.

Forest fire and logging are major reasons for forest degradation in Mongolia. This research showed that logging activity more negatively affected vegetation and soil properties. Thus, restoration of forests degraded by logging should have a higher priority for restoration than forests degraded by forest fire.

Seedlings from seed sources originating under low precipitation conditions showed higher carbon isotope composition than those from seed sources originating under high precipitation. This suggests that population variation should be considered in producing drought-resistant seedlings.

Acknowledgements
This research is a part of research project entitled "Cooperative Research for Restoration of Degraded Ecosystems in Northeast Asian Regions" which is supported by funding from the Korea Science and Engineering Foundation (KOSEF).

RESTORING A MIXED SPECIES FOREST LANDSCAPE ON PRIVATELY OWNED LAND UNDER HEAVY DEER BROWSE PRESSURE

Palle Madsen[1], Rita M. Buttenschøn[1], Torben L. Madsen[2], Carsten R. Olesen[3]

Abstract—The restoration challenge is very much a regeneration challenge in Denmark. We carry out research and development to find new and highly needed low-cost artificial regeneration methods that will allow forest practise to establish densely stocked regeneration of desired tree species under even a heavy deer browsing regime. Particularly we address the need to artificially regenerate broadleaves at cleared sites following clear-cut or storm-felled Norway spruce (*Picea abies*) to improve future forest stability and resilience. Deer fences are expensive to establish, maintain and remove, and not popular for many reasons. Deer and the related hunting interests are today very important sources of income and forest value, particularly for private forest owners. This paper will present results on regeneration success of direct-seeded deer-browse-tolerant regeneration established over a five-year period.

Changes in the Forestry Paradigm—Forest management in Denmark is coming out of a 200-year-old forestry tradition developed to prevent shortage in wood supplies. A movement of nature-based forestry has emerged during the last 15 years (Hahn and others 2005) and the Danish national forest service has recently initiated implementation of this forest management approach (Danish Forest and Nature Agency 2003). This shift in forestry paradigm – from "traditional forestry" to nature-based forestry – represents a shift from a largely timber-production-oriented approach to a more multi-functional oriented approach, and is closely related to the ecosystem management paradigm (Puettmann and Ammer 2007). The needs have considerably increased on both privately and publicly owned land to address multiple services, aims, or functions by the forest landscape management. Such aims may include (1) improved wildlife habitat and hunting interests, (2) improved landscape aesthetics and recreational values including ownership pleasure and increased property value, (3) biodiversity and environmental protection, and (4) ground water protection. Timber production is still an important forestry aim and means to create income, but recent decreases in timber prices have caused considerable reductions in economical revenues and as such in staff and willingness to invest in forest regeneration unless supported by government subsidies.

Additionally, frequent gales and events of spruce decline have negatively influenced forestry revenues and fulfilment of forestry aims. Conifers and Norway spruce (*Picea abies*) in particular are prone to wind damage and poor health. Therefore, there is a great need and desire to substantially expand the proportion of broadleaves and more stable conifers on the expense of Norway spruce which now is the dominating species in Danish forestry.

Privately Owned Fores—About two-thirds of the Danish forestland is privately owned. Private owners may have very different expectations for the outputs of their ownership but they generally tend to emphasize aims like improved wildlife habitat and hunting, personal recreational values (pleasure of ownership), landscape or property aesthetics, and increased property value supported by the previous mentioned aims. As a result, private forestland prices have continuously increased in spite of reduced timber prices.

Forest Restoration and Regeneration—In Denmark the nature-based forestry concept is very wide known but it is just newly introduced on most of the forestland where it is applied today (Hahn and others 2005). This concept largely includes most of the well-known silviculture strategies except for strictly plantation forestry. Emphasis is on increased forest stability, resilience and tolerance to a future changed, but unknown climatic conditions achieved by a better species match to site and by favouring more unevenage and mixed-species stand structures. In other words there is now an ongoing large-scale effort on forest restoration. It involves to a large extent artificial regeneration (planting or direct seeding) because the desired species are not sufficiently present at a large proportion of the regeneration sites. Additionally, Denmark is running an afforestation program to double the forestland within approximately 100 years (Madsen and others 2005). This program also involves considerable investments in artificial regeneration.

[1] Forest & Landscape Denmark, Copenhagen University, Vejle, Denmark; pam@life.ku.dk
[2] St. Hjøllund Plantage A/S, Bryrup, Denmark
[3] National Environmental Research Institute, Århus University, Rønde, Denmark

Native species, which are almost exclusively broadleaves, have greatly gained popularity, but site-adapted non-native species are welcome, too, as long as they are reasonable stable, produce desired products and can naturally regenerate. Among the conifers this includes several North-American species such as Douglas-fir (*Pseudotsuga menziesii*), Western red cedar (*Thuja plicata*) and to some extent Sitka spruce (*Picea sitchensis*) as well as Japanese larch (*Larix kaempferi*) and one of our very few native conifer species: Scots pine (*Pinus sylvestris*). The native broadleaves include for example beech (*Fagus sylvatica*), oaks (*Quercus robur* and *Quercus petrea*), ash (*Fraxinus excelsior*), wild cherry (*Prunus avium*), small-leaved lime (*Tilia cordata*), and birches (*Betula pubescences* and *Betula pendula*). Under discussion is whether sycamore maple (*Acer pseudoplatanus*) is among our native species or not, but it is certainly a common and often desired species that regenerates naturally at many sites.

Increased Deer Populations—Denmark has experienced a five-fold increase since 1940 in the roe deer (*Capreolus capreolus*) population (Olesen et al. 2002). The estimated roe deer population is 350,000 and the total Danish land area is 43,000 km^2. However, 18 % is considered urban areas and 60 % is farmland. Only 12 % is forestland and as the main roe deer habitat is in forests or at the edges between farmland and forest roe deer population densities are typically considered to be 20-35 deer per 100 ha of roe deer habitat. Our other native deer species, red deer (*Cervus elaphus*), is also increasing its 10-12,000 animal population at present. The red deer distribution is much more restricted to certain regions in Denmark, particularly the western and less densely populated part of the country (Jutland) (Asferg and Olesen 2004). The annual harvest of the two native deer species is approximately 100,000 and 2,800 for roe deer and red deer, respectively. The two introduced deer species, fallow deer (*Dama dama*) and Sika deer (*Cervus nippon nippon*), have a more scattered distribution and the annual harvest is 3,500 and 500 deer, respectively.

Many Deer – a Problem or the Goal?—Negative effects of the overabundance of deer are well known in many countries. These effects may include diseases, traffic collisions, reduced biodiversity, and damaged farm crops. In the silvicultural context regeneration failure and reduced forest floral diversity are among the most common (e.g. Ellenberg 1988, Horsley and others 2003, Roony 2001). Likewise, Danish silviculturists are often unhappy about deer and certainly not when the deer become more abundant at times when restoring more stable, resilient and natural forest ecosystems by increasing the broadleaves is expected to take place. The broadleaves are generally much more prone to deer browse than conifers, particularly when planted in forests or plantations dominated by conifers.

Conversely some literature suggests that deer may not be an exclusively destructive factor and that there may not be a simple relationship between roe deer density and the impact on forest regeneration and ground flora (Gill 1992). Reimoser and Gossow (1996) described how forest structure (e.g. stand structure, stand edges) and forest distribution and pattern on the landscape may influence the amount of game damage to vegetation. Other studies suggest that varying herbivory pressure in space and time, providing alternative food supplies, hiding cover, and improved regeneration density may support ways to multi-functionality including relatively dense deer populations, plant diversity, and forest restoration for more sustainable timber production (e.g. Harmer 2001, Hester 2000). Such experience creates optimism for the development of compatible approaches to forest and wildlife management, particularly if underlying causal mechanisms can be determined.

Deer are, however, often greatly appreciated by forest owners, hunters, and people seeking recreation in the woods. In fact many forest owners these days get more income and pleasure out of the deer than out of the timber production. As a result a reduced deer population scenario is unrealistic in most places in Denmark.

Why is Traditional Planting Problematic?—Traditional plantings of broadleaves largely depend on protection by deer fences. Beech is probably the species that most often can successfully establish without being fenced as it is not a highly preferred browse species except in the very early stages of plant development. Individual protection of single trees is not common, since the stock densities are usually 2-5,000 seedlings ha^{-1} depending on species, site, subsidy requirements, and management aim. Individual tree protection is mainly used for landscape, park or roadside plantings. Moreover, government subsidies are decreasing, and lower stock densities may become the simple and short-sighted forest management response, with possible negative effects on the future timber production.

Deer-browse Tolerant Regeneration—Both the literature and practical experience show that densely stocked regeneration is more robust against deer browse than sparsely stocked regeneration (Riemoser and Gossow 1996). Species that are highly preferred by the deer such as silver fir (*Abies alba*), oaks, and rowan (*Sorbus aucuparia*) have a better chance to avoid browsing if growing in dense clusters than as single trees.

Such knowledge fuelled our ideas for the present development project and we concluded that the deer-browse-tolerant regeneration should include dense stocking. Additionally, we hypothesized that including fast growing nurse (pioneer) species preferred by the deer would improve the protection of our main species against not only deer but also late spring frost and perhaps grass competition.

Development—The approach we seek is development of new regeneration methods and management approaches that include the wildlife (deer) – forestry interface. If this fails deer may very well keep the restoration from happening unless the government is willing to continuously and considerably subsidise the process. Our general idea and approach for the development process is that the solution is to be found within the interface of forest, landscape and wildlife management including:

- development of inexpensive deer-browse-tolerant regeneration methods
- increased food supply for the deer within the forests by the deer-browse-tolerant regeneration and by various types of fodder fields
- increased food supply and improved food quality for the deer by livestock grazing pastures and part of the forest edge, and by offering sugar beets for the deer (6 tons at one feeding station per winter)
- creation of forest structures to improve both cover and food for the deer at a larger proportion of the forest area than in forests managed with even-aged stands and clear felling
- improved deer management to reduce deer stress and thereby improve hunting efficiency to better control or keep the deer populations at certain levels.

This paper deals with more specific hypotheses on the inexpensive and deer-browse tolerant regeneration methods:

1. Direct seeding of deer-browse-tolerant regeneration can at sites with high deer-browse-pressure provide well-stocked (> 4,000 ha^{-1}) after two growing seasons of main species (beech, oak, sycamore maple, Douglas-fir and Japanese larch) without protection by deer fence.
2. Direct-seeded deer-browse-tolerant regeneration including directly seeded nurse species provides significantly higher stock densities of the main species after two growing seasons. Nurse species are: Scotch broom (*Cytisus scoparius*), rowan, and silver birch (*Betula pendula*).

We want to stress that our intention is not to keep the deer out of the regeneration. Because it is an important aim for many owners and much forest management to support deer populations, we want to keep as much of the forest area accessible for the deer as possible and if the regeneration can support the carrying capacity for deer it is even better. Additionally, we do not regard browsing as a severe problem for the regeneration as a long as it does not kill the regeneration or keeps the regeneration from growing.

Materials and Methods

Materials and methods will be only briefly described here:

- The main species are beech, oak, sycamore maple, Douglas-fir, Japanese Larch.
- The nurse species are birch, rowan, and Scottish broom.
- Each year (2002-2006) half of the regeneration plots included nurse species and the other half were without to test the nurse species effects.
- Over a five-year-period starting in 2002 we established annually 8 ha of experimental regeneration at distributed at 8 sites each year. In 2005 we had to limit the area to only one site due to lack of tree seed on the market. We have established about 32 ha experimental regeneration in total.
- The host district (Store Hjøllund Plantage A/S) is a privately owned 1,400 ha almost exclusively conifer plantation (98% conifers, 71% Norway spruce) including an additional 300 ha of grassland, heathland and firelines.
- The host district is located on sandy soil types ranging from poor to moderately fertile in the central part of Jutland. The best soil types are located in a rolling landscape, which formed the glacier lines during the last ice age. The poorest soil types are found on what are flat outwash plains that were never covered by ice during the last ice age. Late spring frost is a big problem for regeneration on the flat terrain.
- We sow in May in mineral soil scarified rows (approximately 0.8 m wide) and 2 m between rows at various soil types and on clear-cuts as well as under light shelter woods or in stand edges. The area of the single regeneration planting ranges between 0.5 to 2 ha.
- The sowing density is 60,000 and 1,300,000 seeds ha^{-1} of the main and the nurse species, respectively.
- The regeneration cost for the deer-browse-tolerant regeneration is 2,000 US\$ ha^{-1}.

Radio Collared Deer—In February-April 2006 the first four red deer and three roe deer were radio collared. We use the Lotek Wildcell collars (GPS/GSM) to control the dataloggers on the collar and to download data. The collars drop off within a year. The aim is to document the deer preferences for the various forest and landscape structures. In the context of forest and landscape management we analyze and document for example the deer preferences for the

- deer-browse-tolerant regeneration compared to other open sites in the forest
- live-stock grazed versus non-grazed grassland and impact on deer of live-stock presence
- fodder-fields and feeding stations.

Results and Discussion

To be presented at the conference.

Litterature Cited

Asferg, T., Olesen, C.R. 2004. Danmarks hjortevildt. Naturhistorisk Museum. *Natur og Museum* 43(4): 3-35.

Danish Forest and Nature Agency 2003. The Danish National Forest Programme in an International Perspective. Ministry of the Environment, Danish Forest and Nature Agency, Haraldsgade 23, DK-2100 Copenhagen Ø. http://www.sns.dk.internat/dnf-eng.pdf.

Ellenberg, H.. 1988. Eutrophierung – Veränderungen der Waldvegetation – Folgen für den Reh-Wildverbiss und desssem Rückwirkungen auf die Vegetation. *Schweizerische Zeithschrift für Forstwesen* 139: 261-282.

Gill, R.M.A. 1992. A review of damage by mammals in north temperate forests: 1. Deer. *Forestry*: 65: 145-169.

Hahn, K., Emborg, J., Larsen, J.B., Madsen, P. 2005. Forest rehabilitation in Denmark using nature-based forestry. In: Stanturf, J.; Madsen, P. (eds.), *Restoration of Boreal and Temperate Forests.* CRC Press, Boca Raton, Florida; 299-317.

Harmer, R. 2001. The effect of plant competition and simulated summer browsing by deer on tree regeneration. *Journal of Applied Ecology* 38: 1094-1103.

Hester, A.J., Edenius, L., Buttenschøn, R.M., Kuiters, A.T. 2000. Interactions between forests and herbivores: the role of controlled grazing experiments. *Forestry* 73: 381-391.

Horsley, S.B., Stout, S.L., DeCalesta, D.S. 2003. White-tailed deer impact on the vegetation dynamics of a northern hardwood forest. *Ecological Applications* 13: 98-118.

Madsen, P., Jensen, F.A., Fodgaard, S. 2005. Afforestation in Denmark. In: Stanturf, J.; Madsen, P. (eds.), *Restoration of Boreal and Temperate Forests.* CRC Press, Boca Raton, Florida; 211-224.

Olesen, C.R., Asferg, T., Forchhammer, M.C. 2002. Rådyret –fra fåtallig til almindelig. National Environmental Research Institute, Denmark. Tema Report no. 39, 60 pp.

Puetmann, K.J., Ammer, C. 2007. Trends in North American and European regeneration research under the ecosystem management paradigm. *European Journal of Forest Research* 126: 1-9.

Reimoser, F., Gossow, H. 1996. Impact of ungulates on forest vegetation and its dependence on the silvicultural system. *Forest Ecology and Management* 88: 107-119.

Rooney, T.P. 2001. Deer impacts on forest ecosystems: a North American perspective. *Forestry* 74(3): 201-208.

REHABILITATION OF LOGGED-OVER DIPTEROCARP FORESTS USING THE INDONESIAN SELECTIVE CUTTING AND LINE PLANTING SYSTEM

Prijanto Pamoengkas and Ulfah Juniarti Siregar

Abstract—The Selective Cutting and Line Planting (SCLP), starting in 2005 has been considered better practice and was put on trial as a model to improve degraded dipterocarp natural forest in Indonesia. In this system, after selective cutting is done, a 3-m-wide planting strip and 22-m-wide inter-space line are made alternately. The initial 3-m width of the planting strip will be increased to 10-m by expanding into the inter-space line within 5 years, to allow more light to penetrate. The planting distance is 5 m by 25 m, using three species of dipterocarps, i.e. *Shorea leprosula, S. parvifolia* and *S. johorensis*. Preliminary data showed that line planting and intensive tending could accelerate diameter growth of the newly planted dipterocarps up to 2 cm yr^{-1}, thus reducing the time to reach harvestable dimensions; instead of 50 years to produce a tree of 50 cm dbh, it may take only 25-30 years.

Tropical rainforests are drawing much attention nowadays, primarily due to increasing threats to future sustainability. Tropical forests generally have faster growth due to the considerable absorption of solar energy, as well as an important role in maintaining the balance of global carbon. In Indonesia the principal cause of natural forest destruction is commercial timber harvesting, especially Dipterocarp species. It is estimated that the growth and regeneration rate of Dipterocarp has decreased in the logged-over forest. Many logged-over forests still contain enough residual dipterocarp trees to give rise to a sufficient supply of ephemeral seedling stock. In other forests, however, the conditions are extremely bad; residual Dipterocarp trees are scarce, and ephemeral seedling stock no longer exists. A program is needed for both conditions, either to restore the badly degraded forests, or to accelerate seedling growth in the common logged-over forest.

The main challenge in a restoration program is to create appropriate growing conditions, particularly light conditions required by each species, to grow from juvenile to mature stage. Another challenge is to increase forest productivity related to wood production. In Indonesia, round wood production from the concession area and plantations has decreased since 1999 from 20.6 million m^3 to 8.1 million m^3 in 2002. The prediction of round wood demand in 2004 is 42.3 million m^3, in which the contribution from natural forest is about 5.7 million m^3 only. Within this context of increasing productivity of natural forest, the selective cutting and strip (or line) planting system (SCLP) was recently considered a proper approach. In this system, after selective cutting is done, 3-m-wide planting strips and 22-m-wide inter-space lines are made alternately. The initial 3-m width of the planting strip will be increased to 10-m by expanding into the inter-space line within 5 years, to allow more light to penetrate.

The objectives of this paper are to review the results of SCLP application in a natural forest, on vegetation aspects and trends in growth of dipterocarp plants. This work is a part of a wider study on application of SCLP system on ecosystem function conducted at PT. Sari Bumi Kusuma concession area, Central Kalimantan. This company is one of the concession areas that have implemented the SCLP system in Indonesia.

Methodology

Selection of the Study Area—The study area was located at PT. Sari Bumi Kusuma concession area, in Central Kalimantan province. The forest location studied consisted of various-aged stands, and has been managed and subjected to application of the SCLP system. After selective logging was done, 3-m-wide planting strips alternated with 22-m-wide inter-space. The 3-m wide opening of the planting strip was then gradually increased, becoming 4-m-wide after 1-yr, then 6-m after 3-yr, and finally 10-m wide after 5-yr. Within the planting strip, the planting distance is 5 m by 25 m. There are three species of dipterocarps used for planting, i.e. *Shorea leprosula, S. parvifolia* and *S. johorensis.*

Establishment of Time Series Plots—The dynamics of stand structure should be studied in a series of different-aged stand, and using a primary forest as a reference area. However, such study would require a very long time. Therefore, a

Table 1. Species composition of the three species groups in the SCLP area and primary forest

Stand	Species composition (%) Commercial Dipterocarp	Non-Commercial Dipterocarp	Other species
To	20.6	20.6	58.8
TJ_1	20.0	15.0	65.0
TJ_2	16.3	20.4	63.3
TJ_3	23.1	18.0	58.9
TJ_4	16.7	16.7	66.6
TJ_5	16.3	7.0	76.7
PF	18.4	21.1	60.5

Department of Silviculture, Faculty of Forestry, Bogor Agricultural University, Kampus IPB Darmaga, Po Box 168, Bogor 16680, INDONESIA;email prijantop@yahoo.com

pseudo-time series was used in this study, which comprised of primary forest (PF), stand of one month after logging (To), and stands containing 1 to 5 years of plantation (TJ_1, TJ_2, TJ_3, TJ_4, TJ_5). By studying this pseudo-time series, one can obtain some indication of the recovery and development of the stands. Data were collected by a systematic sampling survey. This sampling system was applied in 14 plots, having a size of 4 ha each. Thus, the totally aggregated area was 56 ha. The following data were recorded: at the planting strip, data on diameter at breast height was taken, while at the inter-space line, data on number of seedlings, saplings, poles and trees were obtained.

Table 2. Density of seedlings in SCLP plot and primary forest

Stand	Commercial Dipterocarp	Non-Commercial Dipterocarp	Other species	Total (stems ha^{-1})
PF	812	9125	6250	16187
T_0	5375	4750	9187	19312
TJ_1	375	13437	9125	22937
TJ_2	1500	6250	5500	13250
TJ_3	3000	8750	9375	21125
TJ_4	5375	12875	7687	25937
TJ_5	313	11062	10187	21563

Table 3. Density of saplings in SCLP plot and primary forest

Stand	Commercial Dipterocarp	Non-Commercial Dipterocarp	Other species	Total (stems ha^{-1})
PF	210	1280	1780	3270
T0	140	510	1610	2260
TJ_1	70	540	560	1170
TJ_2	220	1340	850	2410
TJ_3	90	1310	960	2360
TJ_4	220	1870	810	2900
TJ_5	310	1220	850	2380

Result and Discussion

Species Composition—Generally, the residual stand was dominated by group of other than Dipterocarp species (60-80%). The proportion of the commercial Dipterocarp group in all plots was relatively constant, with the value from several plots higher than were found in the primary forest. Dipterocarps made up about 20% of the total number of trees (Table 1). These data indicated that apparently selective cutting did not affect the proportion of commercial Dipterocarps in a logged-over forest, as their proportion did not decrease much. Therefore, in term of species composition, selective cutting had little effect in the residual stands. The remarkable decline in individual diameter classes, especially trees > 50 cm, in all plots, can be explained by timber extraction of larger trees. The plotted abundance of the residual trees, according to diameter classes, was typical reversed J – shape, which means that there was no pronounced change on trees abundances in all plots.

Table 4. Density of poles in SCLP plots and primary forest

Stand	Commercial Dipterocarp	Non-Commercial Dipterocarp	Other species	Total (stems ha^{-1})
PF	65	135	143	343
T_0	77	122	177	377
TJ_1	45	85	147	277
TJ_2	52	122	192	367
TJ_3	35	70	127	233
TJ_4	62	157	232	452
TJ_5	105	132	140	378

Development of Seedlings, Saplings and Poles in the Inter-space Line—The number of individual seedlings, saplings and poles is a good criterion for evaluating the degree of recovery after selective logging. Selective cutting usually has a positive effect on seedling regeneration and density. The total number of seedlings did not show a trend in all SCLP plots (Table 2).

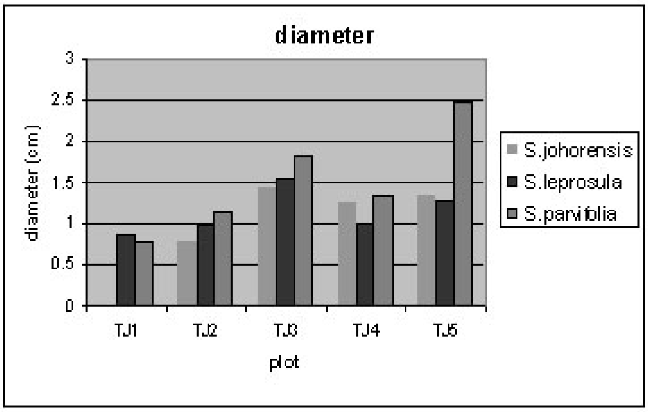


Figure 1. Diameter increment of dipterocarp plants in all plots

Considering the recruitment of saplings, selective cutting apparently did not give a stimulus to sapling density, as indicated by a lower density in SCLP plots than the primary forest. The number of saplings in the logged over stand was generally higher than the primary forest. In the case of SCLP the recruited seedlings, which already existed before, have not reached the sapling stage, which may be due to increasing competition (Table 3).

Looking at the total number of poles in all plots, it shows that the number of poles was higher compared to the primary forest (Table 4). In general, the non-dipterocarp group contributed a higher number of seedlings, saplings, and poles in the inter-space line than did commercial dipterocarps. Based on the pattern of natural regeneration in the inter-space line after 4-yrs of SCLP treatment, it is suggested that after 4-yrs, the inter-space area should be subjected to some silviculture treatment, such as thinning of non-Dipterocap species, to give better growing space for Dipterocarp species by reducing competition.

Growth of Dipterocarp in the Planting Strip— The diameters of three Dipterocarp species, i.e. *Shorea parvifolia, S. leprosula* and *S. johorensis* were measured in different planting strips, which have different widths, as a consequence of treatments to increase the width according to the increasing age of the plantations. Data show that there was a similar response of those species on diameter increment between 1-yr-old with 3-m-wide strip and 2-yrs-old with 4-m strip width. The growth in the 3-m and 4-m strips indicated that those species were responsive to excessive light, and or high soil temperature. The 6-m-wide strip containing 3-yr-old plants yielded better diameter growth in comparison to 1-, 2-, and 4-yrs of SCLP. At 5-yrs of SCLP, *S. parvifolia* seemed to get a slight benefit from a widere opening, as reported by Wan Razali (1989). Meanwhile *S. johorensis* seemed to be the most sensitive. Appanah and Weinland (1993) emphasized the importance of removing the overstorey in strip planting. The results of this study also confirm the importance of sufficient amount of overhead light when planting *Shorea parvifolia, S. leprosula* and *S. johorensis*; however, each Dipterocarp species seems to have different requirements for light and possibly temperature within the planting strip.

Conclusion

The application of the SCLP system on management of logged-over Dipterocarps forest does not seem to cause dramatic changes in vegetation structure. The number and proportion of species, as well as natural regeneration in the inter-space line area are more or less similar to primary forest. The growth of the planted seedlings in the planting strip was also similar and slightly better than natural regeneration. The growth response of *S. parvifolia* to the width of planting strip or excessive light is better compared to *S. johorensis* and *S. leprosula*.

Literature Cited

Appanah S., Weinland, G. 1993. Planting quality timber trees in Peninsular Malaysia – a review. Malayan For. Rec. No.38. Kepong: Forestry Research Institute Malaysia.

Noorlaksmono, H. 1993. Policy and Regulation on Silviculture aspect of the Indonesian Concession System in Practical Implementation and Consequences for Sustainable Forest Management. Thesis presented to the Faculty of Forestry Science, Georg-August University, Goettingen, Germany.

Sist, P., Saridan, A. 1998. Description of primary lowland forest of Berau. Di dalam: Bertault JG, Kadir K, editor. Silvicultural research in a lowland mixed dipterocarp forest of East Kalimantan. Jakarta: CIRAD-forest, Forda, Inhutani I. hlm 51-73.

Wan Razali. 1989. Levels of productivity in plantation of fast growing indigenous species in Malaysia: problem and prospects. Proc. GTZ regional forestry seminar. Eschborn, Germany.

Weidelt, H.J. 1994. Tropical Silviculture (Provisional Lecture Note I and II).: Faculty of Forestry Science, Georg-August University Gottingen. Goettingen, Germany.

FOREST RESTORATION USING FOREST CANOPY DENSITY MAPPING (FCDM) TECHNOLOGY

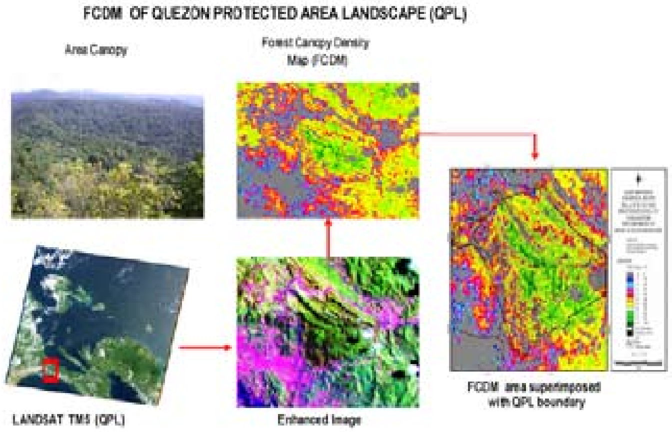
Merlinda R. Manila

Introduction

Adequate and reliable information on the status of forest land is a pre-requisite for the implementation of appropriate forest management practices. In the past, several forest policies, programs and activities were introduced in order to harmonize and balance the needs of the present and future generations. However, deforestation was at an alarming rate affecting upland and lowland communities alike, and caused many problems including open access, marginalization of the uplands, fluctuation of forest productivity, increased erosion and siltation, loss of biodiversity and deterioration of watersheds (Guiang 2001). Conventional forest management with the objective of maximizing commercial returns is no longer feasible to cope with the challenges of forestry in the developing world particularly Asia Pacific region (Roy 2003). The implementation of various forestry programs on forest enhancement and poverty alleviation through community-based approach and plantation establishments covering coastal, lowland and upland areas remained ineffective as evidenced by continuous depletion of forest resources. The absence of a clear scenario for many of these forestlands aggravated the acceleration of land degradation.

To address these constraints, the Department of Environment and Natural Resources (DENR) Region CALABARZON in the Philippines through ITTO project PD 239/03 Rev.1 (F) utilized the Forest Canopy Density Mapper (FCDM) Ver.2 software to achieve efficient, cost-effective planning, restoration, rehabilitation and monitoring of forest resources. The FCDM is image analysis semi-expert remote sensing software developed in previous ITTO projects, namely; PD 32/93 Rev. 1(F) and PD 60/99 Rev.1 (F). This current project, therefore, highlighted the technology transfer component through capacity building of DENR staff in order to impart knowledge and skills in the operations of FCDM supported by remote sensing and geographic information system (GIS) technologies.

The pilot application of FCDM in CALABARZON region is an initiative of the Forest Resources Development Division which is primarily tasked in planning, restoration, monitoring and evaluation of open and degraded forest areas, among others. The execution of PD 239/03 evolved from the need to streamline and systematize the gathering and management of forest information for decision-making, restoration of degraded forestlands, planning, management and monitoring. Furthermore, the application of FCDM software has improved information-gathering methods with use of LANDSAT TM5, LANDSAT ETM7 and ASTER satellite imageries. With the FCDM application, the region was able to generate forest canopy density maps showing the stratified location of forest areas that need immediate rehabilitation and protection.



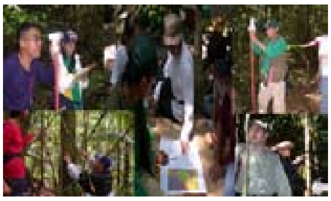
Forest Canopy Density (FCD) refers to the proportion of an area in the field that is covered by the crown of trees and expressed in percentage of the total area. The degree of forest density is expressed in percentages: i.e. 10% FCD; 20%; 30%; 40% and so on (Rikimaru, 2003). The source remote sensing data for FCD model is LANDSAT TM data.

The Forest Canopy Density Mapper (FCDM) Ver2 Software

The Semi-expert System, FCD-Mapper, is a computer software package compatible with window based personal computer. The FCD-Mapper contains the algorithms and other formulas utilized to compute values of the several indices contained in the Forest Canopy Density Mapping Model, or simply the FCD Model, for the analysis of satellite imagery data. Forest Canopy Density (FCD) refers to the proportion of an area in the field that is covered by the crown of trees and expressed in percentage of the total area. The degree of forest density is expressed in percentages (Rikimaru 2003). The source remote sensing data for FCD model is LANDSAT TM data.

M. Manila is Project Coordinator and concurrent OIC-Chief, Forest Resources Development Division DENR IV CALABARZON, Forestry Sector, 1515 Roxas Blvd., Manila, Philippines; bingmanila@yahoo.com.

The consequent production of FCD maps showing the stratified forest canopy density in different classes, i.e. from 0% to 100% categories, has been directly communicated to the decision-makers, planners and stakeholders for the purpose of preparing well-planned interventions in forest conservation, development and management. The stratified maps superimposed by other thematic maps (i.e. land classification, contour, tenurial instruments, natural parks, watershed, road network, drainage system, etc.) provided the necessary avenues to address land-conflict resolutions towards forestland occupancy particularly of the local upland communities and concomitantly their obligation to participate in the restoration of degraded timberland areas.



The FCDM software utilizes forest canopy density as an essential parameter for characterization of forest conditions. Further, the FCDM data shows the degree of degradation over a certain forest area, thereby indicating the required intensity of rehabilitation treatment. The FCDM can also detect and monitor the transformation of forest conditions over time including land degradation. Additionally, it can assess the progress over time of reforestation activities.

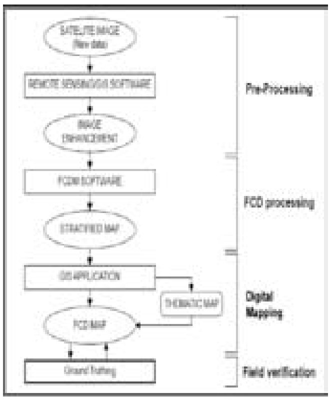


Figure 1. FCDM Flow Chart

Establishment of FCD Facility

The pilot-testing of FCDM application in the Philippines was guided by the project specific objective of establishing a remote sensing-based system for assessment and monitoring of forest resources. Thus, a remote sensing and GIS-cum-training facility was finally established at the CALABARZON regional office. The RS/GIS facility was equipped with necessary hardware and installed software such as FCDM Ver2, PCI Geomatica Ver.9.1, remote sensing and GIS. Moreover, each provincial DENR office of CALABARZON was also provided with the same hardware and software purposely to support in the information gathering,

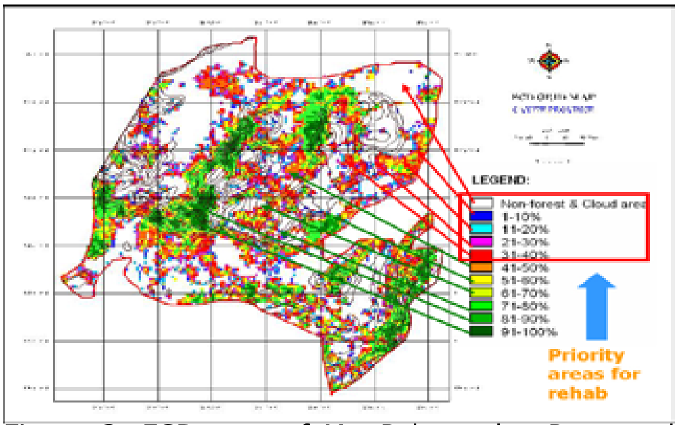


Figure 2. FCD map of Mt. Palay-palay Protected Area Landscape, Cavite, Philippines showing the FCD Range from1-100% classes superimposed

analysis and production of digital maps covering their respective administrative jurisdiction.

The conduct of a series of hands-on trainings on basic remote sensing (BRS), FCDM, GIS, management information system (MIS) and computer literacy courses for technical and support staff from the regional, provincial and district offices of CALABARZON, the Forest Management Bureau (FMB), the National Mapping and Resource Information Authority (NAMRIA) and the Department of Interior and Local Government (DILG)-Region IV office have provided the required knowledge and skills to backstop and support the FCDM application down to the field level. A total of 40 trained staff members are now on board and functioning actively at the regional and provincial offices. The training was conducted in four batches spread over two years of the project life, with resource persons from NAMRIA, DENR and Japan Overseas Forestry Consultants Association (JOFCA), which actually developed the FCDM software for the ITTO.

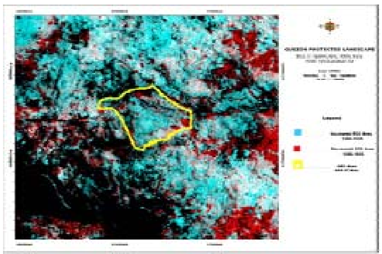


Figure 3. Forest Cover from 1988 to 1994 (QPL)

Ground Truthing

To validate and confirm the results of FCDM, the ground truthing activity was undertaken at Quezon Protected Area Landscape (QPL) in Quezon Province. Various testing plots were established in the area, and from which data were collected on forest canopy density stratification, tree species distribution, stand density or stocking and volume. The results

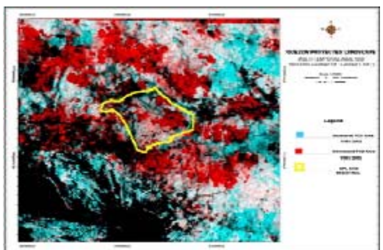


Figure 4 Forest Cover from 1994

of the ground truthing activities showed the positive trend of FCD accuracy on the maps produced when compared with the information gathered from the ground, such as 59.1%, 51-60% class; 74.3%, 61-70% class; 78.7%, 71-80% class; and 91.5, 90-100% class. The forest canopy density and ground vegetation cover density were measured using the GRS densitometer unit.

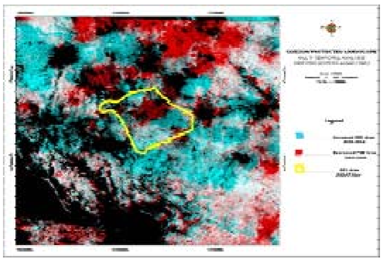


Figure 5. Forest cover from

FCDM Compatibility with Forest Restoration
The general features of FCD maps showing the stratified location of forest density in different classes provides important information to come up with reliable land-use plan indicating, among others, the different land categories and set aside specific areas for upland community development, biodiversity conservation, forest protection, conservation and rehabilitation. With these scenarios, the restoration of the forest landscape, economic stability and enhanced ecosystems are highly attainable and doable by all sectors of society. Furthermore, satellite imagery prepared through FCD technology can be extremely useful in the dialogue at various levels which is essential in planning rehabilitation programs. It is usually easier to generate public support for rehabilitation if information on actual conditions is broadly shared. FCD map superimposed with grid and contour lines and the ability to compute the number of hectares in various categories provides the planners with a valuable tool in budget planning, including financial and economic feasibility studies.

FCD technology demonstrated that it is feasible to develop methods, procedures and techniques for analyzing satellite imagery data to produce information tailored for several important requirements in forest management. The FCD application also confirmed that is possible to enhance the result of the FCD map as a result of the ground truthing, thereby presenting an accurate overview of forest status in a manner readily understood by foresters, senior decision-makers, the media, environmentalist and the general public. Thus, in addition to its utilization as a tool in resource management, FCD map can now become a vehicle for sharing updated information across sectors and improving communication between technical and other concerned public.

Multi-temporal Analysis
Understanding the change of the forest cover over time of the target area for rehabilitation/ restoration provides an appropriate management strategy as regard to community settlers/occupant needs, species compatibility, infrastructure, political, natural calamities, etc. Time series results provide vital information to all direct and indirect stakeholders, to come up with consensus/ resolutions as to the issues on conservation and development of the forest/watershed area. The Quezon Protected Area Landscape (QPL) and its adjacent areas located within the three (3) municipalities of Quezon Province has been tested for trending of its forest cover from 1988 to 2004. Landsat TM/ETM+ and ASTER satellite imageries were used for this trending.

Comparing year 1988 to 1993 (cyan color represent the existing forest cover while red color represent the reduced forest vegetation), there was abundant vegetation within QPL and its adjacent areas (Figure 3). For 1993 to 2002, there was a significant reduction of vegetation cover on the same areas (Figure 4). For 2002 to 2004, there was a slight recovery of vegetation inside the QPL area and some of the adjoining sites (Figure 5).

It is worth mentioning that the significant reduction of vegetative cover from 1993 to 2002 (Fig. 4) was attributed to a new diversion road constructed outside the QPL area. The road accessibility provided the means for kaingin-making (slash-and-burn) activities adjacent to the QPL site. Some portions of the forest were affected by clear cutting of trees to favor the planting of coconuts by new forest occupants.

In 2002 to 2004 (Fig.5), there was slight increase of the vegetation cover because the planted coconut trees began to advance its age through time thereby creating crown cover replacing the removed endemic trees. In addition, the massive mobilization of all stakeholders directly benefiting from the watershed of QPL vigorously sought the protection of the forest from further destruction. The implementation NIPAS Law (RA 7586) made the creation of a Protected Area Management Board (PAMB), a decision-making body for QPL that accelerated the high intense concern on the protection of the area from further intrusion by squatters in nearby municipalities.

Lessons Learned:

- institutionalized in the DENR CALABARZON operations acquired knowledge and skills on remote sensing, GIS and use of FCDM
- image interpretation and analysis using FCDM Ver2 software is doable without assistance from a Remote Sensing Specialist
- integration of FCDM outputs with other RS/GIS software
- simultaneously collection and data processing of FCDM data from the regional and provincial offices and vice versa
- updated forest status data is readily accessible

at the regional and provincial level for decision-making in planning and monitoring activities.

Specific examples applications are:

- forestland occupancy resolution in QPL
- systematic prioritization of forestland areas for restoration, rehabilitation, harvesting development and watershed management
- systematic identification of areas suitable for biodiversity conservation, wildlife habitat corridors
- identification of areas for roadside planting activities
- use by the local government units in the preparation of comprehensive land use plans (CLUPs)
- use as reference by private land owners in the location and identification of tree plantation establishment.

Acknowledgment

A Foreign Assisted Project of the DENR IV CALABARZON-ITTO thru a grant from the International Tropical Timber Organization (ITTO) funded by Japan and Republic of South Korea.

Literature Cited

Anonymous. 2006. Status of tropical forest management. International Tropical Timber Organization. A special edition of the *Tropical Forest Update* 2006/1.

DENR IV CALABARZON. 2003. Development and installation of a forest resources monitoring system (FORMS) by utilizing the forest canopy density (FCD) model developed in ITTO project PD 60/99 Rev.1 (F). 2003. ITTO PD 239/03 Rev1. (F).

DENR IV CALABARZON. 2005. Development and installation of a forest resources monitoring system (FORMS) by utilizing the forest canopy density (FCD) model developed in ITTO project PD 60/99 Rev.1 (F). Third Progress Report for ITTO PD 239/03 Rev1. (F).

Guiang, E. 2001. Impacts and effectiveness of logging bans in natural forests: Philippines. *Forests Out Of Bounds: Impacts And Effectiveness Of Logging Bans In Natural Forests In Asia-pacific.* Asia-Pacific Forestry Commission. FAO. Regional Office for Asia and Pacific, Bangkok, Thailand.

JOFCA. 1997. Utilization of remote sensing in site assessment and planning for rehabilitation of logged-over forests project. Project Report for ITTO on PD 32/93 Rev.2 (F).

JOFCA. 2003. Optimum utilization of RADAR-SAR data in conjunction with enhanced FCD model to monitor change in the status of forest resources. Project Report for ITTO on PD 60/99 Rev.1 (F).

Manila, M. 2006. Pilot application of forest canopy density mapper (FCDM) in the Philippines. A paper submitted to ITTO for publication.

Rikimaru, A. 2003. Concept of FCD mapping model and semi-expert system. FCD-Mapper Ver.2, Semi-Expert Remote Sensing System for Forest Canopy Density Mapping. ITTO/JOFCA. 2003.

Ronquillo-Manila, M., Gallego D. 1993. Simulation study of logging ban as a management approach to forest conservation in the Philippines. *Araneta Research Journal* Vol. 30.

Roy, P.S. 2003. Space remote sensing for forest management. FCD-Mapper Ver.2,

Semi-Expert Remote Sensing System for Forest Canopy Density Mapping. ITTO/JOFCA 2003.

RESTORING FORESTS FOR MULTIPLE VALUES ON MINED LAND IN THE APPALACHIAN REGION, USA

James A. Burger[1] and Carl E. Zipper[2]

Abstract—Over 500,000 ha of native Appalachian forest land have been converted to mine spoils, large portions of which are covered with abandoned, unproductive grass and shrub land; few mines were reforested due to inadequate technology, economic disincentives, and regulatory constraints. A long-term reclamation research program was established in 1980 to develop mined land reclamation techniques for creating productive mine soils for forest land uses. Our studies show that soil quality was routinely degraded in the process of mining, but, if the land is properly reclaimed, forest growth and yield of post-mining forests can be as productive as native forests.

The deciduous forest of the central Appalachian coal field region, USA, is one of the most diverse, productive, and valuable temperate forests in the world. Strip mining for coal totally removes the forest ecosystem including the soil and surface geologic strata. Over 500,000 ha of native Appalachian forest land have been converted to mine spoils, large portions of which are covered with abandoned, unproductive grass and shrub land; few mines are reforested due to inadequate technology, economic disincentives, and regulatory constraints.

Most woody species used for reclamation for wildlife habitat and unmanaged forest are early-successional shrubs and trees that have low value or no value for forest products. They are used because they can better tolerate the poor physical and chemical conditions of the mine soils being placed on the surfaces of most reclaimed mine sites throughout the Appalachian region. They will eventually be replaced by more valuable native species through the process of natural succession, but given established rates of natural forest succession, it will be 200 to 300 years before a commercially-valuable species composition similar to the adjacent native forest will occur. Therefore, given today's wood products market, current reforestation practice on mined land will not produce economically-valuable forest stands.

Research Results

Our research, however, shows that a valuable mixture of mid- to late-successional native hardwoods can be established immediately after active mining. Mid- to late-successional species require mid- to late-successional soil (Torbert et al. 1998). High soil quality can be achieved by creating mine soils made from selected rock strata, which is provided by mixing existing soil with blasted weathered rock taken from within 3 m of the surface (Burger et al. 2002). Several meters of this material is placed on the surface and serves as the new forest soil. By mixing native soil with weathered overburden, the new mine soil is inoculated with the soil organisms with which most native woody species share symbiotic relationships and on which their growth depends. Soil compaction on mined sites was common; soil building and tillage techniques devised through research greatly increased soil quality. Tree-compatible ground covers were developed for erosion control, and silvicultural practices were modified for mined land applications.

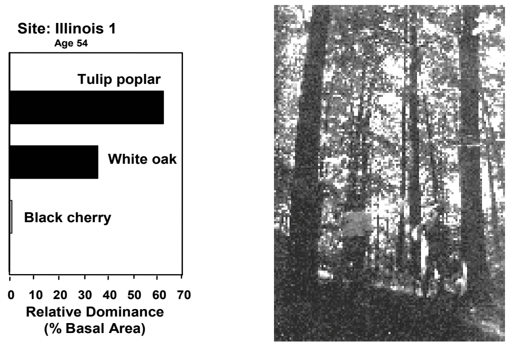


Figure 1. A 54-yr-old forest on mined land dominated by tulip poplar and white oak that were planted after mining.

Mixtures of 1000 trees ha^{-1} of mid- to late-successional hardwoods are planted along with 100 trees ha^{-1} of wildlife species and nitrogen-fixing legumes. Seeds of early-successional species are carried in or blown in by birds or wind and can, with a sparse ground cover, become established. Other native forbs and woody plants volunteer to create a diverse mix of native species similar to the adjacent, undisturbed forest. Planted as seedlings, which gives them a head start; the slower-growing commercial species remain part of the stand composition through time and dominate toward

[1] Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, Ph: 540-231-7680, jaburger@vt.edu
[2] Crop and Soil and Environmental Sciences Department, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, czip@vt.edu

the end of the 50- to 80-yr stand growth cycle. This reforestation procedure eliminates the need for the 200-yr primary successional growth period required when blasted unweathered rock is used as the growth medium.

The success of planted, mid- to late-successional species was demonstrated in one of our studies (Rodrigue et al. 2002), where we inventoried the composition of fourteen 20- to 56-yr-old forest stands planted on mined land. The data showed that commercially-valuable mid- to late-successional species survived, grew at a rapid rate, and have become important components of the forest stands. Figure 1 is an example of one of the mined sites, which is a 54-yr-old site planted to tulip poplar (*Liriodendron tulipifera* L.) and white oak (*Quercus alba* L.). The two planted species dominated the site, with about 2% of the basal area consisting of volunteer black cherry (*Prunus serotina* L.). This stand will be harvestable by age 60 with a projected value of \$9000 ha^{-1}.

Conclusion

Our data show that mid- to late-successional species can be planted with other compatible, valuable species and grown as components of new forests that bring great value to landowners. Furthermore, our studies also show that productive, reforested mined sites can sequester carbon at a rate of 4 Mg ha^{-1} yr^{-1}, which is important for sequestering and storing carbon released to the atmosphere in the process of burning coal for power production.

Based on our research outputs, several states in the Appalachian region have revised their reclamation regulations and guidelines. Our revised reclamation techniques for forestry are cost-effective, meet all federal and state regulatory requirements, and enable miners to produce high-quality mined sites for restoring native forest ecosystems. As a result, thousands of hectares of forest land are being restored for multiple forest values.

Literature Cited

Burger, J.A., Scott, D.A., Mitchem, D.O. 2002. Field assessment of mine soil quality for establishing hardwoods in the Appalachians. p. 226-240. In: R. Barnhisel and M. Collins (eds.). *Reclamation with a Purpose*. 19th Ann. Mtg., American Society of Mining and Reclamation, Lexington, KY.

Rodrigue, J.A., Burger, J.A., Oderwald, R.G. 2002. Forest productivity and commercial value of mined land reclaimed prior to enactment of federal reclamation law. *Northern Journal of Applied Forestry* 19:106-114.

Torbert, J.L., Tuladhar, A.R., Burger, J.A., Bell, J.C. 1998. Minesoil property effects on the height of ten-year-old white pine. *Journal of Environmental Quality* 17:189-192.

RESTORATION OF EX GOLD MINING AREA BY RECYCLING TAILING WASTE IN THE ESTABLISHMENT OF *EUCALYPTUS PELLITA* AND *GMELINA ARBOREA* PLANTATIONS IN PT. ANEKA TAMBANG PONGKOR, BOGOR, INDONESIA

Chairil Anwar Siregar, I Wayan S. Dharmawan and Harris H. Siringoringo

Abstract—Restoration and abundant tailing wastes are critical problems to be solved by gold mining concession holders. Tailing contains high concentrations of lead and iron and, if not properly managed, will cause severe soil environmental pollution. This study was designed to evaluate possibility of recycling tailings as a plant growth media for rehabilitating degraded land in gold mining area through incorporation of high levels of organic fertilizer, charcoal and inoculation with mycorrhizal fungi. Toxicity tests indicated that tailing soil mixed with compost at a ratio of 3:1 by volume produced the best growth of *Capsicum annum* and *Eucalyptus pellita* seedlings. Field research shows that organic fertilizer significantly affects the growth of four-month-old, one-year-old and two-year-old *Eucalyptus pellita*. The best plant growth was observed in the tailing, dung and solum treatment at a ratio of 1:1:1 by volume. This response was not observed in *Gmelina arborea*.

Activity occurring in forested area such as deforestation and mining all give rise to accelerated soil degradation. In turn, this can lead to a diversity of environmental problems for example an excessive siltation of drainage systems, a decline in land productivity, dune encroachment, and the presence of heavy metal declining microbial activity that will end up with the formation of devastated land.

The existing environmental problems requiring fast reclamation is the degraded land caused by gold mining activity in Pongkor, West Java. This soil degradation problem is becoming more complicated due to the fact that the concession overlaps with Gunung Halimun Salak National Park occurring at 600 to 700 m above sea level with topography ranging from wavy to dissected. In addition, the presence of huge number of illegal mining leads to more accelerated soil degradation.

In the study area, deforestation, and construction work evidently trigger the poor quality of chemical and physical nature of the soil so that the rehabilitation activity through plantation projects fail most of the time. Generally, the poor growth and development of plantations is caused by low concentrations of soil macro nutrients such as C, N, P, K, Ca, Mg and the presence of highly extractable Al, Mn, Fe, and Pb that can be toxic to the plant. Moreover, soil compaction and the presence of hardpan can also cause the poor plant growth as a result of less root absorbing surface in limited volume of soil.

Tailings are abundant solid wastes from the gold mining process and are stored in tailing dams. This waste can become the pollutant if improperly managed, due to its high concentration of heavy metals such as Pb, Cu, and Fe. The tailing problem can be more serious economically due to the fact that whenever huge amount of the solid waste can no longer be piled up in the tailing dam. Establishment of another tailing dam is very costly.

Manipulation of tailing chemical properties is directed toward reducing the heavy metal ions activity in the soil so that the toxicity level to the plant is mitigated. The chelating process by organic fertilizer is one of the techniques that can be practiced. The objective of this research is to formulate manipulation technology for modifying the chemical properties of tailings bearing high concentrations of heavy metals, by incorporating the tailing with organic fertilizers so that it can be utilized for planting media to rehabilitate the abandon gold mining area.

Methodology

Experimental Design—Preliminary toxicity tests of tailing soils using *Capsicum annum* and *Gmelina arborea* were conducted. The treatments tested were F0=tailing 100%; F1=tailing:compost (1:1, v/v); F2=tailing:compost (3:1, v/v); F3 =tailing:charcoal (3:1, v/v). The number of seeds germinated for the toxicity test was 100 seeds.

A field experiment was conducted using *Gmelina arborea* and *Eucalyptus pellita* as indicator plants. A completely randomized experimental design with 3 replications was employed. One experimental unit was a plot sized 12 m by 10 m, consisting of 30 plants with spacing of 2 m by 2 m. Treatments tested were 4 levels of organic fertilizer namely control (T, tailing), charcoal (C), dung (O) and mixture of charcoal and dung (C+O). All fertilizer was incorporated into the soil before planting as followed: 1) T+C = solum 1/3 vol + tailing 1/3 vol + C 1/3 vol, 2) T+D = solum 1/3 vol + tailing

Forestry Research and Development Agency (FORDA), Jl. Gunung Batu No. 5, Bogor, INDONESIA, e-mail: siregarca@yahoo.co.id

1/3 vol + D 1/3 vol, 3) T+C+D = solum 1/3 vol + tailing 1/3 vol + (C 1/6 vol + D 1/6 vol), and 4) Control T = solum 1/3 vol + tailing 2/3 vol. Note that basic treatments were 1/3 vol of soil solum and 200 gr NPK fertilizer. Size of planting hole was 50 x 50 x 50 cm3. The Tukey HSD was used for means separation test (SAS Institute 1998). Some important parameters observed were plant height and diameter growth and soil chemical properties.

Results and Discussion

Toxicity Test of Tailing--Results of toxicity tests of plant media by employing *Gmelina arborea* and *Capsicum annum* are summarized in Tables 1 and 2.

The toxicity tests on *Gmelina arborea* and *Capsicum annum* indicated that F2 medium (tailing : compost, 3 : 1 v/v) gave the best results as compared to the other media in terms of normal seedlings percentage, height, total fresh weight and total dry weight. In contrast, F3 medium (tailing:charcoal, 3:1 v/v) gave the worst results (Tables 1 and 2). This fact evidently indicates that tailing media containing high concentrations of heavy metals are very toxic (Alloway 1995, Palmborg and others 1998) to the growth of the indicator plants. This result also further indicates that activated charcoal (provided by PT. ANTAM) is not effective in reducing the toxicity level of the tailing as was expected.

The positive effect of organic fertilizer (compost) on the growth of *Capsicum annum* and *Gmelina arborea* seedlings could be due to effective functions

Media	Germination		Seedling				Height	Total fresh weight	Total dry weight
			Normal		Abnormal				
	Number	%	Number	%	Number	%	cm	------------gr-------------	
F0	90	90	32	35.6	58	64.4	9.7	46.6	10.2
F1	43	43	15	34.9	28	65.1	6.3	70.5	12.5
F2	83	83	53	63.9	30	36.1	10.9	84.3	17.6
F3	65	65	24	36.9	41	63.1	6.2	36.1	5.2

F0 = tailing 100%; F1 = tailing:compost (1:1, v/v); F2 = tailing:compost (3:1, v/v); F3 =tailing: charcoal (3:1, v/v); Number of seeds for germination was 100 seeds.

Table 1. Toxicity test on *Gmelina arborea.*

Media	Germination		Seedling				Height	Total fresh weight	Total dry weight
			Normal		Abnormal				
	Number	%	Number	%	Number	%	cm	-------------gr-------------	
F0	87	87	0	0	87	100	6.9	8.2	1.2
F1	43	43	20	46.5	23	53.5	8.3	11.9	1.5
F2	75	75	56	74.7	19	25.3	9.5	33.6	4.6
F3	20	20	0	0	20	100	2.6	0.7	0.1

F0 = tailing 100%; F1 = tailing:compost (1:1, v/v); F2 = tailing: compost (3:1, v/v); F3 =tailing:charcoal (3:1, v/v); Number of seeds for germination was 100 seeds.

Table 2. Toxicity test on *Capsicum annum.*

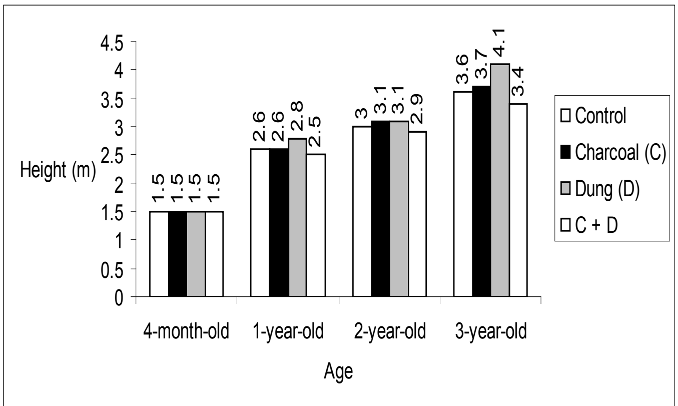
of compost since it could supply enzyme, humic acid, several minerals, and vitamins available to the plant growth.

Species	Parameters	Age			
		4-month-old	1-year-old	2-year-old	3-year-old
G. arborea	Height	NS	NS	NS	NS
	Diameter	NS	NS	NS	NS
E. pellita	Height	**	*	*	NS
	Diameter	**	*	*	NS

* = significant at the 5% level; ** = significant at the 1% level; NS = not significant at the 5% and 1% levels.

Table 3. Summary of significant test of organic fertilizer on height and diameter of *Gmelina arborea* and *Eucalyptus pellita* in field

Growth of *Gmelina arborea* and *Eucalyptus pellita*--Significant tests of organic fertilizer treatment on height and diameter of *Gmelina arborea* and *Eucalyptus pellita* in field plantation at age 4 months, 1 year, 2 years, and 3 years are summarized in Table 3. Results obtained from this research indicated that organic fertilizer did not significantly affect the growth of 4-month-old, one-year-old, two-year-old, or three-year-old *Gmelina arborea* in terms of height and diameter at breast height. However, the effect of organic fertilizer application significantly affected the growth of *Eucalyptus pellita* in terms of parameter observed at the age of 4 months, 1 year, and 2 years. After two-years-old, at the age of three years the plant growth response was not profound. In other words, the trend of growth response as affected by organic fertilizer treatment was flattened when the plantation was over 2-years-old or older, and this is true for both cases (Figure 1 and 2). This stagnant plant growth was believed due to an exhausted nutrients supply from limited volume of soil in the planting hole. Additional fertilizer is required to solve this problem in the future.
Some important physical and chemical



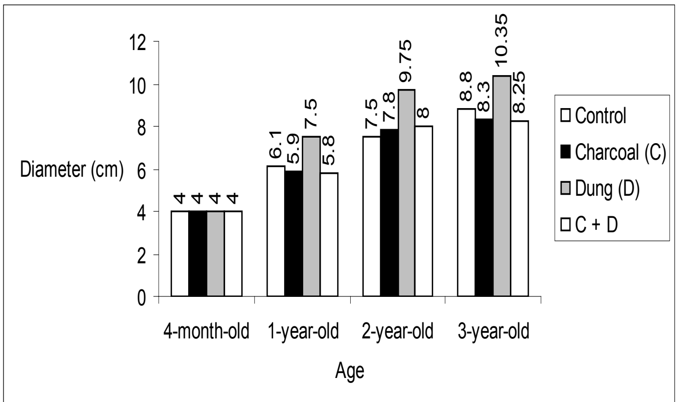


Figure 1. Effect of organic fertilizer on height and diameter of *Gmelina arborea* plantation

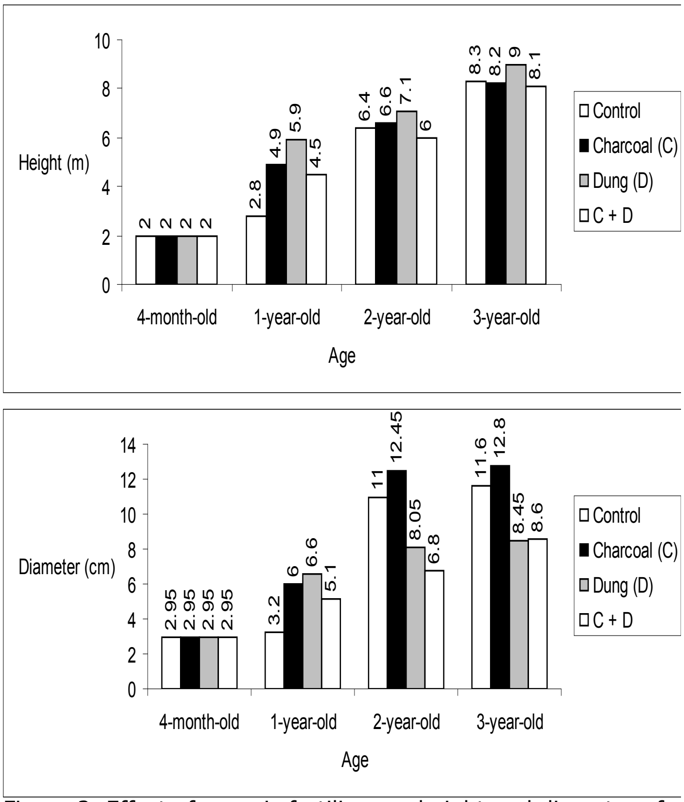


Figure 2. Effect of organic fertilizer on height and diameter of *Eucalyptus pellita* plantation

characteristics of the soils and materials (tailing, soil, dung, and charcoal) used in field experiment are summarized in Table 4. The field of experiment

Analysis	Media			
	Tailing	Soil	Dung	Charcoal
pH H_2O	7.7	6.9	6.1	9.6
pH KCl	7.6	6.8	5.6	9.0
C, %	0.06	0.40	9.05	3.90
N, %	0.01	0.04	1.06	0.15
C/N	6	10	9	26
P_2O_5, mg/100 g	41	216	383	-
K_2O, mg/100 g	19	67	407	-
P_2O_5 Olsen, ppm	10	469	231	-
K_2O Morgan, ppm	59.0	651.8	2822.2	-
Ca, me/100 g	26.28	12.40	24.23	-
Mg, me/100 g	0.76	0.82	7.78	-
K, me/100 g	0.12	1.38	5.63	-
Na, me/100 g	0.22	0.08	0.40	-
Total, me/100 g	27.38	14.68	38.04	-
CEC, me/100 g	4.82	13.24	39.65	13.16
BS, %	> 100	> 100	96	-
Fe total, ppm	21448	16389	-	-
Zn total, ppm	212.7	155.0	-	-
Pb total, ppm	110	45	-	-
Cu total, ppm	31	32	-	-
Fe Morgan, ppm	13.47	5.95	-	-
Zn Morgan, ppm	6.17	3.02	-	-
Pb Morgan, ppm	10.2	3.9	-	-
Cu Morgan, ppm	2.0	4.3	-	-
Texture : Sandy (%)	75	66	-	-
Loamy (%)	16	17	-	-
Clay (%)	9	17	-	-

Table 4. Physical and chemical analysis of soil, tailing, dung, and charcoal used in *Gmelina arborea* and *Eucalyptus pellita* plantation

site is land with stone outcropped in which the solum was not in place.

Dung application appears to be the best treatment to produce better plant growth. This better growth response could occur since the rhizosphere in the planting hole was enhanced through the establishment of organic matter originating from dung manure; and in turn, this improved the surrounding soil-root-absorbing surface where the nutrient solubility and decreasing toxicity of heavy metals became favourable for plant growth. Moreover, organic fertilizer could also enhance the growth of soil microorganisms such as mycorrhizal fungi, to improve soil aggregation and thus soil structure and aeration, and its functional group can chelate the heavy metal ions in soil solution (as a chelating agent) so as to suppress ion activity of the toxic metals (Gaur 1975, Russo 1994, Turk 1995).

Charcoal application evidently could not improve the plant growth as it was expected. Charcoal is often utilized as a soil conditioner to accelerate growth of plants (Glaser and others 2002, Ogawa 1994). The failure of charcoal to improve the plant growth in this case partly could be due to the chemical nature of the activated charcoal that is high in pH (very alkaline).

Conclusions

Some important findings encountered from this research are as followed:

1. Organic fertilizer especially dung manure could improve the growth of *Eucalyptus pellita* and slightly improve the growth of *Gmelina arborea* in the degraded land containing high concentrations of heavy metals such as Pb.
2. The plant growth was stagnant at the age of 3 years or older, and this problem could be solved by the application of additional chemical and organic fertilizer.

Acknowledgments

This paper is based on a number of green house and field researches supported by PT Aneka Tambang Pongkor, Bogor, Indonesia and Forestry Research and Development Agency (FORDA), Ministry of Forestry, Indonesia.

Literature Cited

Alloway, B.J. 1995. *Heavy Metals in Soils*, 2nd Edition. Blackie Academic and Professional. London.

Gaur, A.C. 1975. A manual of rural composting, Project Field Document No. 15. FAO, UNO, Roma.

Glaser, B., J. Lehmann and W. Zech. 2002. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal, a review. *Biology and Fertility of Soils* 35: 219-230.

Palmborg, C., L. Bringmark, E. Bringmark and A. Nordgen 1998. Multivariate analysis of microbial activity and soil organic matter at a forest site subjected to low level heavy metal contamination. *Ambio* 27: 53-57.

Russo, R. O. 1994. Effects of a new humic algal vitamin biostimulant (Roots) on vegetative growth of coffee seedlings. Dissertation abstract. Yale University, School of Forestry and Environmental Studies, New Haven, Connecticut.

SAS Institute. 1998. SAS User's Guide: statistics version, release 6.12. SAS Institute. Cary, NC.

Turk, C. M. 1995. The effect of microorganisms on soil structure development in copper mine tailing. Dissertation abstract. The University of Arizona.

THE IMPACT OF A MONOCULTURE PLANTATION (RUBBER PLANTATION) ON SOIL QUALITY DEGRADATION

T. K. Weerasinghe and H. A. S. Weerasinghe

Abstract—From the recent past, it is observed that the rate of anthropogenic activities have increased considerably bringing about disturbances to the valued natural ecosystems thus decreasing the quality in a remarkable way. This study is an attempt to identify the fate of the oil environment with the introduction of monocultures. Soil samples were obtained according to a randomly stratified sampling technique and the soil samples were tested on-site and off-site for physical, chemical and biological characteristics. Data were analyzed using one-way analysis of variance. The results for physical parameters indicated that there were significant differences for %soil moisture, and field capacity. The low value obtained for field capacity at the rubber plantation could be considered as an indication of possible changes of the structure of soil due to human influences caused during the preparation of the site for a plantation. However, no significant change was observed for mineral soil composition of the two sites. With respect to the chemical parameters, soil pH did not show a reasonable difference although it was one of the key parameters that give a quick idea about a disturbance. We observed a significant difference between the two sites on the measurements of soil conductivity, soil organic carbon, and cation exchange capacity. These results clearly indicate the fate of a natural soil due to human influences. These results further reveal that disturbance has created an environment that lacks required soil fertility characteristics, thus developing signs of possible soil degradation. The study also observed very low soil phosphate under the rubber plantation. This may be due to low retention of phosphates in soils under rubber or can be a result of this disturbance. A high soil nitrate value was recorded at the plantation site and this could be a result of addition of fertilizers for plantations. The obtained soil microbial biomass values clearly showed that the plantation site was biologically disturbed. The results clearly revealed that some of the soil parameters were changed as a result of the changed vegetation indicating possible soil quality deterioration under rubber monoculture plantations.

Department of Botany, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka; tkwee@ou.ac.lk

REHABILITATION OF DEGRADED LANDS IN SUB-SAHARAN AFRICA

Dominic Blay

Abstract—One of the biggest problems threatening the lives of millions of inhabitants in Sub-Saharan Africa (SSA), especially those residing in the rural areas, is land degradation. Although a worldwide problem, land degradation is said to be most acute in SSA where it is characterized by decreasing production of forest products and food, and worsening levels of poverty and malnutrition. However rehabilitation of the degraded lands is seen as a most viable way of mitigating the effect of land degradation. As a result the urgency for rehabilitation has been widely recognized for many years and sub-Saharan Africa has been the focus of many initiatives in this area.

However it has currently been recognised that for rehabilitation to be beneficial, it should improve and maintain environmental integrity and sustainable livelihood. The focus of this paper will thus be on these two main issues.

For the improvement and maintenance of environment integrity, the paper will discuss the causes and impact of land degradation in Africa, different approaches used for rehabilitation, how widely they have been used and the results achieved. The impact of these on the conservation of biodiversity and provision of environmental services will also be discussed.

On the improvement of people environmental well-being, this paper will discuss the policy framework including governance, land tenure and the benefit sharing arrangements that impact on rehabilitation in Africa. The social, economic, cultural conditions after rehabilitation will also be discussed.

The paper will also discuss constraints facing rehabilitation initiatives as well as success or failures achieved, reasons for success or failure, and lessons learnt that will ensure successful implementation of rehabilitation initiatives. Finally, the paper will discuss the way forward for rehabilitation of degraded lands in Africa which would take care of current and emerging issues in landscape rehabilitation.

Forestry Research Institute of Ghana University P. O. Box 63, Kumasi, GANA; dominicblay@yahoo.co.uk

CHANGES IN FOREST SOILS AS THE RESULT OF EXOTIC DISEASES, TIMBER HARVEST, AND FIRE EXCLUSION AND THEIR IMPLICATIONS ON FOREST RESTORATION

Russell T. Graham and Theresa B. Jain

Introduction

In the western United States and throughout the world, three general classes of coniferous forests can be identified with each having similar vegetative complexes, native disturbances, and climate (Daubenmire and Daubenmire 1968, Hann et al. 1997). Dry forests, often dominated by pines (*Pinus*), cold forests often dominated by spruces (*Picea*), and moist forests dominated by hemlocks (*Tsuga*) represent the majority of the world's forests. The soils within each of these forest classifications are a product of their inherent climate and vegetation dynamics. Because soils are the foundation of the forest ecosystem, they are integral to all forest restoration efforts. However, because people value and cherish trees, they are often the focus of most restoration activities and the changes occurring in forests are most noticeable in the tree component. Presently in the western United States the most evident changes in many forests are the large number of trees occupying them compared to the amounts of trees that occurred in historical (pre-1900) forests. In several forests not only has the number of trees increased but their composition is far different than what occurred historically. Normally, in the absence of disturbance, early-seral (shade intolerant) vegetation is succeeded by mid- and late-seral (shade tolerant) vegetation. For example, in the western United States, in the absence of disturbance, quaking aspen (*Populus tremuloides*), an early-seral species, can be succeeded by late-seral ponderosa pine (*Pinus ponderosa*) in some locales in less than 100 years and it may take western redcedar (*Thuja plicata*) hundreds of years to succeed mid-seral western white pine (*Pinus monticola*) (Daubenmire and Daubenmire 1968). Five key disturbances, or the lack thereof, influencing forest successional patterns and rates are human uses and resource extractions, fire, insects, diseases, and weather (Graham and Jain 2006).

In the western United States, harvesting of early-seral species started in earnest early in the 20th Century and by the 1960s, harvesting peaked and by the 1980s it began to diminish (Lewis 2005). This harvesting greatly decreased the amount of old forest structures occurring in the landscape and, along with fire exclusion, facilitated many forests to be dominated by late-seral vegetation. Fire suppression in the United States and in other parts of the world started during the 1800s but only became effective in the 1930s with the development of airplanes, road systems, fire danger ratings, and effective fire fighting techniques (Steen 1976). Insects and diseases, along with weather (e.g., snow, wind, ice), historically influenced forest development, however in concert with harvesting and fire exclusion, their impacts along with climate change appear to be greater than what they were historically. As a result, restoring forests to a desired state or developmental pathway requires the understanding of how all of these disturbances interact with the vegetation within a given biophysical setting. Restoration objectives are relevant to forests in all three classifications but, because the amount of departure or change exhibited in the dry and moist forests is the greatest, we will limit our discussion to these two forest classifications while examining the implications soil changes have on restoration efforts (Covington and Moore 1994, Hann et al. 1997). In addition, we will use the dry and moist forests of the western United States to illustrate how soil, as well as vegetation, should be included in restoration planning and activities. Nevertheless, the concepts we point out will most likely have application in similar forests throughout the world where restoration activities are planned or are being considered.

Moist Forest Changes

In the western United States fire exclusion, insects, diseases, and weather interacted with climate change (climate cycles) to modify the moist forests from those dominated by early- and mid-seral species (e.g., pines) to forests dominated by mid- to late-seral species (e.g., cedar) (Hann et al. 1997). Historically, wildfires burning the moist forests were highly variable. It has been estimated that non-lethal (surface) fires occurred at relatively frequent intervals (15 to 25 yrs) within 25% of the moist forests. Lethal crown fires burned about 25% of the moist forests every 20 to 150 years but occasionally extended to 300 year intervals. The mixed fire regime (combination of lethal and non-lethal) burned about 50% of the moist forests at 20 to 150 year intervals with some lethal events occurring at 300 year intervals. Fires typically started burning in July and were usually out by early September with the change in weather. Most fires were small but occasionally large fires did occur with 74% of fires killing a portion of the canopy. Fire exclusion has impacted the moist forests and

USDA Forest Service, Rocky Mountain Research Station, Moscow, ID, USA; rtgraham@fs.fed.us

it is estimated that surface fires now burn 10% of the moist forests, mixed fires burn 30% and 60% of the moist forests are currently burned by crown fires (Hann et al. 1997).

Although fire exclusion played a role in altering the moist forests of the northern Rocky Mountains, introduction in 1909 of the European white pine blister rust (*Cronartium ribicola*), caused the greatest change (Fins et al. 2001). The disease attacked and killed western white pine, the primary commercial species of the moist forests. Upon introduction of blister rust, a massive effort was initiated to control the disease by removing currant (*Ribes* spp.) bushes (the alternate host). Beginning early in the 1900s and, in earnest during the 1930s, *Ribes* bushes were pulled, sprayed, and grubbed throughout the northern Rocky Mountains. The effort has been described "like bailing the ocean with a teacup" and efforts to control the disease proved futile. By 1968 the western white pine blister rust program and management of the species was "realigned," resulting in the accelerated removal of naturally occurring western white pine before they succumbed to the rust (Hutchison 1942, Ketcham et al. 1968).

The forest changes resulting from the introduction of blister rust were exacerbated by harvesting of ponderosa pine and western larch (*Larix occidentalis*) two additionally high value timber species of the moist forests (Hutchison 1942). The partial and intermittent canopy removal and minimal soil surface disturbance caused by both tree harvest and western white pine mortality were ideal situations for grand fir (*Abies grandis*) and western hemlock (*Tsuga heterophylla*) establishment, which aggressively encroached along with Douglas-fir (*Pseudotsuga menziesii*) and readily filled the niches western white pine, ponderosa pine, and western larch once held (Hann et al. 1997, Jain et al. 2004).

Recent (1991) native insect and pathogen activity in the moist forests far exceed those of the past (Hessburg et al. 1994). The Douglas-fir beetle (*Dendroctonus pseudotsugae*), mountain pine beetle (*Dendroctonus ponderosae*), spruce budworm (*Choristoneura occidentalis*), and tussock moth (*Orgyia pseudotsugata*) historically endemic, are now often epidemic. Similarly, the rot diseases *Armillaria spp*. and *Phellinus weirii* that were historically endemic are now common in the current fir-dominated forests. Weather, another formidable disturbance, in the form of snow or wind, often creates a variety of canopy openings ranging from gaps to large openings (≈16 ha). In early-seral species (ponderosa pine, western larch, western white pine) dominated forests, snow will often slip from the trees, minimizing breakage, while other species in the intermediate crown classes (grand fir, Douglas-fir) will break, creating gaps and openings, decreasing forest densities, and altering species composition. Today, species such as grand fir and Douglas-fir that dominate sites have dense crowns that hold snow often leading to stem breakage, facilitating insect (i.e. Douglas-fir beetle) epidemics and regeneration opportunities for the true firs and hemlocks (Jain et al. 2004, Graham and Jain 2006).

Western white pine, ponderosa pine, and western larch dominated forests are generally tall and self-pruning even in moderately dense stands. They have large branches high in the crowns and the base of the crowns is well above surface fuels. In general, this crown architecture protects the nutrients stored in the canopy from surface fires. In contrast, young- to mid-aged (<150 years) western hemlock and grand fir generally do not self-prune. Forests dominated by grand fir tend to concentrate both nitrogen and potassium in their foliage which often extends to the soil surface. Generally, this combination of a low canopy structure with nutrients and microbial activities concentrated in or near the soil surface make both of these critical ecological resources susceptible to mechanical and fire destruction. This canopy architecture favors lower crown base heights, higher crown densities, and canopies with higher nutrient (especially potassium) content than occur in western larch, ponderosa pine and/or western white pine dominated forests (Harvey et al. 1999, Mika and Moore 1990).

Dry Forest Changes

In the western United States, domestic livestock grazing and harvesting of ponderosa pine forests was occurring by the mid 1800s. In mesic forests, grand fir and/or white fir (*Abies concolor*) and Douglas-fir rapidly colonized these sites when ponderosa pine was harvested. Especially where ponderosa pine was the late-seral species, grass cover tended to decrease ponderosa pine seedling establishment and survival. However, when heavy livestock grazing ceased (and the damage livestock did to seedlings) in the early 1900s in the southwestern United States, dense stands of ponderosa pine seedlings became established. Because of fire exclusion, climate changes, and other factors, these trees readily developed into dense stands (Covington and Moore 1994, Pearson 1950, Stein 1988, Graham and Jain 2006).

Before successful fire exclusion, temperature and precipitation patterns combined with natural and human ignitions, allowed fires to burn the dry forests at relatively frequent (e.g., < 40 years) intervals (Barrett and Arno 1982, Stewart 1951). Cultural burning by Native Americans augmented and even dominated burning in several locations. In the northern Rocky Mountains of Idaho and western Montana, dry settings (late-seral ponderosa pine and/or Douglas fir forests) were historically burned by non-lethal wildfires at 15 to 23 year mean return intervals and these fires could be quite large often burning for weeks to months. Mesic forests containing ponderosa pine (where grand fir and/or Douglas-fir were the late-seral species) were burned frequently by mixed fires at mean return intervals extending to over 60 years. Non-lethal fires dominated the central and southern Rockies (where ponderosa pine and/ or Douglas-fir were late-seral species), although mixed severity fires also occurred, especially along the Front Range of the Rocky Mountains in Colorado. On the driest settings (late-seral ponderosa pine and/or woodlands), because of discontinuous surface fuels, fires tended to be few. In contrast to other locales dominated by late-seral ponderosa pine, the forests of the Black Hills of Wyoming and South Dakota possibly experienced greater extents of lethal fires because of the abundant ponderosa pine regeneration that normally occurred. Nevertheless, historical wildfires likely burned through most ponderosa pine forests leaving in their wake a wide variety of species compositions and vegetative structures arranged in a variety of mosaics (Shepperd and Battaglia 2002, Shinnen and Baker 1997, Bradley et al. 1992).

Within the dry forests, dense conditions often developed, exacerbated by fire exclusion that increased the abundance of insect and disease epidemics, significantly altering the composition and structure of these forests. Historically, western pine beetle (*Dendroctonus brevicomis*), pine engraver (*Ips spp*.), fir engraver (*Scolytus ventralis*), and tussock moth (*Orgyia pseudotsugata*) were insects associated with regularly burned areas. In most years bark beetles occurred at endemic levels in ponderosa pine, Douglas-fir, and grand fir killing large weakened trees that were struck by lightning, infected by root disease (*Armellaria spp*.), or too old to resist attack. Pine engraver and fir engraver beetles attacked young, densely stocked ponderosa pine, killed trees scorched by low-intensity surface fires, and severely infected trees containing root rot or dwarf mistletoe. Because of forest changes, these same insects have reached epidemic levels in many forests and today ponderosa pine continues to be susceptible to the western pine beetle. Mountain pine beetle is affecting current dry forests where Douglas-fir and grand fir are the late-seral species. The pine engraver beetle is more abundant and destructive now with some of the severest outbreaks occurring on low-elevation sites where ponderosa pine is the late-seral species. Pandora moth (*Coloradia pondora*) defoliates ponderosa pine and scattered outbreaks have occurred in Arizona, California, Colorado, and Oregon during the 20th century. Dense stands of Douglas-fir and grand fir that developed where these species are late-seral are very susceptible to both defoliators and root diseases (Harvey et al. 2000, Hessburg et al. 1994).

Harvesting western larch, ponderosa pine, and the ingrowth of grand fir/white fir and Douglas-fir in the dry forests facilitated the accumulation of both above- and below-ground biomass and associated nutrients close to the soil surface. Even low-intensity surface fires often now consume the surface organic layers, killing fine roots, volatilizing nutrients, killing trees, and increasing soil erosion potential. In addition, fir ingrowth creates nutrient-rich ladder fuels that facilitate crown-fire initiation, increasing the likelihood of nutrient loss. The risk of nutrient loss is greater on infertile sites because dense stands of late-seral species are more demanding of nutrients and water than the historical stands dominated by widely-spaced early-seral species (Harvey et al. 1987, Minore 1979, Harvey et al. 1999).

With the advent of fire exclusion, animal grazing, timber harvest, and climate cycles in areas where grand and/or white fir are late-seral species, ponderosa pine is being succeeded by Douglas-fir, grand fir and/or white fir. Fire intolerant vegetation, dense forest canopies, and homogenous and continuous horizontal and vertical structures are developing thus creating forests favoring crown fires rather than low intensity surface fires that historically occurred in these forests. Within the Northwestern United States, the extent of mid-seral (e.g., Douglas-fir, grand fir) vegetation has increased by nearly 8 million acres and the extent of single storied mature vegetation (e.g., ponderosa pine) has decreased by over 4 million acres since the early 1900s (Hann et al. 1997). Another way to view these changes is that the successional processes in some locations have been compressed by a factor of at least 10. For example, ponderosa pine may or may not be succeeded by grand fir in 300 to 400 years within forests historically burned by frequent fires but in many locations grand fir has succeeded ponderosa pine in less than 50 years. Grand fir in particular has the propensity to concentrate nutrients in their foliage and when these trees are burned by wildfires or prescribed fires, nutrients in these abnormal forest structures can be lost from the forest. Nitrogen can be replaced through fixation (i.e., symbiotic or non-symbiotic), deposition, and lightning relatively quickly (10s to 100s of years), however, nutrients such as potassium are replaced through the weathering of rocks, a very long-term (100s to 1000s of years) process (Gruell et al. 1982, Harvey et al. 1999, Smith and Arno 1999).

Forest Floor Changes

The shift in species composition from western white pine, western larch and/or ponderosa pine to Douglas-fir, grand fir/white fir, and/or western hemlock dominated forests (including the shrub and forb components) has changed litter (soil surface) type from that which occurred historically. In addition, the accumulation of both above- and below-ground biomass from roots, needles, and boles in fir forests is accelerating activities of decomposers by increasing and changing the basic substrate they utilize. Associated with these changes in litter type and quantity is a likely change in ectomycorrhizal relationships, soil surface chemistry, including allelopathic substances with the potential to alter a variety of microbial activities (Harvey et al. 1999, Harvey et al. 2000). Also, these forest floor alterations have been exacerbated in many locales singly, or in combination, by soil compaction and displacement, fire exclusion, timber harvesting, animal grazing, and climate shifts. For example, decomposed true firs create white rotten wood which rapidly disperses into the soil and is quickly consumed by decomposers. In contrast, decomposed ponderosa pine, western white pine, and western larch create brown rotten wood which can persist in soil for centuries and has been shown to retain nutrients and hold water. Western larch and ponderosa pine tend to be deep-rooted in contrast to the relatively shallow-rooted western hemlock and grand fir, which have abundant feeder roots and ectomycorrhizae in the shallow soil organic layers. The soil microbial activities in fir-dominated forests compared to pine-dominated forests may diminish the post-fire acquisition and cycling of nutrients. Moreover, these changes in soil microbial activities may increase the likelihood of uncoupling any continuity between current and preceding vegetative communities (Harvey et al. 1987, Harvey et al. 1999, Harvey et al. 2000, Graham and Jain 2006).

In the dry forests, biological decomposition is more limited than biological production. When fire return intervals reflected historical fire frequencies, the accumulation of thick organic layers was minimized and nutrient storage and nutrient turnover was dispersed into the mineral soils. In the absence of fire, bark slough, needles, twigs, and small branches can accumulate on the forest floor allowing ectomycorrhizae and fine roots of all species to concentrate in the surface mineral soil and thick organic layers. In addition, historical ponderosa pine forests were likely well-matched to soil resources, relatively resistant to detrimental fire effects, well-adapted to wide ranges of site and short-term climate variation, subject to modest (largely beneficial) insect and pathogen mortality and could be considered long-lived and relatively stable. In contrast, forests that were dominated by ponderosa pine and are now dominated by Douglas-fir, grand fir or white fir are probably not well-matched to soil resources and are also not likely resistant to the wide range of site and climate variations found within the dry forests. As a result, they are often subject to high insect and pathogen mortality and can not be considered either long-lived or stable (Harvey et al. 1999).

Restoration Strategies

Even though trees are the dominant forest structures associated with restoration strategies soils and changes in them that may have occurred because of the disruption or alteration of disturbances are integral to all restoration activities. In general, restoration strategies that affect soils can be direct or indirect. Very often the reintroduction of fire directly into forests in which the natural fire regime has been interrupted for decades is suggested as a restoration tool. As mentioned before, deep layers of organic materials often accumulate on the forest floor in the absence of fire, and if they are not managed appropriately, both soil and tree structures can be damaged when the forest floor is burned. We have applied prescribed fire around the base of large trees and mixed the surface of these layers when the lower forest floor (duff) layers are cool (< 4.4° C) and their moisture contents exceed 100%. We have successfully reduced the amount of organic materials around these trees without stressing or killing them. However, depending on the amount of material accumulated, it may take numerous treatments to reduce these uncharacteristic depths to levels reminiscent of those that occurred historically. When the forest floor conditions warrant it, appropriately planned fires can be broadcast throughout the forest reducing the risk of killing these often large and valuable trees. Raking away the deep organic layers from the base of trees may prevent heat from killing the cambial tissue during a fire but if fine roots occur in these layers, this physical destruction may stress or even kill the tree similar to destroying them with fire. These conditions do not develop in all dry forests in which fire has been excluded but it can easily be checked by grabbing a hand sample of organic material and, if roots are present, judicious application of fire is warranted (Graham and Jain 2006).

Particularly in the moist forests, a large proportion (≈40%) of the surface organic layers and incorporated into the mineral soil can be decayed wood. This material is often rich in nutrients and water, is the site of numerous fine roots and the center of ectomycorrhizal activity (Harvey et al. 1987). The source of these materials is coarse woody debris (CWD) and the manipulation of CWD indirectly affects these soil materials. CWD originates from tree boles and large limbs usually defined as materials exceeding 8.0 cm in diameter. Historically CWD did not readily accumulate in the dry forests burned by frequent fires but in forests having mixed and lethal fire regimes where these materials often accumulated between fires. When groups and patches of trees were killed by a fire, the fallen dead boles could be readily buried by eroding soil. These materials, depending on the forest setting, contributed to the organic component of the forest soil. After a major disturbance (e.g., wildfire, timber harvest), to ensure that this soil component is readily available to future forests, 6.5 to 37.0 Mg ha^{-1} of CWD are recommended depending on the forest locale (Graham et al. 1994). Over the years these materials can be buried and/or decompose and slowly become part of the soil matrix. If there is a choice between species of CWD to leave or manage for, those that form red-rotted materials (e.g., pines) are preferred to those forming white-rotted materials (e.g., true firs) because red-rotted materials are much longer lasting (100s vs. 10s of years) (Reinhardt et al. 1991, Harvey et al. 1999, Harvey et al. 2000, Graham and Jain 2006) .

The uncharacteristic plurality of mid- and late-seral species occupying many forests not only alters the rotten wood dynamics in forests but these species tend to concentrate nutrients in their foliage. The removal or burning of this mid- and/or late-seral tree encroachment can remove nutrients which are often in short supply. Forest treatments can be tailored to restore the desired forest structures yet conserve the nutrients. Mechanical mastication of these often fine fuels can be used to keep the nutrients on site but these treatments need to be applied to not exacerbate the fire hazard. Depending on the forest locale this can be accomplished by creating a variety of materials and creating a variety of forest floor conditions that encourage the decomposition of the materials.

Restoration activities can conserve organic materials and, where they are depauperate, activities encouraging their creation are warranted. Mechanical piling and mastication of forest residues can be used to manage CWD and fine materials but, as in all forest management activities, the conditions of the soils and materials after mechanical treatments depend on the machine used, the biophysical conditions of the forests, and more importantly the operator of the machine. The operator determines the conditions of the organic material after treatment and the amount of allied soil disturbance (e.g., soil compaction and displacement). There is a trend, especially near urban areas to chip small trees, limbs, and CWD as a method of decreasing the fire hazard. Thin layers of wood chips spread on the forest floor tend to dry and rewet readily and deep layers of chips and chip piles may have insufficient air circulation making both conditions poor for decomposition. When layers of small woody material are spread on the forest floor they can insulate the soils and when decomposition does occur, the decomposing organisms utilize large amounts of nitrogen reducing its availability to plants. Large chunks and a variety of piece sizes and their uneven dispersal create conditions favorable for rotting organisms no matter the fungal species, its favored substrate, or its moisture and heat requirements.

Fire is very appropriate for use in restoring forests and forest soils. However, unless fuel and weather conditions are appropriate, fire can create conditions adverse to vegetative development and impair soil productivity. The amount of forest floor consumed by a fire is dependent on its moisture content particularly in the lower humus and fermentation layers. Fire applied when the moisture content of these lower duff layers exceeds 100% most often conserves the organic materials. Burning under these conditions, the nutrients (P, N, K) in the litter and fine fuels (≤ 8.0 cm) have the opportunity to condense in these lower layers and, therefore, are not lost from the site. Fires that leave a variety of burn severities also create a multitude conditions for seed germination and vegetation development (Ryan 1982, Hungerford et al. 1991).

Integrated Soil and Organic Material Restoration Strategies

Even though the concept of integrating soil and organic material into restoration strategies might appear to be new, they have their genesis in the practice of silviculture. Silviculture is the art and science managing forests to meet management objectives and restoration is a very appropriate objective. In addition, soils and organic materials are integral forest components and are as appropriate as trees for focusing silvicultural methods and systems. A silvicultural system is a planned series of treatments through the life of a forest and using such an approach for planning soil restoration treatments is appropriate. In addition, such activities could be incorporated into holistic silvicultural systems that integrate all forest components relevant to contemporary forest management objectives including, but not limited to restoration, timber, wildlife habitat, or water production to name a few (Graham and Jain 2004).

Literature Cited

Barrett, S. W.; Arno, S. F. 1982. Indian fires as an ecological influence in the Northern Rockies. *Journal Forestry* 80(10): 647-651.

Bradley, A. F.; Fischer, W. C.; Noste, N. V. 1992. Fire ecology of the forest habitat types of eastern Idaho and western Wyoming. Forest Service, General Technical Report INT-290. 92 p.

Covington, W. W.; Moore, M. M. 1994. Post-settlement changes in natural fire regimes and forest structure: Ecological restoration of old-growth ponderosa pine forests. In: *Assessing forest ecosystem health in the Inland West*. New York: The Haworth Press Inc. 153-181.

Daubenmire, R.; Daubenmire, J. B. 1968. Forest vegetation of eastern Washington and northern Idaho. Technical Bulletin 60. Pullman, WA: Washington Agricultural Experiment Station. 104 p.

Fins, L. Byler J.; Ferguson, D.; et al. 2001. Return of the giants: Restoring white pine ecosystems by breeding and aggressive planting of blister rust-resistant white pines. Moscow, ID: University of Idaho. 20 p.

Graham, R. T.; Jain, T. B. 2004. Past, Present and Future Role of Silviculture in Forest Management. In: Forest Service, RMRS-P-34. 1-14.

Graham, R. T.; Harvey, A. E.; Jurgensen, M. F. et al. 1994. Managing coarse woody debris in forests of the Rocky Mountains. Forest Service, Research Paper INT-RP-477. 13 p.

Graham, R. T.; Jain, T. B. 2006. Ponderosa pine ecosystems. In: Forest Service, General Technical Report PSW-GTR-198. 1-32.

Gruell, G. E.; Schmidt, W. C.; Arno, S. F.; et al. 1982. Seventy years of vegetative change in managed ponderosa pine forest in western Montana: implications for resource management. Forest Service, General Technical Report GTR-INT-130. 42 p.

Hann, W. J.; Jones, J. L.; Karl, M. G., et al. 1997. Chapter 3: Landscape dynamics of the Basin. In: Forest Service, General Technical Report PNW-GTR-405. 338-1055.

Harvey, A. E.; Jurgensen, M. F.; Larsen, M. J.; et al. 1987. Decaying organic materials and soil quality in the Inland Northwest: a management opportunity. Forest Service, General Technical Report INT-225. 15 p.

Harvey, A. E.; Graham, R. T.; McDonald, G. I. 1999. Tree species composition change- Forest soil organism interaction: potential effects on nutrient cycling and conservation processes in interior forests. In: Forest Service, General Technical Report PNW-GTR-461. 137-145.

Harvey, A. E.; Graham, R. T.; McDonald, G. I. 2000. Fire/decay: managing codependent processes across the landscape. In: Joint fire science conference and workshop. International Association Wildland Fire. 179-189.

Hessburg, P. F.; Mitchell, R. G.; Filip, G. M. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. In: Eastside forest ecosystem health assessment, Volume III, Forest Service, Pacific Northwest Research Station. 72 p.

Hungerford, R. D.; Harrington, M. G.; Frandsen, W. H.; et al. 1991. Influence of fire on factors that affect site productivity. In: Forest Service, General Technical Report INT-280. 32-50.

Hutchison, S. B.; Winters, R. K. 1942. Northern Idaho forest resources and industries. Miscellaneous Publication 508. U.S. Department of Agriculture. 75 p.

Jain, T. B.; Graham, R. T.; Morgan, P. 2004. Western white pine growth relative to forest openings. *Canadian Journal Forest Research* 34: 2187-2197.

Ketcham, D. A.; Wellner, C. A.; Evans, Jr. S. S. 1968. Western white pine management programs realigned on Northern Rocky Mountain National Forests. *Journal Forestry* 66(4): 329-332.

Lewis, J. G. 2005. *The Forest Service and the Greatest Good: A Centennial History*. Durham, NC: Forest History Society. 286 p.

Mika, P. G.; Moore, J. A. 1990. Foliar potassium explains Douglas-fir response to fertilization in the Inland Northwest. *Water, Air, and Soil Pollution* 54: 477-491.

Minore, D. 1979. Comparative autecological characteristics of northwestern tree species---A literature review. Forest Service, General Technical Report PNW-87. 72 p.

Pearson, G. A. 1950. Management of ponderosa pine in the southwest as developed by research and experimental practice. Monograph 6. Forest Service. 218 p.

Reinhardt, E. D.; Brown, J. K; Fischer, W. C.; et al. 1991. Woody fuel and duff consumption by prescribed fire in northern Idaho mixed conifer logging slash. Forest Service, Research Paper INT-443. 22 p.

Ryan, Kevin C. 1982. Burning for site preparation on steep-slope helicopter-logged clearcuts in northwestern Montana. In: Symposium proceedings: site preparation and fuel management on steep terrain. Pullman, WA: Washington State University. 25-33.

Shepperd, W. D.; Battaglia, M. A. 2002. Ecology, silviculture, and management of Black Hills ponderosa pine. Forest Service, General Technical Report RMRS-GTR-97. 112 p.

Shinnen, D. J.; Baker, W. L. 1997. Non equilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. *Conservation Biology* 11(6): 1276-1288.

Smith, H. Y.; Arno, S. F. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Forest Service, General Technical Report RMRS-GTR-23. 55 p.

Steen, H. K. 1976. *The U.S. Forest Service*. Seattle and London: University of Washington Press. 356 p.

Stein, S. J. 1988. Explanations of imbalanced age structure and scattered distribution of ponderosa pine within a high-elevation mixed coniferous forest. *Forest Ecology and Management* 25: 139-153.

Stewart, O. C. 1951. Burning and natural vegetation in the United States. *Geographical Review* 41: 317-320.

BROAD-SCALE RESTORATION OF LANDSCAPE FUNCTION WITH TIMBER, CARBON AND BIOENERGY INVESTMENT

R.J. Harper [1,3,4] K.R.J. Smettem[2,4], J.F. McGrath [1,3] and J.R. Bartle [4]

Abstract—Salinization threatens up to 17 million ha of Australian farmland, major fresh water resources, biodiversity and built infrastructure. In higher rainfall (>600 mm yr^{-1}) areas of south-western Australia a market-based approach has resulted in the reforestation of 250,000 ha of farmland with *Eucalyptus globulus* pulpwood plantations. This has had significant collateral environmental benefits in terms of reducing salinity and restoring landscape function in several key water supply watersheds. This success has not been replicated in the lower (300-600 mm yr^{-1}) rainfall areas of this region, which is a global biodiversity hotspot. Wood yields are lower and there is often a land-holder preference to maintain existing agricultural activities. Several new forest products, such as sequestered carbon and biomass for renewable energy generation, are being evaluated as it is considered that a multi-product approach is more likely to be profitable than timber production alone. Carbon sequestration may occur both as an adjunct to wood production systems and also where restoration of biodiversity is the primary aim. The development of full markets for these products is dependent on the establishment of national emissions and renewable energy policies and targets, and in the case of liquid biofuels further technological development.

Three broad approaches to integrating trees into the dryland farming systems are being assessed viz. (a) belts of trees with farming maintained in the alleys, (b) blocks of trees located on areas of water accumulation or of high recharge, and (c) short phases (3-5 years) of trees alternated with cropping. Both the alley and phase farming systems offer the prospect of producing biofuels from farmland without either using food-grains or displacing farming production. Paradoxically, for systems that are attempting to stabilize landscape hydrology, a major issue for reforestation is water management and this can be manipulated through species selection, tree placement and canopy management. If inappropriate species or planting densities are used, in relation to a site's water supply, the trees will die. Although this is an aim of the phase farming system, for the other systems, avoidance of annual and periodic drought is a prime consideration.

A number of major environmental issues currently confront Australia. These include the relentless salinization of land and water resources, recurrent wind and water erosion and the prospect of climate change due to increases in the concentration of greenhouse gases in the atmosphere. In south-western Australia it is estimated that without remedial actions up to 7 million ha of land will be affected by salinity by 2050 (National Land and Water Resources Audit, 2001), all inland watersheds will be salinized, up to 450 species are at risk of extinction (Keighery et al. 2004) and apart from significant loss of farmland productivity (Kingwell et al. 2003) there is significant threat to infrastructure (State Salinity Council 2000). Part of this region comprises one of 25 global biodiversity conservation hotspots (Myers et al. 2000).

Salinization in this region is caused by the remobilization of salts stored in deep regolith by rising groundwater, following the replacement of deep-rooted perennial plants with shallow rooted, annual plants, and consequent groundwater recharge (Peck and Williamson 1987). There is evidence that salinity has been a cyclical phenomenon, albeit at millennial timescales in this landscape, with previous periods of salinization and recovery, (Harper and Gilkes 2004). It has long been known that watershed reforestation will restore the hydrologic balance (Wood 1924) and thus reverse salinization; however the scale of investment required is immense. Investment in reforestation from public funds, at the scales required, is likely to be limited. Shea and Bartle (1988, 1989) advocated the concept that providing favourable economic and policy settings for reforestation would result in its widespread adoption by external investors, with consequent collateral environmental benefits. This has in fact occurred, with the model of self-funding land conservation resulting in Australian and foreign timber companies establishing 250,000 ha of *Eucalyptus globulus*

[1] Forest Products Commission, Locked Bag 888, Perth Business Centre, Perth, WA. Australia. 6849; richard.harper@fpc.wa.gov.au
[2] Agricultural and Eco-Hydrology Group, School of Environmental Systems Engineering, The University of Western Australia, Nedlands, WA. 6849. Australia.
[3] Cooperative Research Centre for Forestry, Private Bag 12, Hobart, Tasmania 7001 Australia.
[4] Cooperative Research Centre for Plant Based Management of Dryland Salinity, The University of Western Australia, Nedlands, A. 6849. Australia.

plantation since 1990 (National Forest Inventory 2006). Analysis suggests that some watersheds, such as those of the Denmark and Collie Rivers that were previously salinizing, now have either stabilizing (Mauger et al. 2001) or reducing (Bari et al. 2004) salt loads.

This reforestation success, however, has been restricted to the >600 mm rainfall zone of south-western Australia. Salinity is also a major issue in the 300-600 mm rainfall zone, a region that comprises around 15 million ha of cleared farmland. Land use comprises rotations of cereal cropping with annual improved pastures, with farming having replaced a range of natural vegetation communities including woodlands. Forestry has not achieved widespread adoption for reasons including sub-economic yields and large transport distances to processing and export facilities.

Several approaches are being developed in this region to replicate the success of widespread, privately funded reforestation in the higher rainfall areas and stabilize landscape hydrology and function. These are described in this paper.

New species and products from trees

One approach to the problem of lower profitability from forestry in areas with limited rainfall is to seek multiple products from one stand of trees. These not only include traditional products such as timber as sawlogs or reconstituted wood products, from a range of species such as *Pinus pinaster, Eucalyptus saligna* and *E. cladocalyx*, but also potential new products such as sequestered carbon and biomass for electricity or liquid fuel production (Table 1). There have been preliminary attempts to develop other environmental markets based on payments for land, water and biodiversity conservation benefits both in this region and eastern Australia.

Table 1. New tree species and products in the 300-600 mm rainfall zone.

Species	Products	Target area (mm annual rainfall)
Pinus pinaster	Timber, carbon sequestration, biofuel	>500
Eucalyptus saligna, E. cladocalyx	Timber, carbon sequestration, biofuel	>500
Mallee eucalypts	Carbon sequestration, biofuel, activated carbon	300-600
Biodiversity restoration	Carbon, biodiversity	>300

Carbon sequestration

Increased concentrations of greenhouse gases have been linked to global warming. The international response to this warming, the Kyoto Protocol to the United Nations Framework Convention on Climate Change includes provisions that enable greenhouse sinks, or the sequestration of carbon in soils and vegetation to be used by Parties to fulfill their obligations. The Kyoto Protocol also allows for trading in emission reductions, and this opens the possibility that investment in carbon sinks may help underwrite broader natural resource management objectives (Shea et al. 1998, Koziell and Swingland 2002, Sandor et al. 2002). Consequently, the Western Australian Government passed the Carbon Rights Act 2003 which establishes a statutory basis for the ownership and protection of carbon rights, in order to facilitate trading. Although the Kyoto Protocol has not been ratified by Australia it is likely that a national emissions trading scheme will develop and this will include carbon sequestration on reforested farmland.

Harper et al. (2003, 2007) estimate that the total amount of carbon that could be sequestered by reforesting cleared farmland, under Article 3.3 of the Kyoto Protocol, is 2.2 billion tonnes CO2-e, with the amount sequestered decreasing in a general fashion with decreasing rainfall, and also depending on the amount of farmland actually planted. Carbon sequestration can occur as a result of a range of reforestation activities, ranging from being an adjunct of timber production to being the sole product from the restoration of biodiversity in natural woodlands (Table 1). In the latter case, carbon investment will provide a direct route to landscape and biodiversity restoration, although the rates of sequestration with native species may be less than those produced by plantation systems (Harper et al. 2007).

Biomass

Woody plant materials have potential both as a feedstock for electricity production or for liquid fuels (Bartle 2001, Schuck 2006) and where these replace fossil fuels they represent a means of reducing net greenhouse gas emissions. In the case of electricity production a 1 MW trial plant has been built and evaluated in the region, with this also including other products such as eucalyptus oils and activated carbon (Schuck 2006). The technology for industrial-scale production of liquid fuels from woody materials is still under development. The rate of adoption of biomass production will also depend on state and national renewable energy policies, the cost competitiveness of biomass compared with oil-based fuels and alternative renewable energy sources and the demand for reconstituted wood products.

Integrating forestry with agriculture

The major approach in the 300-600 mm yr^{-1} rainfall zone has been to integrate forestry with agriculture and thus maintain agricultural production, in contrast to higher rainfall areas where there has been a replacement of farming with forestry. Hatton et al. (2003) question whether it is possible to obtain a landscape water balance similar to that which occurred prior to deforestation on the basis that the reforested systems will not have leaf areas approaching those of the natural vegetation. Despite this prognosis, three main approaches to integrate trees into farming systems appear promising:

1. Belts of trees arranged across the landscape, with agriculture practiced in the alleys between. The premise of this system is that the belts of trees will intercept surface and groundwaters before they salinize the valleys. Despite soil profiles that often comprise clays with bulk densities of up to 2.0 Mg m^{-3} the roots of mallee eucalypts can penetrate to depths of 5 to 10 m within 7 years of planting and 12 to 40 m laterally (Robinson et al. 2006, Wildy et al. 2004). Although this extensive exploration of soil profiles provides access to additional moisture and will boost tree productivity it may result in competition for moisture with crops, particularly in drier years. Species that can be used in this system include coppiced eucalyptus mallees (Bartle 2001), producing biomass and sequestering carbon particularly in the roots, or eucalyptus species such as *E. cladocalyx*. This latter species is suitable for both timber production and carbon sequestration.

2. Identifying soils and landscape positions that either contribute greater amounts of recharge to groundwaters, or accumulate surface waters and allow greater productivity. Harper et al. (2005) combined soil and climate data with a simple water balance model to identify areas in a watershed that contributed a disproportionate amount of recharge to groundwater, in relation to their areal extent. A reforestation strategy aimed at restoring landscape function would identify and plant these areas first. Relatively fresh water can accumulate in lower landscape positions, both as a result of surface flows in response to peak rainfall events (Gregory et al. 1992) or as seepage from perched groundwater (George 1990). Access to such water, in addition to that provided by rainfall, may also extend the profitable range of different forest enterprises (Cooper et al. 2005). Similarly, it may be possible to enhance water supply by capture and diversion of water on slopes.

3. Phase farming with trees (PFT) is a concept that is based on the assumption that trees will rapidly deplete soil moisture profiles to sufficient depth (>10 m) to provide a dry soil buffer for leakage from subsequent agricultural crops (Harper et al. 2000). This has been subsequently shown to occur with soil water contents depleted to wilting point to depths of 6.5 m beneath high density (4000 stems ha^{-1}) plantings of *E. occidentalis* within 3 years of planting (Harper et al. in review). Assuming a recharge rate of 40 mm yr^{-1} this could result in a cropping rotation of 3 years trees and 11-20 years of agriculture. Rates of total dry biomass production varied with species, planting densities and slope position, with biomass yields of 15-22 t ha^{-1} 3-yr^{-1} possible (Sochacki et al. in press), or around 8.6 million tonnes of biomass a year on a sustainable basis, when planted on suitable land. To optimize biomass production and water use in this system a balance is required between planting density and water availability for a particular site.

Both the alley and phase farming systems offer the prospect of producing biofuels from farmland without either using food-grains or displacing farming production.

Paradoxically, for systems that are attempting to stabilize landscape hydrology, a major issue in drier areas is managing water supply to the trees. South-western Australia is a region with a Mediterranean climate which is characterized by an annual summer drought, winter droughts with a return frequency of around 10 years and strong prospects of future climate change. If inappropriate species or planting densities are used, in relation to a site's water supply, the trees will die. Although this doesn't matter for the phase farming system, lessening the impact of drought is the major aim of systems that involve permanent reforestation. Strategies to achieve this include site selection procedures that avoid shallow soils and silvicultural management, particularly by managing leaf area, and the selection and breeding of species that have better tolerance to these conditions.

Conclusions

Widespread forest landscape restoration has occurred in the higher (600 mm yr^{-1}) rainfall areas of south-western Australia as a result of the identification and development of a profitable reforestation investment. Approaches that consider the production of multiple products from reforestation, including carbon sequestration and biomass appear promising for the 300-600 mm yr^{-1} rainfall zone, given the current widespread concern with climate change, as both represent mitigation options. Systems that integrate reforestation with farming also appear promising as a means of restoring landscape hydrological balance and landscape function. Financial mechanisms to recognise and value land and biodiversity conservation benefits are also needed to stimulate reforestation at the required scale.

Literature Cited

Bari, M.A., Mauger, G.W., Dixon, R.N.M., Boniecka, L.H., Ward, B., Sparks, T. and Waterhouse, A.M. 2004. Salinity situation statement Denmark River. WRT 30, Department of Environment (Western Australia), Perth.

Bartle, J.R., 2001. New perennial crops: Mallee eucalypts - a model, large scale perennial crop for the wheatbelt, Managing Agricultural Resources. Proceedings of Outlook Conference 2001. ABARE, Canberra, Canberra, pp. 117-128.

Bartle, J.R. and Shea, S., 1989. Development of a pulpwood cropping industry in Western Australia. *Land and Water Research News* 1: 5-9.

Cooper, D., Olsen, G. and Bartle, J., 2005. Capture of agricultural surplus water determines the productivity and scale of new low-rainfall woody crop industries. *Australian Journal of Experimental Agriculture* 45: 1369-1388.

George, R.J. 1990. Reclaiming sandplain seeps by intercepting perched groundwater with eucalypts. *Land Degradation and Rehabilitation* 2: 13-25.

Gregory, P.J., Tennant, D., Hamblin, A.P. and Eastham, J. 1992. Components of the water balance on duplex soils in Western Australia. *Australian Journal of Experimental Agriculture* 32: 845-855.

Harper, R.J., Beck, A.C., Ritson, P., Hill, M.J., Mitchell, C.D., Barrett, D.J., Smettem, K.R.J. and Mann, S.S., 2007. The potential of greenhouse sinks to underwrite improved land management. *Ecological Engineering* 29: 329-341.

Harper, R.J. and Gilkes, R.J. 2004. Aeolian influences on the soils and landforms of the southern Yilgarn Craton of semi-arid, south-western Australia. *Geomorphology* 59: 215-235.

Harper, R.J., Hatton, T.J., Crombie, D.S., Dawes, W.R., Abbott, L.K., Challen, R.P. and House, C. 2000. Phase farming with trees: a scoping study of its potential for salinity control, soil quality enhancement and farm income improvement in dryland areas of southern Australia, Rural Industries Research and Development Corporation, Canberra.

Harper, R.J., Robinson, N., Smettem, K.R.J. and Sochacki, S.J. In review. Phase farming with trees: the acceleration of farm forestry to combat dryland salinity, Rural Industries Research and Development Corporation, Canberra.

Harper, R.J., Smettem, K.R.J. and Tomlinson, R.J. 2005. Using soil and climatic data to estimate the performance of trees, carbon sequestration and recharge potential at the catchment scale. *Australian Journal of Experimental Agriculture* 45: 1389–1401.

Hatton, T.J., Ruprecht, J. and George, R.J. 2003. Preclearing hydrology of the Western Australian wheatbelt: Target for the future? *Plant and Soil* 257: 341-356.

Keighery, G.J., Halse, S.A., Harvey, M.S. and N.L., M. (Editors). 2004. A biodiversity survey of the Western Australian Agricultural Zone. *Records of the Western Australian Museum Supplement* 67, 384 pp.

Kingwell, R., Hajkowicz, S., Young, J., Patton, D., Trapnell, L., Edward, A., Krause, M. and Bathgate, A. 2003. Economic evaluation of salinity management options in cropping regions of Australia, Grains Research and Development Corporation and National Dryland Salinity Program, Canberra.

Mauger, G.W., Bari, M., Boniecka, L., Dixon, R.N.M., Dogramaci, S.S. and Platt, J. 2001. Salinity situation statement Collie River. WRT 29, Water Resources Commission.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.

National Forest Inventory. 2006. Australia's Plantations 2006. Department of Agriculture, Fisheries and Forestry, Canberra.

National Land and Water Resources Audit. 2001. Australian Dryland Salinity Assessment 2000. Extent, impacts, processes, monitoring and management options. National Land and Water Resources Audit, Canberra.

Peck, A.J. and Williamson, D.R. 1987. Effects of forest clearing on groundwater. *Journal of Hydrology* 94: 47-65.

Robinson, N., Harper, R.J. and Smettem, K.R.J. 2006. Soil water depletion by Eucalyptus spp. integrated into dryland agricultural systems. *Plant and Soil* 286: 141-151.

Shea, S.R. and Bartle, J.R. 1988. Restoring nature's balance: the potential for major reforestation of south western Australia. *Landscope* 3: 3–14.

Sochacki, S.J., Harper, R.J. and Smettem, K.R.J. In press. Estimation of woody biomass from a short rotation bioenergy system in semi-arid Australia. *Biomass and Bioenergy*, in press.

State Salinity Council, 2000. Natural Resource Management in Western Australia. The Salinity Strategy, Government of Western Australia.

Wildy, D.T., Pate, J.S. and Bartle, J.R. Budgets of water use by Eucalyptus kochii tree belts in the semi-arid wheatbelt of Western Australia. *Plant and Soil* 262: 129-149.

Wood, W.E., 1924. Increase of salt in soil and streams following destruction of the native vegetation. *Journal of the Royal Society of Western Australia* 10: 35-47.

THE ROLE OF FOREST LANDSCAPE RESTORATION IN SUPPORTING A TRANSITION TOWARDS MORE SUSTAINABLE COASTAL DEVELOPMENT

Peter R. Burbridge[1]

Abstract—This paper presents a case for integrating Forest Landscape Restoration into the principles and practice of Integrated Coastal Management as a means of supporting the transition towards more sustainable use of coastal areas and coastal ecosystems. Two examples of non-sustainable use of coastal forest systems are presented to illustrate how Forest Landscape Restoration could be used to support the return of these systems to productive use as well as helping to maintain the health and productivity of other coastal ecosystems. The complementarity of the principles for Integrated Coastal Management and Forest Landscape Restoration is examined to illustrate how these two development planning and management mechanisms can be integrated. Common obstacles to the implementation of Integrated Coastal Management and Forest Landscape Restoration are identified and elements of good practice that can be used to overcome such obstacles are presented. The paper concludes with the identification of potential social and economic benefits that could be derived from integrating Forest Landscape Restoration into the principles and practice of Integrated Coastal Management.

Coastal areas are under great pressure from development throughout the world. Various estimates indicate that some 60% of the World's population lives within 100 km of the sea and some 75% of urban areas with more than 1.5 million inhabitants are located in estuaries or open coastlines (Bodungen and Turner 2001). Poorly planned and managed development in coastal areas has led to wide-scale degradation of coastal systems, including forests. In Europe estimates suggest that more than 70% of Europe's coastal areas have been degraded (EC 1999). In tropical regions there have been major pressures to develop coastal areas that have, in many cases, proved non-sustainable.

It is anticipated that coastal regions will be the focus for future development and that the resulting pressures will increase competition for access to and use of coastal areas. Unless major advances are achieved in coastal area planning and management, and in watershed management, there will be increased stress on coastal systems.

Coastal forest systems in the tropics, and to a lesser extent in temperate regions, have been a major focus for conversion to other uses. Many of these developments have proven non-sustainable. Examples include conversion of tidal swamp forests for irrigated rice cultivation in Sumatra (Collier 1979, Burbridge et al. 1981), conversion of *Melaleuca* wetland forests for agriculture in Vietnam (Maltby et al. 1996), and conversion of mangrove forests to shrimp mariculture in areas of Asia and Latin America (Stevenson and Burbridge 1997). In Thailand some 70% of the mangrove found along the Gulf of Thailand has been degraded through the development of shrimp ponds, urban development, development of infrastructure, and mining of placer deposits of tin in mangrove systems (Stevenson et al. 1999, Kongsangchai 1984). The destruction of these coastal forests has led to the loss of a wide range of economic and environmental goods and services that could sustain many different forms of economic and social development (Turner et al. 1997, Burbridge 1994, Dixon and Burbridge 1984, Burbridge et al. 1981)

The destruction and mismanagement of coastal forests and other coastal ecosystems has resulted in many coasts being in a state of almost continuous dis-equilibrium (Burbridge and Pethick 2002). As a result of this dis-equilibrium and the impacts of poorly planned and managed development in watersheds upstream, including the clearance of forests to accommodate alternative forms of development, human uses of coastal areas have been made more vulnerable to natural hazards such as flooding. There has been increased funding for international programmes designed to study the relationships between watershed management and coastal development. Examples include the EUROBASINS studies, and Hill to Ocean (H20). However, FLR does not appear to be playing a central role in such studies.

There are initiatives to rehabilitate tropical coastal forest systems. However, the success of these initiatives will depend heavily upon a wide range of factors, including:

[1] Professor Emeritus Tropical Coastal Management, University of Newcastle-upon-Tyne United Kingdom; pburbridge@gmail.com

[2]The term Integrated Coastal Zone Management ICZM is also used to define the zone of transition from purely marine to purely terrestrial environments, however this has lost favour as a result of growing recognition of the trans-boundary management considerations, such as changes in hydrology, that have a major impact on the management of coastal areas and human activities.

- Competition for access to and use of coastal systems
- Public support from stakeholders
- Adverse interactions among coastal development activities
- Sectoral-based management of coastal development
- Poor watershed management
- Failure to link watershed management with coastal area development
- Global change, including climate change and the influence of man on hydrology, sediment budgets, energy and nutrients reaching coastal systems from upland areas.

Forest Landscape Landscape Restoration concepts and principles could help to sustain the rehabilitation of coastal forest systems and reduce the vulnerability of coastal development from natural and man-induced hazards, such as flooding.

Concepts and Principles of Integrated Coastal Management

During the past 35 years, increasing recognition of problems associated with poorly planned and managed development in coastal regions has led to the development of concepts and principles to support more integrated forms of coastal development, including the conservation of coastal ecosystem functions. A new discipline termed Integrated Coastal Management (ICM)[2] has been adopted by many countries as a means of promoting more sustainable use of coastal areas and natural resources (Chua 2004, Sorenson 2000, 2002). This has been complemented by the development of watershed management concepts and principles and more recently by the principles and good practices of Forest Landscape Management (Maginnis and Jackson 2002, ITTO

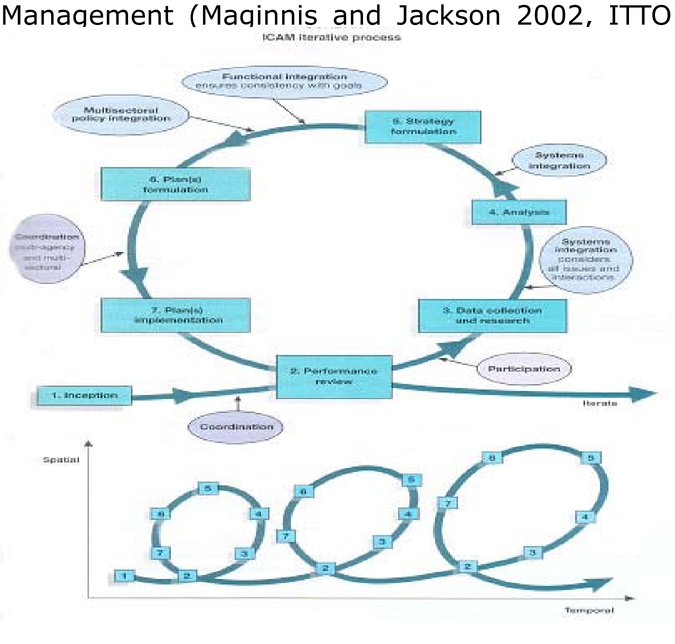


Figure 1. The iterative process of Integrated Coastal Management. (Source: Olsen 2001).

2002, WWF 2002).

The Concepts of ICM—Integrated Coastal Management (ICM) describes a framework and process for formulating and implementing plans and management strategies to promote wise and sustainable use of coastal areas and resources.

The Basic Objective of ICM—The basic objective of ICM is to maximise long-term economic and social benefits from the wise use of coastal resources. At the same time, it is very important that ICM is seen as a practical means of meeting short-term development objectives, such as helping to diversify economic activities in rural areas.

ICM as an Iterative Process—ICM is based on an iterative cycle of actions designed to help develop a robust and adaptive process for improving the planning and management of human activities in coastal areas. The main steps in this process are:

- Awareness- Based on traditional knowledge and user-friendly scientific information
- Dialogue among key stakeholders
- Cooperation among stakeholders including sectoral governmental agencies
- Coordination among stakeholders in the formulation and implementation of policies, plans, investment and management strategies
- Integration of policies, plans, investment and management initiatives for coastal areas and human activities.

There is no Golden Rule or universal framework for promoting ICM. The development of Integrated Coastal Management can be viewed as an iterative process whereby it is possible to start with specific problems and issues and then to develop increasingly comprehensive and sophisticated ICM initiatives.

The main elements of the management process include:
- Comprehensive assessment of environmental, social and economic issues that influence the sustainable development of coastal areas and associated natural resources;
- Setting of objectives that meet local, regional and national social and economic needs and aspirations
- Formulation of plans and management strategies designed to anticipate and respond to issues as well as the development needs and aspirations of coastal societies;
- Monitoring the success of ICM plans and management strategies and incorporating improvements to those plans and strategies as part of a cyclical process.

Figure 1 illustrates the iterative nature of the ICM process.

Complementarity of ICZM and FLR

The Concept of Forest Landscape Restoration—

ICZM Principles	FLR Principles
The coastal zone is unique and has special needs for management and planning	It considers landscapes in a broader level, including biological and social values and parameters
Water is the major integrating force in coastal resource systems	
Coastal zone land and water uses must be jointly planned and managed	FLR emphasises integration of land uses.
Sustainable development of coastal resources is a major purpose of coastal management and planning	Sustainable use of forest systems and forest functions is emphasised
Multiple use of renewable coastal resources is emphasized by coastal management and planning	Restoration of the multiple functions of forest ecosystems
The focus of coastal management and planning is on common property resources	FLR attempts to rehabilitate degraded common property resources
Integrated, multiple-sector involvement is essential to coastal management and planning	Is a multi-sectoral approach extending the decision-making process to all key stakeholders
All levels of government must be involved in the coastal management and planning process	The varying scales at which FLR can be practiced encompass different levels of government.
Coastal management and planning boundaries are issue based and adaptive	FLR boundaries are adaptive.
Coastal management and planning is structured for incremental implementation	FLR can be applied in an incremental manner, moving from small scale to larger scales within a functional landscape.
Coastal management and planning emphasises the nature-synchronous approach to development	FLR seeks to work with natural system processes, including seasonal variations in hydrology.
CMP emphasises the importance of Environmental Assessment	Seeks to advance both ecological integrity and human well-being, particularly in respect to improving rural livelihoods
Special forms of economic and social evaluation are required by coastal management and planning	Focuses on the goods, services and processes rather than just trees (on the quality and quantity of forests)
Ensure the support and involvement of all relevant bodies	FLR seeks to integrate stakeholders in developing a consensus on restoration priority actions
Use a combination of instruments	FLR combines existing development, conservation and natural resource management principles
Use participatory planning to develop consensus	FLR involves stakeholders and encourages participation as well as it secures the long-term existence of the benefits for the society
Ensure that decisions taken today do not foreclose options for the future	Sustainability of forest systems within a functioning landscape is seen as a means of sustaining the health and productivity of all natural systems supported by forest ecosystems.
Involve adaptive management in the ICM cycle	FLR embodies adaptive management principles and practices.

Table 1- Principles of ICZM and FLR (Sources: Northwest Oregon State Forests Management Plan FINAL PLAN, Chapter 3 Guiding Principles, Vision, and Goals, Jan. 2001; Pfund, J-L. and T. Stachmuller 2005, IUCN 2005, WWF 2002)

"Simply put, forest landscape restoration brings people together to identify, negotiate and implement practices that optimise the contribution of forests and trees to the pattern of land uses that improve environmental, social, cultural and economic benefits across the landscape." (Source: Global Partnership for Forest Landscape Restoration)

Maginnis and Jackson (2002) have stated that "Forest landscape restoration aims to re-establish ecological integrity and enhance human well-being in degraded forest landscapes." The main principles of forest landscape restoration have been described in the Forest landscape Restoration brochure prepared under the Global Partnership for FLR (2005) as:

- restoration of a balanced and agreed package of forest functions;
- active engagement, collaboration and negotiation among a mix of stakeholders;
- working across a landscape; and

DEVELOPMENT ACTIVITY		COASTAL FOREST TYPE	
	Mangrove	*Melaleuca*	Tidal Swamp Forest
Agriculture and farming			
Aquaculture and mariculture			
Forestry			
Dredging and filling			
Harbours			
Roadways and causeways			
Shipping			
Electric power generation			
Heavy industry			
Upland mining			
Coastal mining			
Oil and gas development			
Military facilities, training and testing			
Sanitary sewage discharges			
Solid waste disposal			
Water development and control			
Coastal Defence and Shoreline management			
Tourism and Recreation			
Potential Impacts: Significant Adverse Effect Likely Adverse effects possible			

Table 2: Vulnerability of coastal forest systems to development in coastal areas and from upland development.

- learning and adapting.

IUCN (2005) emphasise a number of functions of the FLR approach, namely:

- It brings people together to identify and put in place a mix of land-use practices that will help restore the functions of forests across a whole landscape, such as a water catchment.
- It focuses on restoring forest functionality at a landscape level rather than a site level, which translates into gaining the optimal quantity and quality of forest resources necessary for improving and maintaining people's well-being and ecological integrity.
- In addition to restoring forest functions, the aim of the approach is to strengthen the relationship between rural development, forestry and other natural resource management and conservation approaches.
- It shifts the emphasis away from simply maximizing tree cover on individual forest sites to optimizing the supply of forest benefits within the broader landscape.

Principles of FLR—There appear to be a wide range of principles for FLR extending from the individual site (Oregon) through to more general principles that pertain to larger geographic scales. The key characteristics of FLR defined by (Sayer et. al. 2003) include:

- FLR focuses on the complementary relations between the different components of landscape mosaics and not just on the management unit
- FLR seeks involvement of all stakeholders in equitable negotiations over outcomes

- FLR allows for maximising production in specialised management areas whilst allowing other benefits to be managed at a larger scale
- FLR can reduce the opportunity costs of very extensive single use approaches such as large-scale industrial plantations or very extensive protected areas.
- FLR will often yield higher biodiversity pay-offs than further investment in protecting the remote residual forests on poor soils that are often the focus of conservation initiatives
- FLR can bring multi-functional forests to areas of high human population density and thus serve a valuable educational and awareness raising function as well as directly contributing to the quality of life of people in densely populated and degraded areas.

Pfund and Stachmuller (2005) identified similarities in the goals and components between FLR and other innovative approaches to development, including the Ecosystem Approach, the Sustainable Liveliehoods Approach, Farming Systems ("Gestion de Terroir"), Integrated Natural Resources Management (see their Table 1: Comparison of FLR and similar approaches according to main criteria). There are also potentially powerful links between FLR and Integrated Coastal Management (ICM). Table 1 indicates the similarities of the principles of ICZM and FLR.

Linking FLR and ICM

The concepts and principles of FLR and ICM are complementary. The adoption of the functional landscape approach logically links river basin systems and coastal systems. Table 2 illustrates the vulnerability of coastal forest systems to poor planning and management of development in catchments. Key factors to consider are the standards of planning and management of human activities in the broader landscape and their influence on the hydrology, sediment budgets, nutrient fluxes and energy fluxes that maintain the health and productivity of coastal forests downstream.

The most common causes of stress and degradation in coastal forests are changes in hydrology- mainly in the form of reduced surface and ground water flows into the forest system, changes in materials fluxes (sediments and nutrients) and changes in the energy required to maintain the health and productivity of forest systems.

Global Change and Coastal Forest Landscape Restoration—The Land Ocean Interactions in the Coastal Zone (LOICZ) project published a synthesis of its first ten years of research in which a number of conclusions concerning coastal systems and their relationship with river basin systems, marine systems and the global ecosystem have a bearing on Forest Landscape Restoration; namely:

1. The coastal domain is the most dynamic part of the global ecosystem and the real most subject to natural and man-induced global change
2. At a global scale, coastal systems (including forests) play a significant role in regulating global change
3. Although major river systems have a profound influence on coastal and near-shore marine systems at a regional level, the mounting pressures from human development and their effects on coastal systems are felt most acutely at small- to medium-catchment scales
4. Changes to coastal systems cannot be confined within administrative boundaries. Instead, studies need to be oriented towards watershed and catchment based perspectives to understand coastal dynamics and to integrate the results into human management activities (Crossland et al. 2004).

The above findings reinforce the emerging concepts of integrated coastal management where the "coastal zone" is treated as part of a dynamic continuum linking terrestrial and marine components of the earth's ecosystem, rather than an isolated "zone" in which systems such as coastal forests can be managed without reference to natural and man-induced changes in hydrology, or fluxes of materials in upland and oceanic systems (Burbridge et al. 2004). It is therefore critically important to integrate coastal forest systems into the framework of Forest Landscape Management and Restoration at a river-basin scale and to couple the management of human activities within river basin systems and management of forest systems in coastal areas.

FLR and ICM processes—Forest landscape restoration is described by Maginnis and Jackson (2002, page 10) as "a process that aims to regain ecological integrity and embrace human well being in deforested or degraded forest landscapes." The focus of FLR is on restoring forest functionality in terms of enabling the forest system to generate goods, services and ecological processes at a broader landscape level rather than promoting increased tree cover within a particular location (Maginnis and Jackson 2002).

The ICM process described above also seeks to promote sustainable use of the diverse functions and natural resources generated by coastal ecosystems at a broad landscape level. The ICM process is built around the concept that the coastal zones represents a transition between marine and terrestrial components of the earth and gives emphasis to developing specially adapted "integrated planning and management measures" that respect and work with the natural processes that support the inter-linkages among coastal ecosystems and the human activities they sustain. The ICM process can also be applied at different scales within the coastal landscape from a specific site through to the mosaic of natural systems and human activities. At the same time, the process of developing ICM is embodying a broader landscape perspective that links river catchments and near-shore marine systems.

As illustrated in Table 2 there are a number of principles that are essentially the same or complement one another that are central to both the FLR and ICM development planning frameworks. This complementarity provides major opportunities to strengthen the integration of the two approaches. To some extent this is already being attempted in international initiatives such as the Hill to Ocean (H_2O) programme, EUROBASINS, LOICZ and the E.U. Water Framework Directive.

The question I would pose is "Are we giving enough emphasis to stronger integration of FLR and ICM?" The answer is NO. The coastal domain is the most dynamic part of the global ecosystem, and is the realm most vulnerable to natural and man-induced global change. Human development in coastal regions represents a powerful catalyst for direct changes in coastal systems, including coastal forests, and more broadly at a global system scale. At a global scale, coastal systems play a significant role in regulating global change. By developing stronger integration of FLR at a catchment-scale with ICM, there is a major opportunity to substantially reduce the negative impacts of human activities and so have a positive influence on global change.

There are a number of good practices embodied in FLR and ICM that we should give stronger emphasis to in reducing the negative effects of human development in river basins and coastal regions. These are set out in the following paragraphs that set out elements of Good Practice for ICM and FLR (CAMPNET 1989, Olsen 1996, Sorensen 1996, GEF/UNDP/IMO 1996):

- Start at the local level and focus on priority issues in developing linked ICM and FLR initiatives
- Work at both the national and local levels with strong linkages between levels
- Build programmes around issues that have been identified through the participatory process
- Build constituencies and political support for resource management through public education programmes
- Where political systems allow, develop and open, participatory process, involving all stakeholders in planning and implementation;
- Develop "ownership" of the ICM and FLR plans and management strategies, involve the stakeholders/constituents in the examination of issues and problems and so developing a common understanding of how each is affected and how they could benefit from working together in deriving a common solution
- Build capacity at the national, regional, and local levels to practice integrated, community based management of FLR and ICM through training, learning-by-doing and cultivating host country colleagues who can forge long-term partnerships based on shared values
- Treat FLR and ICM management processes as complementary learning-by-doing processes and aim to complete the loop between the formulation of plans and management strategies and their implementation, monitoring and, where necessary, adjustment as quickly as is feasible. This will help to demonstrate the effectiveness of innovative policies, plans and management strategies
- Encourage the adoption of policies which lead to economically and ecologically sustainable and equitable resources management
- Strengthen existing mechanisms for cross-sector cooperation, coordination and integration of policies, management plans, investment and resources utilisation associated with both ICM and FLR
- Integrated Coastal Management must be seen as an iterative process in which incremental improvements in cooperation among agencies is one of the most important achievements we should look for; cooperation then forms the basis for coordination and integration
- Adopt an incremental, adaptive and long-term approach to linking FLR and ICM, recognising that ICM initiatives must undergo cycles of development, implementation and refinement, building on prior success and adapting and expanding to address new of more complex issues
- Develop national ICM and FLR policies, strategies, and management guidelines
- Encourage improved coordination and integration of donor assistance programs.

Two examples of non-sustainable development of coastal forest systems— Two examples of coastal forest degradation that illustrate how FLR could benefit the conservation and sustainable management of these coastal forests and other inter-related coastal ecosystems are presented. Each example demonstrates the need to understand the forest ecosystem, the functions they perform and the activities they can sustain. In both examples the integration of FLR and ICM could help to resolve issues affecting their sustainable use.

Case One: *Melaleuca leucadendron* Wetland Forests in the Mekong Delta, Vietnam

Vietnam has two major river systems the Red River and the Mekong River. There has been a long history of agricultural development of the floodplains and other alluvial lands bordering the Red River. Today, the Red River and associated river basin lands form the "Food Basket" of Vietnam.

The Mekong river system and its extensive delta have very different soils from the Red River system. For example there are extensive areas of potential acid sulphate soils (PASS) in the Mekong that are not common in the Red River delta. The difficulty of exploiting the PASS for agriculture has meant that extensive areas of *Melaleuca leucadendron* and *M. quinquinerva* forest remained until the 1970s. During that period war led to the draining of the wetland forest areas, use of defoliants and use of fire to destroy the forests and deny a safe haven for combatants. Following cessation of hostilities, the Vietnamese attempted to extend the drainage canals and to convert large tracts of *Melaleuca* wetland forest into irrigated agricultural lands. Most of these agricultural conversions failed due to exposure of the PASS to the atmosphere and the resulting high acidity in the groundwater, irrigation water and soils once the water table was lowered. There was subsequent large-scale abandonment of the agricultural areas.

In the early 1980s the World Conservation Union (IUCN) was asked to help the Vietnamese Government find ways of rehabilitating some 260,000 ha of degraded former *Melaleuca* forests in the Long Xuen Quadrangle and find ways of helping landless farmers to make a living. The Vietnamese officials had come to realise that the rehabilitation of the wetland forest would sustain a wide variety of economic goods and services as well as restoring valued environmental services. This presented a major challenge as any management solution would require restoration of the hydrology of the wetland forest sites to submerge the PASS and curtail the exposure of these soils to the atmosphere. The complex network of drainage and irrigation canals had been adopted as major means of access by boats which made it difficult to fill in or block canals and other man-made water channels. At a broader scale, there are major plans to dam the Mekong and divert waters for agriculture in countries upstream.

The solution proposed by IUCN was to modify an agro-silviculture model adopted by the Vietnamese Forestry authority, which had 10 ha units with a core area of 7.5 ha for *Melaleuca* replanting and 2.5 ha for agriculture, including a house for the farmer and family. It was reasoned that if agriculture based on field crops failed because of the PASS, then it would make sense to reduce the areas for crops and to develop alternative forms of livelihood for the farmers participating in the agro-silviculture system.

The modified model incorporated an area devoted to a nursery for stocks to be replanted in the expanded reforestation area, and the area set aside for agriculture was reduced to 2 ha. A system of raised beds covering 0.25 ha was developed to leach out the acid from the soils and to form the basis for acid tolerant cash crops, such as coffee, citrus and pineapple, and for the cultivation of medicinal plants and food crops for the household (Burbridge 1995).

Arrangements were made with the regional agricultural cooperatives to help market the cash crops. New forms of income generation were developed based on on-site distillation of essential oils from the leaves and bark of the *Melaleuca*, and honey production. Seed trials were introduced to find early flowering varieties of *Melaleuca* to accelerate the production of honey.

There remained the problem of restoring the hydrology while maintaining access to and from the rehabilitation sites. A simple system of hand-operated locks was suggested as an alternative to filling in canals and using pumps to re-establish the water table.

The ideas and preliminary development work for the rehabilitation of the *Melaleuca* wetland forests by the IUCN was then taken over by an Australian Aid (AusAid) project. A Darwin initiative was also undertaken to help refine the work by the IUCN (See Maltby et al. 1996).

The challenges faced in rehabilitating the *Melaleuca* wetland forests in the Mekong Delta are common to those faced today in lowland and forest systems. The principles and practices that have been developed for FLM would have been of great help to those of us struggling to integrate watershed management, restoration of local hydrologic conditions as a basis for rehabilitation of soils and re-creation of flooding and humidity conditions conducive to the successful replanting of *Melaleuca*, as well as developing agro-silviculture systems that landless farmers could adopt and manage as the basis for sustainable use of the wetland forests.

Case Two: Freshwater, Tidally-Influenced Peat

Swamp Forests in Indonesia.

Indonesia has extensive areas of tidally-influenced, freshwater swamp forests. These forests are capable of yielding some 25 m^3 of high value timber and timber products from Dipterocarp and other species (Abell 1979).

During the 1960s and 1970s these forests were considered suitable for conversion to agricultural lands to support the Transmigration Programme where landless farmers and people displaced by the development of dams, industry, and urban development in Java could be relocated. An elegant scheme for using the tidal regime in estuaries to "pump" freshwater into irrigation channels during rising tides and then drain the wastewater as the tide fell was developed by the Dutch in the 1930s and adopted by the Transmigration Programme.

Large-scale clearance of tidal swamp forests and excavation of primary, secondary, and tertiary canals was undertaken to form Transmigration sites. However, advice from soil scientists and water resources specialists was largely ignored in the drive to meet political targets for the resettlement of people. This resulted in the development of areas of deep peat and potential acid sulphate soils (PASS) and consequent problems of release of sulphurous acids, carbonic acids, subsidence of soils, and shrinkage of the interstitial spaces in the soil matrix. This led to poor crop production and large areas became unsuitable for the continuation of agriculture. This resulted in the abandonment of agriculture and the growth of illegal logging in surrounding production forests and areas set aside for nature conservation.

A further set of problems arose as the watershed above the estuaries was developed for urban, industrial and agricultural purposes. These developments altered the hydrology of the river systems to the point where the tidal irrigation system was disrupted. In the dry season there was reduced base water flow in the river, which resulted in greater penetration of saline waters into the estuary, which forced brackish water into the irrigation canals and led to salinisation of groundwater and soils. In the rainy season, accelerated surface water runoff that resulted from changes in land use in the catchment led to flooding in the areas converted from wetland forest. The extent, duration, and severity of impact on crops and homes were increased due to the erosion, subsidence, and shrinkage of the soils in the Transmigration sites. The difficulties of maintaining any form of agriculture led to large scale abandonment of areas converted for transmigration.

A second stage of transmigration development was embarked upon in the early 1980s where consultants were asked to examine sites where agriculture had proven unsustainable and to make recommendations for their rehabilitation for new forms of agriculture, rehabilitation as forest systems, or conversion to an alternative use. The author was involved in developing the system for determining the causes that led to non-sustainable use at Transmigration sites, and to determine what options might be available for their rehabilitation. The system was based on a reversal of the environmental impact assessment process where the impacts were identified along with the causal factors, and then examination of the Transmigration planning and management arrangements to determine what led to the creation of the adverse impacts.

The findings from this process were used to improve the planning and management of Transmigration, and to identify options where carefully planned and implemented measures could lead to successful rehabilitation of the Transmigration sites.

Potential Benefits from Integrating ICM and FLR—The examples of the conversion and both the *Melaleuca* Wetland Forest in Vietnam and the Tidal Swamp Forests in Indonesia demonstrate the need for a much broader perspective on the relationship between coastal forest development and rehabilitation and the management of watersheds than is commonly adopted in making decisions for their development. These examples also demonstrate the potential benefit of integrating FLR concepts into the evolving concepts of Integrated Coastal Management. The potential environmental, social and economic benefits that could be derived from integrating Forest Landscape Restoration into the principles and practice of Integrated Coastal Management include:

- Maintaining the hydrology and material fluxes essential to the health and productivity of coastal ecosystems
- Restoring the functions and natural resources generated by riparian ecosystems, coastal ecosystems and marine ecosystems
- Reducing the adverse effects of natural and man-induced hazards
- Ameliorating global change
- Supporting the expansion and diversification of economic activities in the coastal realm and within watersheds
- Protecting the health and welfare of communities
- Helping nations meet international obligations under conventions, protocols, treaties and other legally or morally binding instruments.

The above list can be extended and the author hopes that discussions during the meeting will stimulate further identification of benefits.

Conclusions

There are potentially powerful synergies between the concepts and principles of FLR and ICZM that can be applied and developed at different levels of landscape from an individual forest system level, such as a mangrove, to a much broader river basin level. With increasing understanding of the powerful forces driving and being driven by global climate change, it will be increasingly important to adopt a strategic perspective on the power of integrating FLR and ICZM as essential elements in the search for more sustainable uses of terrestrial and near-shore marine ecosystems.

Literature Cited

Abell, T.M.B. 1979. The forest resource. Republic of Indonesia and United Kingdom Transmigration Project: Site Investigation along the Trans-Sumatra Highway, Overseas Development Administration, Land Resources Centre, London

Bodungen, v. B., and R.K. Turner. 2001. Science and integrated coastal management: An introduction, In: B.v. Bodungen and R.K. Turner (eds.). *Science and Integrated Coastal Management.* Dahlem Workshop Report 85, Dahlem University Press, Berlin, pp 1-15

Brown, B.E., and P.R. Burbridge. 1999. *Coastal Management in Southeast Asia.* DFID, London

Burbridge, P.R., Buddemeier, R.W., Letissier, M., Costanza, R. 2005. Synthesis of main findings and conclusions. Chapter 5 in C.J. Crossland et al. (eds.). *Coastal Fluxes in the Anthropocene*. IGBP Series, Springer, Berlin. Heidelberg and New York

Burbridge, P.R., Pethick, J. 2002. Sustainability and management: Coastal systems. In: Wefer, Lamy and Mountoura (eds.). *Marine Science Frontiers for Europe*. Springer, pp 216-228

Burbridge, P.R. 1998. Coastal Zones from the "Water" point of View. Paper presented at the 34th International Planning Congress, International Society of City and Regional Planners, 26 September- 2 October, 1998, Azores, Portugal.

Burbridge, P.R., Dankers, N., Clark, J.R. 1997. Multiple-use assessment for coastal management. In Clark, J. R. (ed.). *Coastal Zone Management for the New Century*. www.iccops.it/references/bibliografia.htm - 199k

Burbridge, P.R., 1996. Social, cultural and economic factors that influence the sustainable development of peatlands. Chapter 10 In: E. Maltby, C.P. Immrizi and R. J. Safford (eds.). *Tropical Lowland Peatlands in SE Asia : Proceedings of a Workshop on Integrated Planning and Management of Tropical Lowland Peatlands*. Bogor Indoenesia 1994, Samara. IUCN, Gland, Switzerland, pp 163-171.

Burbridge, P.R. 1995. Case Study - Vietnam, Mekong Delta: Difficulty of repairing damaged wetlands. In J.R. Clark (ed.). *Coastal Zone Management Handbook*. CRC Press Inc., Lewis Publishers, New York.

Burbridge, P.R. 1994. Integrated planning and management of freshwater habitats, Including wetlands, In A. Sasekumar, N. Marshall and D. Macintosh (eds.). *Ecology and Conservation of Southeast Asian Marine and Freshwater Environments including Wetlands.* Developments in Hydrobiology 98, Kluwer Academic Publishers, Dordrecht/ Boston/London.

Burbridge, P.R. 1991. Zonation of mangrove ecosystems for integrated multiple use management. In J. Kusler and S. Daly (eds.). Proc. Int. Wetlands Symposium on Wetlands and River Corridor Management. Charleston, USA.

Burbridge, P.R. 1990. Tidal wetland resources in the tropics. *Journal of Resource Management and Optimization* 7(1-4): 115-138.

Burbridge, P.R. 1989. Multiple-use assessment for coastal management. Coastal Zone '89. H.C.O.T. Magoon, D. Miner, L. Th. Tobin, D. Clark. New York, American Society of Civil Engineers. 1: 33-45.

Burbridge P.R., Dixon, J.A. 1984. The economics of mangrove development. Section IV in Hamilton, L.S. and Snedaker, *S. Handbook on Mangrove Area Managemen*t. UNESCO/ IUCN/East West Centre, Honolulu.

Burbridge, P.R., Dixon J.A., Soewardi, B. 1981. Forestry and agriculture: options for resource allocation in choosing land for transmigration development. *Applied Geography* 1: 237-258.

Carter, J., Gronow, J. 2005. Recent experience in collaborative forest management. CIFOR Occasional Paper No. 43. Center for International Forest Research, Bogor, Indonesia.

Chua, T-E, 2004. Integrated coastal management in transition. PEMSEA Update, IMO-UNDP project on Partnerships for Environmental Management of the Seas of East Asia, Quezon City, the Philippines.

Chua, Thia-Eng. (ed.). 1996. Lessons learned from successes and failures of integrated coastal management initiatives. MPP-EAS Technical Report No. 4, 90 pp. GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in East Asian Seas, Quezon City, Philippines.

Clark, J. R. 1992. Integrated management of coastal zones. FAO Fisheries Technical Paper No. 327. Food and Agriculture Organization, Rome, Italy. 167 pp.

Collier, W., 1979. Social and economic aspects of tidal swampland development. Symposium on Tidal Swampland Development, Palembang, Indonesia, 5-20 February 1979.

Commission of the European Communities (CEC). 1999. Lessons from the European Commission's Demonstration Programme on Integrated Coastal Zone Management (ICZM), CEC, Luxembourg.

Commission of the European Communities (CEC). 2001. *EU Focus on Coastal Zones: Turning the Tide for Europe's Coastal Zones.* European Commission, Brussels.

Della Sala, D.A., Martin, A., Spivak, R., Schulke, T., Bird, B., Criley, M., van Daalen, C., Kreilick, J., Brown, R., Aplet, G. 2003. A citizens' call for ecological forest restoration: Forest restoration principles and criteria. *Ecological Restoration* 21(1): 14-23

Elliot, T. 2002. *Forest Landscape Restoration: Working Examples from Five Ecoregions*. WWF, Gland, Switzerland.

Mansourian, S., Vallauri, D., Dudley, N. (eds.). 2005. *Forest Restoration in Landscapes - Beyond Planting Trees.* Springer, Heidelberg.

FRIS. 2006. Forest Landscape Management, Concepts and definitions update, (November 2006). Forest Restoration Information Service (FRIS), UNEP World Conservation Monitoring Centre (WCMC), Cambridge, England.

Garnett, S.T., Sayer, J., Du Toit, J. 2007. Improving the effectiveness of interventions to balance conservation and development: a conceptual framework. *Ecology and Society* 12(1): 2.

Governments of Brazil and the United Kingdom. (2005). Forest Landscape Restoration Implementation, Report to the 5th Session of the UN Forum on Forests, 4-8 April,2005, Petropolis, Brazil.

ITTO. 2002. *Guidelines for the Restoration, Management and Rehabilitation of Degraded and Secondary Tropical Forests.* ITTO, Yokohama, Japan.

IUCN, 2005, Forest Landscape Restoration: Broadening the Vision of West African Forests, IUCN Forest Conservation Programme, Gland, Switzerland

IUCN, PROFOR, World Bank. (2004). *Ecosystem approaches and sustainable forest management: A discussion document for the UNFF Secretariat.* IUCN, Gland. 14p.

Kongsangchai, J. 1984. Mining impacts upon mangrove forest in Thailand. In: Soepadmo, E., A.N. Rao and D.J. Macintosh (eds.). Proc. Asian Mangrove Symp. on Mangrove Environment and Management. University of Malaysia and UNESCO, Kuala Lumpur, Malaysia, pp 558-567.

Maginnis, S., Jackson, W. 2005. Restoring forest landscapes: Forest landscape restoration aims to re-establish ecological integrity and human well-being in the degraded forest landscapes. IUCN, Gland, Switzerland. 6p.

Maltby, E., Burbridge, P.R., Fraser, A. 1996. Peatland and sulphate soils: A case study from Vietnam. Chapter 14 In: E. Maltby, C.P. Immrizi and R. J. Safford (eds.). Tropical lowland peatlands of SE Asia : Proc. Workshop on Integrated Planning and Management of Tropical Lowland Peatlands. Bogor Indoenesia 1994, Samara, IUCN, Gland , Switzerland, pp 187-197.

New Mexico Forest Restoration Principles. (undated). New Mexico State Land Office, Division of Biological Diversity.

Oregon Department of Forestry. 2001. Northwest Oregon State Forests Management Plan, Salem, Oregon.

Pfund, J,-L., Stachmuller, T. 2005, Forest landscape restoration. In: Wenger, R., Sommer, R. and S.W. von Dach, (eds.). Inforesources Focus no.2/05.

Pokharel, B.K., Stadtmuller, Th., Pfund, J.L. 2005. From degradation to restoration: An assessment of the enabling conditions for community forestry in Nepal. Intercooperation, Swiss Foundation for Development and International Cooperation, Switzerland.

Sayer, J., Kapos, V., Mansourian, S., Maginnis, S. 2003. Forest landscape restoration: the role of forest restoration in achieving multifunctional landscapes. XII World Forestry Congress, 2003, Quebec City, Canada.

Sayer, S, Maginnis, S., (eds.). 2005. *Forests in landscapes: Ecosystem approaches to sustainability.* Earthscan, 248p

Sorenson, J. 2000. *Building a Global Database of Coastal Management Efforts.* University of Massachusetts Press, Boston.

Sorensen, J. 2002. Baseline 2000 Background Report: The status of integrated coastal management as an international practice (Second Iteration — 26 August 2002). Urban Harbors Institute, University of Massachusetts, Boston.

Stevenson, N.J., Lewis, R.R., Burbridge, P.R. 1999. Disused shrimp ponds and mangrove rehabilitation. In: W.J. Streever, (ed.). *An International Perspective on Wetland Rehabilitation.* Kluwer Academic Publishers.

Stevenson, N., Burbridge, P.R. 1997. Abandoned shrimp ponds: Option for mangrove rehabilitation. Intercoast Special Issue on Mangroves, May 1997.

WWF. 2002. *Forest Landscape Restoration: Working Examples from Five Ecoregions.* Doveton Press, England.

WWF. 2003. *Integrating forest protection, management and restoration at a landscape scale.* WWF Forests for Life Programme, 20p.

PERSPECTIVES ON FOREST LANDSCAPE RESTORATION AND STREAM FISHES OF THE SOUTHERN UNITED STATES

Melvin L. Warren, Jr.[1] and C. Andrew Dolloff[2]

Introduction

The southern United States supports one of the richest temperate freshwater fish faunas on Earth. Over 600 native freshwater fishes occur in southern U.S. rivers and streams. An expert review revealed that 27% (188 fish taxa) of fishes are endangered, threatened, or vulnerable (Warren et al. 2000), and that imperilment is widespread with 6-18% of native fishes imperiled in 45 of 51 major southern river basins. Other groups of aquatic organisms in the region also show high levels of imperilment (e.g., freshwater mussels and gastropods, Neves et al. 1997; crayfishes, Taylor et al. 1996; aquatic reptiles, Buhlmann and Gibbons 1997). Large-scale declines of aquatic biota are signals of a pervasive degradation of southern U.S. waters and of the failure of humans to recognize the interactive nature of land and water ecosystems and management (Angermeier 1995, Burkhead et al. 1997, Etnier 1997, Warren et al. 1997). About 10% of the region's fishes could be extinct by 2050 based on national extinction rate projections for fishes (Ricciardi and Rasmussen 1999). The realization of this projection is largely contingent on implementation of effective conservation actions aimed at maintaining and improving the physical and biological integrity of the region's streams and rivers.

Forest landscape restoration is a conservation action that we believe could positively affect conservation of the region's fishes and other aquatic fauna, particularly if used in concert with other management options (e.g., Wissmar and Bisson 2003). Here, we briefly present selected examples from the fauna to link and illustrate potential benefits of forest landscape restoration to fishes in the southern United States. We selected five important and interdependent, but by no means all inclusive, benefits that could emerge from forest landscape restoration, including: instream wood and fish food production; fringing forests and fish foraging; instream wood as habitat and spawning substrate; floodplain forests and fish reproduction; and riparian forest and stream temperature. We recognize the importance of forest landscape restoration to water quality (sediment and nutrient reduction) and quantity and hence to fishes but do not address those benefits here (e.g., Watters 1995). We hope that the benefits and examples presented are heuristic even if obviously oversimplifying the complex nature of fish, riparian zone, and watershed interactions (Veery et al. 2000, Gregory et al. 2003, Hughes et al. 2006).

Instream Wood and Food Production

Wood deposited in streams from the riparian zone plays an important role in aquatic invertebrate production and hence, availability of food to fishes and other vertebrates (Angermeier and Karr 1984; Benke and Wallace 2003). Production of invertebrates on wood can be especially important in habitats with fine, mobile bottom substrates and few bed controls (Angermeier and Karr 1984, Benke et al. 1984, 1985, Benke and Wallace 2003), a common feature of lowland southeastern streams. Large pieces of wood can form debris piles, trap fine organic particles, and provide the substrate necessary for colonization by aquatic organisms (e.g., bacteria, fungi, and invertebrates) that decompose wood, shred organic matter, and filter small organic particles from the water column, all of which ultimately results in establishment of complex food webs (e.g., Anderson et al. 1978, Harmon et al. 1986, Wallace et al. 1992, Benke et al. 2001, Benke and Wallace 2003). Debris dams formed around instream wood can be hot spots of macroinvertebrate production and biodiversity, often supporting much higher densities and greater numbers of species than the streambed (Benke and Wallace, 2003). In large rivers, the riparian zone contributes large instream wood in the form of trees or parts of trees (snags) to the channel, also providing substrate for aquatic invertebrates and foraging habitat for fishes (Nilsen and Larimore 1973, Benke et al. 1984, 1985, Lehtinen et al. 1997). In southeastern blackwater rivers, up to 60% of in-channel invertebrate production is associated with snags, and many riverine fishes exploit snag insects (Benke et al. 1985). For example, in the Satilla River, sunfishes (*Lepomis spp*.) obtained at least 60% of their prey biomass during non-flood conditions from snag-dwelling insects. The 'snag fauna-sunfish' food chain represented an essentially completely separate trophic pathway from the 'bottom fauna-small fish-piscivore' food chain. Other work similarly indicates stream and riverine fishes often show higher abundances, higher foraging success, and increased growth as a result of foraging on macroinvertebrates produced on wood (Angermeier and Karr 1984, Angermeier 1985, Lehtinen et al. 1997, Crook and Robertson 1999, Quist and Guy 2001). In sum, a direct

[1] Center for Bottomland Hardwoods Research,USDA Forest Service, Southern Research Station. Oxford, MS 38655 USA; email-mwarren01@fs.fed.us
[2] Coldwater Streams and Trout Habitat in the Southern Appalachians,USDA Forest Service, Blacksburg, VA 24060 USA

increase in diversity, abundance, and production of fishes in rivers and streams can accrue from the contribution of food production on instream wood.

Fringing Forests and Fish Foraging

In many small streams of the southern United States, short-term inundation of narrow, fringing floodplains following storm events is a relatively common phenomenon. In a small blackwater creek in Mississippi, stream fishes move rapidly onto and extensively within a forested fringing floodplain during short-term over bank flood events (Ross and Baker 1983, O'Connell 2003). Rapid movement onto the floodplain, ingestion of terrestrial invertebrates, and correlation of high spring discharge with summer spawning success suggests that some species, such as the weed shiner (*Notropis texanus*), obtains direct energy subsidies from exploitation of floodplain food resources that are important for subsequent reproduction (Ross and Baker 1983). The exploitable food base on the forest floor and in isolated floodplain pools is rich. More food was available and more food was consumed (especially terrestrial Collembola) by cherryfin shiners (*Lythrurus roseipinnis*) on the inundated floodplain than was available in the stream at low flow (O'Connell 2003). If the interconnectivity by flooding of these small streams and the invertebrate rich forest floor is disrupted, then many small stream fishes, such as weed and cherryfin shiners, are negatively affected (O'Connell 2003).

Instream Wood as Habitat

For many fish species, association with large instream wood is facultative, particularly in streams where rocky substrates or other elements provide cover and form heterogeneous habitats (e.g., riffles, runs, pools). Nevertheless, some species such as the shadow bass (*Ambloplites ariommus*) and smallmouth bass (*Micropterus dolomieu*) show extensive use of wood even in upland, rocky streams (Probst et al. 1984). Fish living in streams of the coastal plain where streambed materials tend to be fine-grained and highly mobile (Felley 1992) benefit from pool and riffle formation caused by instream wood (Dolloff and Warren 2003), but also often use and are highly dependent on wood for cover. For example, two nocturnally active fishes, the brown madtom (*Noturus phaeus*) and the pirate perch (*Aphredoderus sayanus*), are associated strongly with complex woody habitats in small coastal plain streams (Monzyk et al. 1997, Chan and Parsons 2000). The bayou darter, *Etheostoma rubrum*, a threatened species, responds to cold, high-velocity flows of winter by seeking refuge behind logs and other instream wood. Current refugia provided by instream wood likely have a significant impact on overwintering survival and ultimately the population density of the species (Ross et al. 1992). Similarly, brush bundles, leaf packs, and faux root wads placed in shifting sand-bottom coastal plain streams were used by 32 species of small stream fishes across all seasons, but in January (water 2-5°C) up to 70 lethargic cyprinids occupied a single bundle also suggesting such refuges are critical winter habitat (A.J. Sheldon, M.L.Warren, Jr., and W.R. Haag, unpublished data).

In Coastal Plain streams, stable riffle areas underlain by cobble and gravel substrates are rare or absent so that instream wood is often the only element contributing to channel roughness and hence to the formation of complex, flowing habitats (Smock and Gilinsky 1992). The presence of ample wood, even relatively small-diameter pieces, in shallow sandy flowing areas, creates a heterogeneous zone of variable velocities and depths. These wood-formed "riffles and runs" in turn support a significant proportion of the stream fish diversity in Coastal Plain streams and are likely critical to the persistence of many darters (*Etheostoma* spp., *Percina* spp.) and madtom catfishes (Noturus spp.) in these streams (Monzyk et al. 1997, Chan and Parsons 2000, Warren et al. 2002). In streams affected by channel incision, even relatively modest quantities of instream wood shifts fish assemblage attributes from colonizing to intermediate or stable stages (Warren et al. 2002), primarily by influencing habitat development. Use of instream wood or debris piles as cover, for predator avoidance, or to avoid low winter temperatures or high currents is important for many southern U.S. fishes (Dolloff and Warren 2003).

Instream Wood as a Spawning Substrate

Many fishes attach their eggs to instream wood, which is considered an adaptation to decrease silting and potential smothering of eggs (Gale and Gale 1977, Burkhead and Jelks 2001, Fletcher et al. 2004, Sutherland 2007). For example, logs with cracks, loose bark, or deeply ridged bark provide suitable spawning habitat for crevice spawning minnows of the genus *Cyprinella* (Pflieger 1997). The relatively large range of the blacktail shiner, *Cyprinella venusta*, across southeastern U.S. coastal plain streams is likely attributable in part to its ability to use wood for egg attachment. Several darters (*Etheostoma* spp.) adapted to sand-bottomed habitats (Dolloff and Warren 2003) also deposit their eggs on wood, almost exclusively so for the lake dwelling Waccamaw darter, *Etheostoma perlongum*, a threatened species, and the glassy darter, *Etheostoma vitreum* (Winn and Picciolo 1960, Lindquist et al. 1981). The relict darter (*Etheostoma chienense*) attaches its eggs in clusters to the underside of logs and large sticks; the male then guards the resulting clusters until the eggs hatch. Lack of adequate spawning substrate in its native stream, due to extensive channel and riparian modification, is a primary factor limiting recruitment of this endangered species (Piller and Burr 1999). The pirate perch (*Aphredoderus sayanus*) deposits eggs in canals it burrows in underwater root masses of riparian vegetation. The species also deposits eggs in canals formed in root masses by burrowing salamanders and dobsonfly larvae (Fletcher et al. 2004). Madtom catfishes of the genus *Noturus*, the most diverse group of catfishes in North America, secure nests and provide extensive care to nests, eggs, and young; several species in coastal plain streams establish nests on the undersides of large wood (Burr and Stoeckel 1999). Use of wood (e.g., standing timber, downed logs, root wads) for nesting cover is common among southern U.S. game and nongame fishes (e.g., Hunt et al. 2002, Dolloff and Warren 2003).

Forests and Fish Reproduction

Many southern U.S. fishes use inundated forests for spawning and nursery areas (Finger and Stewart 1987, Baker et al. 1991, Killgore and Baker 1996). At least 65 fish species are characteristic of flooded bottomland hardwood forests in the region (Hoover and Killgore 1998), but flooded forests provide nursery habitat to both wetland fishes and those of adjacent streams and rivers. Over half the fishes known from the Atchafalaya Basin of Louisiana use flooded forest for spawning and/or rearing of young (Lambou 1990). In the lower Mississippi River basin, abundance of native sport, commercial, and nongame larval fishes is higher in flooded forests than flooded agricultural land (Hoover and Killgore 1998).

Forests and Stream Temperature

The role of the riparian forest in regulating stream temperature and moderating extremes in temperature is most pronounced in small headwater streams (e.g., Brown and Krygier 1970, Swift and Messer 1971, Swift 1982, Isaak and Hubert 2001, Wehrly et al. 2006). Removal of riparian forests along small upland streams in the southern Blue Ridge Mountains may alter both maximum and minimum stream temperatures for several years (Swift 1982) with extremes in removal producing summer maxima up to 6.7° C above normal (19° C)(Swift and Messer 1971). Even in lowland streams, removal of riparian shade produces larger diurnal temperature extremes than observed in shaded streams (Huish and Pardue 1978) and in summer could produce hypoxic conditions detrimental to fishes (Smale and Rabeni 1995). Temperature effects from riparian forest removal, particularly increases in maximum temperature are best documented in coldwater fishes, especially salmonids (e.g., Meehan 1991). Even so, at least some southern U.S. fishes are dependent on streams in forested watersheds, streams with densely forested and vegetated riparian zones, and heavily shaded spring-heads and spring runs. In some cases, these species are restricted to these habitats in large part because they are adapted to or benefit from temperature regimes in these habitats (e.g., Peterson and Rabeni 1996). When forest cover in riparian areas is removed and water temperatures rise, it may be energetically impossible for a fish species (or life stages) with lower temperature requirements to continue living in the system, regardless of other favorable conditions (e.g., food availability). For example, adult brook trout (*Salvelinus fontinalis*), an important native sport fish in the southern Appalachian Mountains, are limited to cool waters (<19° C) in mature forests (Cherry et al. 1977, Meisner 1990, Clark et al. 2001, Flebbe et al. 2006). However, mortality and growth rates of young of this species can be affected negatively with only slight increases in stream temperatures tolerated by the adult (McCormick et al. 1972, Clark et al. 2001). Similarly, late 20th century decreases in distribution and abundance of smallmouth bass (*Micropterus dolomieu*), another important sport fish, in streams in the prairie-Ozark ecotone of Missouri was related in part to maximum summer water temperature, an effect attributable to removal of riparian forest (Sowa and Rabeni 1995). Other fishes in the southern U.S., many of which are of conservation concern, also appear to be limited to forested habitats at least in part by the lower temperatures produced by shading, including species restricted to upland headwater streams, spring heads, or spring runs. Proportionally, spring-dependent fishes are one of the most jeopardized groups of fishes in the region (Etnier 1997). Removal of riparian vegetation is implicated in extirpation of populations (e.g., Tennessee dace, *Phoxinus tennesseensis*, laurel dace, *Phoxinus saylori*, spring pygmy sunfish, *Elassoma alabamae*), and replacement of a species with more thermally tolerant congeners (e.g., blackside dace, *Phoxinus cumberlandensis*) (e.g., Starnes and Starnes 1981, Starnes and Jenkins 1988, Burkhead and Jenkins 1991, Mayden 1993, Skelton 2001, Warren 2004).

Conclusions

Rapid and continued population growth in the southern United States places ever growing demands on water and other natural resources and significantly challenges aquatic resource management and conservation (Cordell et al. 1998, Wear et al. 1998, Weir and Greis 2002). Land ownership patterns further confound conservation of aquatic resources in the region. Predominantly forested watersheds support most of the biologically significant streams in the region but little of this (~11%) is in public ownership, and hence, most jeopardized fishes and biologically significant waters are not afforded protection through federal land ownership (Neves et al. 1997, Master et al. 1998). About 79% of forested land in the region is held by nonindustrial private landowners, mostly in small parcels of one to several hundred acres

(Conner and Hartsell 2002). These owners, many of whom are absentee owners, are diverse in their knowledge and attitudes towards the environment and their reasons for land ownership (Cordell et al. 1998, Tarrant et al. 2002), and can present further challenges in implementing effective watershed-scale or even local restoration efforts. Nevertheless, forest restoration, especially of riparian areas, can provide multiple potential benefits to stream fishes in the southern United States. Indirect benefits include reduced sediment and nutrient inputs, stream bank stabilization, and temperature moderation, all factors that can affect fish productivity, physiology, reproduction, and assemblage composition. More directly, leaf and wood input into streams provides the primary energy base and substrate for production of macroinvertebrates, the food base for fishes (Dolloff and Webster 2000, Benke and Wallace, 2003, Dolloff and Warren, 2003). Large wood derived from forested riparian zones also provides the primary element of habitat complexity and cover to stream fishes. Taxonomic, geographic, and ecological diversity of the region's fishes provides a template to highlight potential benefits of forest landscape restoration aimed at maintaining fish biodiversity in a variety of biological, ecological, and physical contexts. Syntheses on aquatic resources make it clear that the southern United States faces major challenges in conserving not only native fishes but the entire richly diverse system of streams, rivers, and wetlands in the region (Benz and Collins 1997, Master et al. 1998, Ricciardi and Rasmussen 1999, Veery et al. 2000). We believe forest landscape restoration could be a positive tool in meeting these challenges.

Literature Cited

Abell, R. and J.D. Allan. 2002. Riparian shade and stream temperatures in an agricultural catchment, Michigan, USA. *International Association of Theoretical and Applied Limnology* 28:232-237.

Anderson, N.H., J.R. Sedell, L.M. Roberts, and F.J. Triska. 1978. The role of aquatic invertebrates in processing of wood debris in coniferous forest streams. *American Midland Naturalist* 100:64-82.

Angermeier, P.L. 1985. Spatio-temporal patterns of foraging success for fishes in an Illinois stream. *American Midland Naturalist* 114:342-359.

Angermeier, P.L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. *Conservation Biology* 9:143-158.

Angermeier, P. L. and J.R. Karr. 1984. Relationships between woody debris and fish habitat in a small warmwater stream. *Transactions of the American Fisheries Society* 113:716-726.

Baker, J.A., K.J. Killgore, and R.L. Kasul. 1991. Aquatic habitats and fish communities in the lower Mississippi River. *Aquatic Sciences* 3:313-356.

Benke, A.C. and J.B. Wallace. 2003. Influence of wood on invertebrate communities in streams and rivers. *American Fisheries Society Symposium* 37:149-177.

Benke, A.C., T.C. Van Arsdall, Jr., D.M. Gillespie, and F.K. Parrish. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. *Ecological Monographs* 54:25-63.

Benke, A.C., R.L. Henry, III, D.M. Gillespie, and R.J. Hunter. 1985. Importance of snag habitat for animal production in southeastern streams. *Fisheries* 10(5):8-13.

Benke, A.C., J.B. Wallace, J.W. Harrison, and J.W. Koebel. 2001. Food web quantification using secondary production analysis: predaceous invertebrates of the snag habitat in a subtropical river. *Freshwater Biology* 46:329-346.

Benz, G.W., and D.E. Collins, editors. 1997. *Aquatic Fauna in Peril: The Southeastern Perspective.* Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, GA.

Brown, G.W. and J.T. Krygier. 1970. Effects of clearcutting on stream temperature. *Water Resources Research* 6:1133-1139.

Buhlmann, K.A. and J.W. Gibbons. 1997. Imperiled aquatic reptiles of the southeastern United States: historical review and current conservation status. Pages 201-231 in G.W. Benz and D.E. Collins, editors. *Aquatic Fauna in Peril: The Southeastern Perspective*. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Burkhead, N.M. and H. Jelks. 2001. Effects of suspended sediment on the reproductive success of the tricolor shiner, a crevice-spawning minnow. *Transactions of the American Fisheries Society* 130:959-968.

Burkhead, N.M. and R.E. Jenkins. 1991. Fishes. Pages 321-409 in K. Terwilliger, coordinator. *Virginia's Endangered Species*. McDonald and Woodward Publishing Company, Blacksburg, Virginia.

Burkhead, N.M., S.J. Walsh, B.J. Freeman, and J.D. Williams. 1997. Status and restoration of the Etowah River, an imperiled southern Appalachian ecosystem. Pages 375-444 in G.W. Benz and D.E. Collins, editors. *Aquatic Fauna In Peril: The Southeastern Perspective*. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Burr, B.M. and J.N. Stoeckel. 1999. The natural history of madtoms (genus *Noturus*), North America's diminutive catfishes. *American Fisheries Society Symposium* 24:51-101.

Chan, M.D. and G.R. Parsons. 2000. Aspects of brown madtom, *Noturus phaeus*, life history in northern Mississippi. *Copeia* 2000:757-752.

Cherry, D.S., K.L. Dickson, J.C. Cairns, Jr., and J.R. Stauffer. 1977. Preferred, avoided, and lethal temperatures of fish during rising temperature conditions. *Journal of the Fisheries Research Board of Canada* 34:239-246.

Clark, M.E., K.A. Rose, D.A. Levine, and W.H. Hargrove. 2001. Predicting climate change effects on Appalachian trout: combining GIS and individual-based modeling. *Ecological Applications* 11:161-178.

Conner, R.C. and A.J. Hartsell. 2002. Forest area and conditions. Pages 357-410 in D.N. Wear and J.G. Greis, editors. Southern Forest Resource Assessment. USDA Forest Service, Southern Research Station, General Technical Report SRS-53, Asheville, NC.

Cordell, H.K., J.C. Bliss, C.Y. Johnson, and M. Fly. 1998. Voices from the southern forests. *Transactions of the*

North American Wildlife and Natural Resources Conference 63:332-347.

Crook, D.A., and A.I. Robertson. 1999. Relationships between riverine fish and wood debris: implications in lowland rivers. *Marine and Freshwater Research* 50:9491-953.

Dolloff, C.A. and M.L. Warren, Jr. 2003. Fish relationships with large wood in small streams. *American Fisheries Society Symposium* 37:179-193.

Dolloff, C.A. and J.R. Webster. 2000. Particulate organic contributions from forests to streams: debris isn't so bad. Pages 125-138 in E.S. Veery, J.W. Hornbeck, and C.A. Dolloff, editors. *Riparian Management in Forests of the Continental Eastern United States*. Lewis Publishers, Boca Raton, Florida.

Etnier, D.A. 1997. Jeopardized southeastern freshwater fishes: a search for causes. Pages 87-104 in G.W. Benz and D.E. Collins, editors. *Aquatic Fauna in Peril: The Southeastern Perspective.* Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Felley, J.D. 1992. Medium-low gradient streams of the Gulf coastal plain. Pages 233-269 in C.T. Hackney, S.M. Adams, and W.H. Martin, editors. *Biodiversity of the Southeastern United States, Aquatic Communities*. John Wiley, New York.

Finger, T.R. and E.M. Stewart. 1987. Response of fishes to flooding regime in lowland hardwood wetlands. Pages 86-92 in W.J. Matthews and D.C. Heins, editors. *Community and Evolutionary Ecology of North American Stream Fishes*. University of Oklahoma Press, Norman.

Flebbe, P.A., L.D. Roghair, and J.L. Bruggink. 2006. Spatial modeling to project southern Appalachian trout distribution in a warmer climate. *Transactions of the American Fisheries Society* 135:1371-1382.

Fletcher, D.E., E.E. Dakin, B.A. Porter, and J.C. Avise. 2004. Spawning behavior and genetic parentage in the pirate perch (*Aphredoderus sayanus*), a fish with an enigmatic reproductive morphology. *Copeia* 2004:1-10.

Gale, W.F. and C.A. Gale. 1977. Spawning habits of spotfin shiner (*Notropis spilopterus*)-a fractional, crevice spawner. *Transactions of the American Fisheries Society* 106:170-177.

Gregory, S., K. Bower, and A. Gurnell, editors. 2003. The ecology and management of wood in world rivers. *American Fisheries Society Symposium* 37, Bethesda, Maryland.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15:133-302.

Hoover, J.J. and K.J. Killgore. 1998. Fish communities. Pages 237-260 in M.G. Messina and W.H. Conner, editors. *Southern Forested Wetlands: Ecology and Management.* Lewis Publishers/CRC Press, Boca Raton, Florida.

Hughes, R.M., L. Wang, and P.W. Seelbach, editors. 2006. Landscape influences on stream habitats and biological assemblages. *American Fisheries Society Symposium* 48, Bethesda, Maryland.

Huish, M.T. and G.B. Pardue. 1978. Ecological studies of one channelized and two unchannelized wooded coastal swamp streams in North Carolina. U.S. Fish and Wildlife Service, Biological Services Program FWS/OBS-78/85.

Hunt, J., N. Bacheler, D. Wilson, E. Videan and C.A. Annett. 2002. Enhancing largemouth bass spawning: behavioral and habitat considerations. *American Fisheries Society Symposium* 31:277-290.

Isaak, D.J., and W.A. Hubert. 2001. A hypothesis about factors that affect maximum summer stream temperatures across montane landscapes. *Journal of the American Water Resources Association* 37:351-366.

Killgore, K.J. and J.A. Baker. 1996. Patterns of larval fish abundance in a bottomland hardwood wetland. *Wetlands* 16:288-2965.

Lambou, V.W. 1990. Importance of bottomland hardwood forest zones to fishes and fisheries: the Atchafalaya Basin, a case history. Pages 125-192 in J.G. Gosselink, L.C. Lee, and T.A. Muir, editors. *Ecological Processes and Cumulative Impacts: Illustrated By Bottomland Hardwood Wetland Ecosystems*. Lewis Publishers, Chelsea, Michigan
.

Lehtinen, R.M., N.D. Mundahl, and J.C. Madejczyk. 1997. Autumn use of woody snags in backwater and channel border habitats of a large river. *Environmental Biology of Fishes* 49:7-9.

Lindquist, D.G., J.R. Shute, and P.W. Shute. 1981. Spawning and nesting behavior of the Waccamaw darter, *Etheostoma perlongum*. *Environmental Biology of Fishes* 6:177-191.

Master, L.L., S.R. Flack, and B.A. Stein, editors. 1998. *Rivers Of Life: Critical Watersheds for Protecting Freshwater Biodiversity*. The Nature Conservancy, Arlington, VA.

Mayden, R.L. 1993. *Elassoma alabamae*, a new species of pygmy sunfish endemic to the Tennessee River drainage of Alabama (Teleostei: Elassomatidae). *Bulletin of the Alabama Museum of Natural History* 9:1-16.

McCormick, J.H., K.E.F. Hokansen, and B.R. Jones.1972. Effects of temperature on growth and survival of young brook trout. *Journal of the Fisheries Research Board of Canada* 29:1107-112.

Meehan, W.R. editor. 1991. Influence of forest and rangeland management on salmonid fishes and their habitat. *American Fisheries Society Special Publication* 19, Bethesda, Maryland.

Meisner, J.D. 1990. Effect of climatic warming on the southern margin of the native range of the brook trout, *Salvelinus fontinalis*. *Canadian Journal of Fisheries and Aquatic Sciences* 47:1065-1070.

Monzyk, F.R., W.E. Kelso, and D.A. Rutherford. 1997. Characteristics of woody cover used by brown madtoms and pirate perch in Coastal Plain streams. *Transactions of the American Fisheries Society* 126:665-675.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt, and P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pages 41-85 in G. W. Benz and D. E. Collins, editors. *Aquatic Fauna in Peril: The Southeastern Perspective*. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Nilsen, H.C. and R.W. Larimore. 1973. Establishment of invertebrate communities on log substrates in the Kaskaskia River, Illinois. *Ecology* 54:366-374.

O'Connell, M.T. 2003. Direct exploitation of prey on an inundated floodplain by cherryfin shiners (*Lythrurus roseipinnis*) in a low order, blackwater stream. *Copeia* 2003:635-645.

Peterson, J.T., and C.F. Rabeni. 1996. Natural thermal refugia for temperate warmwater fishes. *North American Journal of Fisheries Management* 16:738-746.

Pflieger, W.L. 1997. *The Fishes of Missouri*. Missouri Department of Conservation, Jefferson City.

Piller, K.R. and B.M. Burr. 1999. Reproductive biology and spawning habitat supplementation of the relict darter, *Etheostoma chienense*, a federally endangered species. *Environmental Biology of Fishes* 55:145-155.

Probst, W.E., C.F. Rabeni, W.G. Covington, and R.E. Marteney. 1984. Resource use by stream-dwelling rock bass and smallmouth bass. *Transactions of the American Fisheries Society* 113:283-294.

Quist, M.C. and C.S. Guy. 2001. Growth and mortality of prairie stream fishes: relations with fish community and instream fish characteristics. *Ecology of Freshwater Fish* 10:88-96.

Ricciardi, A., and J.B. Rasmussen. 1999. Extinction rates of North American freshwater fauna. *Conservation Biology* 13:1220-1222.

Ross, S.T. and J.A. Baker. 1983. The response of fishes to periodic spring floods in a southeastern stream. *American Midland Naturalist* 109:1-14.

Ross, S.T., J.G. Knight, and S.D. Wilkins. 1992. Distribution and microhabitat microdynamics of the threatened bayou darter, *Etheostoma rubrum*. *Copeia* 1992:658-671.

Skelton, C.E. 2001. New dace of the genus *Phoxinus* (Cyprinidae: Cypriniformes) from the Tennessee River drainage, Tennessee. *Copeia* 2001:118-128.

Smale, M.A., and C.F. Rabeni. 1995. Influences of hypoxia and hyperthermia on fish species composition in headwater streams. *Transactions of the American Fisheries Society* 124:711-725.

Smock, L.A. and E. Gilinsky. 1992. Coastal plain blackwater streams. Pages 271-313 in C.T. Hackney, S.M. Adams, and W.H. Martin, editors. *Biodiversity of the Southeastern United States, Aquatic Communities.* John Wiley, New York.

Sowa, S.P. and C.F. Rabeni. 1995. Regional evaluation of the relation of habitat to distribution and abundance of smallmouth bass and largemouth bass in Missouri streams. *Transactions of the American Fisheries Society* 124:240-251.

Starnes, L.B. and W.C. Starnes. 1981. Biology of the blackside dace *Phoxinus cumberlandensis*. *American Midland Naturalist* 106:371.

Starnes, W.C. and R.E. Jenkins. 1988. A new cyprinid fish of the genus *Phoxinus* (Pisces:Cypriniformes) from the Tennessee River drainage with comments on relationships and biogeography. *Proceeding Biological Society Washington* 101:517-529.

Sutherland, A.B. 2007. Effects of increased suspended sediment on the reproductive success of an upland crevice-spawning minnow. *Transactions of the American Fisheries Society* 136-416-422.

Swift, L.W., Jr. 1982. Duration of stream temperature increases following forest cutting in the southern Appalachian Mountains. International Symposium on Hydrometeorology, American Water Resources Association, June 1982, pp. 273-275.

Swift, L.W., Jr. and J.B. Messer. 1971. Forest cuttings raise temperatures of small streams in Southern Appalachians. *Journal of Soil and Water Conservation* 26:111-116.

Tarrant, M.A., R. Porter, and H.K. Cordell. Sociodemographics, values, and attitudes. Pages 175-187 in D. N. Wear and J. G. Greis, editors. Southern Forest Resource Assessment. USDA Forest Service, Southern Research Station, General Technical Report SRS-53, Asheville, NC.

Taylor, C.A., M.L. Warren, Jr., J.F. Fitzpatrick, Jr., H.H. Hobbs, III, R.F. Jezerinac, W.L. Pflieger, and H.W. Robison. 1996. Conservation status of the crayfishes of the United States and Canada. *Fisheries* 22(4):25-38.

Veery, E.S., J.W. Hornbeck, and C.A. Dolloff, editors. 2000. *Riparian Management in Forests of the Continental Eastern United States*. Lewis Publishers, Boca Raton, Florida.

Wallace, J.B., J.R. Webster, and R.L. Lowe. 1992. High-gradient streams of the Appalachians. Page 133-191 in Hackney, C.T., S.M. Adams, and W.H. Martin, editors. *Biodiversity of the Southeastern United States: Aquatic Communities*. John Wiley and Sons, Inc., New York.

Warren, M.L., Jr. 2004. Spring pygmy sunfish, *Elassoma alabamae* Mayden. Pages 184-185 in R.E. Mirarchi, J.T. Garner, M.F. Mettee, and P.E. O'Neil, editors. *Alabama Wildlife. Volume 2. Imperiled Aquatic Mollusks And Fishes*. The University of Alabama Press, Tuscaloosa.

Warren, M.L., Jr., P.L. Angermeier, B.M. Burr, and W.R. Haag. 1997. Decline of a diverse fish fauna: patterns of imperilment and protection in the southeastern United States. Pages 105-164 in G.W. Benz and D.E. Collins, editors. Aquatic *Fauna in Peril: The Southeastern Perspective*. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design and Communications, Decatur, Georgia.

Warren, M.L., Jr., B.M. Burr, S.J. Walsh, H.L. Bart, Jr., R.C. Cashner, D.A. Etnier, B.J. Freeman, B.R. Kuhajda, R.L. Mayden, H.W. Robison, S.T. Ross, and W.C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. *Fisheries* 25(10):7-29.

Wear, D.N. and J.G. Greis. 2002, editors. Southern forest resource assessment. USDA Forest Service, Southern Research Station, General Technical Report, SRS-53, Asheville, NC.

Wear, D.N., R. Aht, and R. Mangold. 1998. People, space, and time: factors that will govern forest sustainability. *Transactions of the North American Wildlife and Natural Resources Conference* 63:348-361.

Wehrly, K.E., M.J. Wiley, and P.W. Seelbach. 2006. Influence of landscape features on summer water temperatures in lower Michigan streams. *American Fisheries Society Symposium* 48:113-127.

Winn, H.E. and A.R. Picciolo. 1960. Communal spawning of the glassy darter *Etheostoma vitreum*. *Copeia* 1960:186-192.

Wissmar, R.C. and P.A. Bisson, editors. 2003. *Strategies for Restoring River Ecosystems: Sources of Variability and Uncertainty in Natural and Managed Systems*. American Fisheries Society, Bethesda, Maryland.

RESTORING HIGHLY MODIFIED LANDSCAPES IN NW EUROPE: WHICH TARGETS ARE FEASIBLE?

Rudy van Diggelen[1], Peter Janiesch[2], Wendelin Wichtmann[3]

Abstract—The present paper will address alternative restoration goals in densely populated areas in North-west Europe. The whole landscape is highly modified after centuries of intensive human use. Especially since the beginning of the 20th century there has been a huge shift in plant species composition of managed grasslands in the countryside. Late-flowering species of low-productive stands have declined significantly, both in dry and wet sites, whereas eutrophic species have increased. Restoration attempts are aimed at improving the conditions for the threatened species and include habitat manipulation such as topsoil removal to lower nutrient availability. These attempts are pretty successful but at the same time threatened by a high nutrient load in the whole landscape, amongst others through a high atmospheric N input. Moreover, intensive use of the past has led to large soil-P stocks in many sites and this combination makes intensive management necessary to keep such sites nutrient poor. Consequently, the target 'species-rich meadows' requires a large financial input for a long time.

Woodland development might be an attractive alternative. Not only would it remove nutrients from the soil and carbon from the atmosphere but it might lead also to a significant biodiversity increase and possibly to economic benefits. We will discuss several restoration alternatives and compare benefits and costs.

[1] Community and Conservation Ecology Group, University of Groningen, The Netherlands;r.van.diggelen@biol.rug.nl
[2] Department of Biology and Environmental Sciences, University of Oldenburg, Germany
[3] Institute for Sustainable Development of Natural Areas, University of Greifswald, Germany.

MONITORING ON THE RECOVERY OF A FOREST ECOSYSTEM POST-FOREST FIRE IN KOREA

Young Geun Lee, Myung Bo Lee, Young Ho Kanga, Jae Hyoung Choa, Tae Sung Kwona, Kang Hyun Kaa

Abstract—Long-term ecological forest research sites were installed to illustrate the changes that occur to a forest ecosystem in a post-forest fire environment in Goseong and Samcheok in Korea, where large-scale forest fires occurred in 1996 and 2000, respectively. The recovery of forest ecosystems has been investigated in terms of changes to vegetation, wild animals, insects etc. Soil outflow arrives at a peak in the first post-fire year and stabilizes by the third year. Water quality recovers during the year following a forest fire. Tree species recover primarily by way of sprouts of *Qurecus* spp., with the recovery of herbaceous species being perennials. The number and species of insects increase rapidly at the beginning period, gradually decreasing over time. The number of bird species decreases after a fire and increases for a limited number of grassland species.

As forest fires are one of the most critical causes of forest disturbance, it is important for the management of forest ecosystems to identify the effects of forest fires on a forest ecosystem, and its ensuing process of recovery. In 1996, when a fire destroyed 3,762 ha of forest area in Goseong, there appeared a number of viewpoints on the effects of fire on a forest ecosystem and appropriate methods of recovery. A long-term ecological research site was designated within the damaged area of Goseong, where soil erosion, hydrological environment, vegetation, and wild animal research have since been conducted. In 2002, another large fire occurred on the eastern coastal area, where 23,794 ha of forest disappeared in ashes. This raised the concern for the ecological changes resulting from forest fires, and their prospects of recovery. As a result, another site for long-term ecological research, of an area of 4000 ha, was established near Wondeok-eup in Samcheok. Research into changes to forest ecosystems and their recovery across ten fields of study has since been conducted there. Outlined below is a summary, by field, of the outcomes of these research efforts.

Results and Discussion

Changes to Inorganic Environments—It is widely known that soil erosion is severe in a fire-damaged forest area, due to losses of indicator vegetation and the deterioration of soil structure. For this reason, the soil recovery phases have been investigated, with the results revealing that the amount of soil erosion is high until the second year, at which point it stabilizes. In terms of the quality of water after forest fires, it deteriorated in the first year due to the rapidly increasing presence of ash, with mountain stream water then returning to Class I water status in the second year. According to annual soil erosion monitoring results from 2000 in both fire-damaged areas and in a non-damaged area in Samcheok, the former revealed a soil erosion rate of 47.5%, higher than the latter which was at 41.3%.

Recovery of Vegetation—The investigations found that oak trees tended to increase in number due to the presence of oak buds in the natural restoration areas within the research sites in both Goseong and Samcheok, whereas pine trees had prevailed prior to the fires. In terms of herbaceous plants, perennial plants such as *Carex humilis* Leyss and *Artemisia keiskeana* Miq. were found to prevail because their roots were preserved during the fires, despite losses above the ground. They were thus able to sprout quickly after the fires.

Insects and Wild Animals—The number of arthropods has increased at a greater rate in the damaged areas; in Goseong, where ten years have passed since the forest fire, the number of arthropods more than doubled in the damaged area, as compared to the non-damaged area. The number of ant species in the damaged area was over three times greater than in the non-damaged area. The number of butterfly species in the damaged area was found to be much higher than in the non-damaged area, with grassland species particularly prevalent in the damaged area. In terms of birds, oriental turtle doves, common cuckoos, and bull-headed shrikes prevailed in the damaged area, whereas the density of long-tailed tits, coal tits, and gold crests, birds that live in arbor tree forested areas, sharply decreased.

Korean Forest Research Institute, 207 Cheongyangni 2-Dong, Dongdamun-Gu, Seoul 10-712, Korea; young417@foa.go.kr

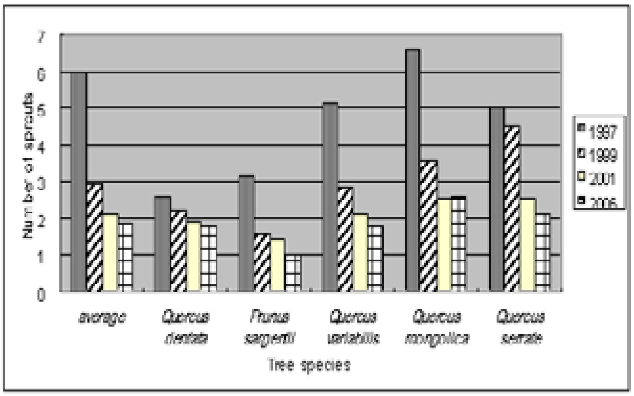


Figure 1. Decrease of sprouts over the post-fire period in Goseong

Literature cited

Kim, J.-H., Yoon, H.,-J., Choi, K. 2004. Characteristic of soil erosion on the forest fire damaged Site in Goseong. *Journal of Korean Forest Society* 93(3): 198-204.

Lim, J,-H., 2000. East Coast fire and climate. *The Korean Society of Agricultural and Forest Meteorology* 2(2): 62-67.

Choung, Y.S., Lee, B.C., Cho, J.H., Lee, K.S., Jang, I.S., Kim, S.H., Hong, S.K., Jung, H.C., Choung, H.L. 2004. Forest responses to the large-scale east coast fires in Korea. *Ecological Reseach* 19:43-54

Stickney, P. F, Campbell, R. B. Jr. 2000. Database for early postfire succession in northern Rocky Mountain forests, USDA Forest Service RMRS-GTR-61CD. 21pp.

EARLY SUCCESSIONAL CHANGES IN FOREST ECOSYSTEMS AFTER A GAP-FORMING DISTURBANCE

Nina G. Ulanova[1], Dmitrii O. Logofet[2]

Abstract—To understand the mechanisms underlying the interrelated dynamics of populations of the first colonisers, we analysed population structures in terms of the chronological age and ontogenetic stages of individual plants. Life cycle graphs (LCGs) were constructed for each population as directed graphs of annual aging and ontogenetic transitions over a grid of feasible age-stage states. The LCGs were the conceptual bases for mathematical modelling of double-structured population dynamics. Novel-type matrix model have been developed to provide for quantitative certainty to theoretical views on the population dynamics of colonizing species at the phase of extensive population growth. The non-linear models incorporate the density-dependent effects responsible for various outcomes of the interrelated dynamics at different phases of the succession.

A strong scientific basis for forest landscape restoration suggests that there exists adequate knowledge of succession dynamics of species that dominate in the lower layers of forests inside of gaps formed in the canopy due to a natural disturbance (windfall or fire) or management actions (cutting trees). The 'floristic relay' of those species depends mainly on the forest type and the kind and strength of the disturbance. Early successional tree species in the boreal forest, such as *Populus tremula* L., *Betula pendula* Roth and *Betula pubescens* Ehrh., have to compete with herbs and shrubs (e.g. *Calamagrostis* spp. and *Rubus idaeus* L.) that grow aggressively after the disturbance. These perennial species, which often grow through the vegetative mode, can dominate a site during the first 10 years after disturbance (Sammul and others 2004, Ulanova 2000, 2006), thus delaying regeneration of tree species, and in some cases, even preventing it. The processes that regulate the clonal growth of plants in the early successional stages largely determine the spatio-temporal structure in the early communities. Each successional stage features specific pathways of individual ontogenesis in the dominating species, and those pathways may differ depending on habitat conditions (Rabotnov 1985, Ulanova and others 2002). Therefore, we suggest that the course of ontogenesis determines the population response to habitat disturbance. Also, using the ontogenetic stages as stages of the plant life history offers new insights into the relationship between competing plants (Silvertown and others 1993, Tolvanen and others 2001, Ulanova 2000, 2006, Welling and others 2005).

We have also succeeded in developing original methods to determine the chronological age of shrubs based on morphological characters of the rhizome and on the number of annual rings observed in raspberry rhizome cuts (Ulanova and others 2002, Ulanova 2006). This has enabled a characterization of each shrub in three "dimensions": the biological age (stage of ontogenesis), the chronological age (in years), and the origin (seed or vegetative). In that methodology, the achievements of the Russian geobotany school in population studies are combined with profound studies of mathematical properties in the corresponding, new-type, matrix models, with field experiments designed with due regard to the calibration needs of those models.

Study Sites and Methods

The studies were conducted on the dynamics of the major dominant species after clear-cutting of spruce forests in the Central-Forest Nature Reserve (Tver' region, 56026'-56031'N; 32029'-33001'E). It is located in the south-western part of the Valdai Upland inside the main Caspian-Baltic Watershed of the Russian Plain. The experimental sites are located in a Norway spruce (*Picea abies* (L.)Karst.)-dominated mature forest stand on a mesic site-type. Population dynamics of *R. idaeus* competing with saplings of *P. tremula* were investigated in a clearcut case study, where the change in dominance was observed during 8 years (1996-2003) just after the winter cutting. The clearcut areas were colonized by *R. idaeus* originating from the soil seed bank and by suckers of *P. tremula*. About 2500 plants on ten 1mx1m permanent sample plots were marked, their ontogenetic stages were checked, and the chronological age recorded during 8 years.

The status of a population is objectively defined as a set of abundances of age-stage-specific groups of individual plants, i.e., the population structure. The different species under study exhibit the same sequence of ontogenetic stages, namely (Ulanova 2000): 1) seedlings, 2) juvenile plants, 3) immature plants, 4) virginal plants 5) young generative plants, 6) mature generative plants, 7) old generative plants, 8) subsenile plants, and 9) senile plants. However, the schedule of those stages varies greatly in time, both among different species and among different local populations of

1 Department of Geobotany, Biological Faculty, Lomonosov Moscow State University, Moscow, Russia; email-nulanova@mail.ru
2 Institute of Atmospheric Physics, Russian Academy of Sciences, Moscow, Russia

the same species. The pertinent sets of age-stage-specific groups of individual plants are therefore different for different species, while the population structures do vary among various populations of the same species. To formalize the study, we have developed an adequate technique for constructing the new-generation matrix models of double-structured population dynamics (Logofet 2002, Logofet and others 2006).

Results

Monitoring marked plants of the studied species for several years enables one to determine the particular chronological ages at which plants proceed from a stage to the next one in the ontogenesis and to find out what transitions occur among the stages in one year. As a result, a formal description of the plants' life cycle takes on the form of a life cycle graph (LCG), which is defined on a two-dimensional, integer-valued «lattice» of states and which reflects multi-variance in the trajectories of ontogenesis and reproduction in a given species under given conditions. The LCGs represent a conceptual basis for developing models that describe the observed dynamics of the double-structured population. Monitoring of marked plants enables calculation (calibration) of the model parameters (i.e., age-stage-specific vital rates) directly from the observed data. Once calibrated, the model produces quantitative characteristics (estimates) of the population structure and dynamics, namely, the maximal rate (λ_1) of population growth and the stable (relative) population structure, at which that rate is achieved. These characteristics serve as a basis for comparison of different species populations or/and various local populations of the same species.

These matrix models and the ensuing estimates can only be valid at the stage of extensive population growth, i.e., during the first 3–5 years of gap overgrowing. After that, the population dynamics include the effects of competition with later tree species and of density self-regulation. These kinds of effect are accounted for in nonlinear expansions of our matrix models. In the nonlinear models, several final states are possible as functions of the initial conditions, i.e., the conditions at the moment of gap formation, the states being differently interpreted in terms of the competition outcome. This property of nonlinear models enables scenario experiments with the models, where different scenarios can be attributed to different levels of forest management.

Conclusions

The LCGs together with the corresponding matrix models, constructed for each population under study, document those changes in the population structure and dynamics which were observed during several years. The linear models produce certain quantitative characteristics to compare the population status and dynamics of various local populations of the same species and of different (successive) species. The nonlinear expansions of those models incorporate the density-dependent effects responsible for various outcomes of the interrelated dynamics at different phases of the succession. This enables prediction of the course of disturbance-driven population dynamics as a function of the initial conditions created by the disturbance, thus contributing to the scientific basis for forest restoration.

Acknowledgments

The research was supported by INTAS (01-0527), SCOPES (7IP062658), Grant of the President of Russia for Leading Scientific Schools (2125.2003.4, 7063.2006.4), and RFBR grants (04-04-48469, 05-04-49291).

Literature cited

Logofet, D.O. 2002. Three sources and three constituents of the formalism for a population with discrete age and stage structures. *Mathematical Modelling* 14: 11-22. In Russian.

Logofet, D.O., Ulanova, N.G., Klochkova, I.N. [and others]. 2006. Structure and dynamics of a clonal plant population: classical model results in a non-classic formulation. *Ecological Modelling* 192(1-2): 95-106.

Rabotnov, T.A. 1985. Dynamics of plant coenotic populations. In: *The population structure of vegetation. Handbook of vegetation science.* 3 vol. Dordrecht: Junk: 121-142.

Sammul, M., Kull, K., Niitla, T. [and others]. 2004. A comparison of plant communities on the basis of their clonal growth patterns. *Evolutionary Ecology* 18 (5-6): 443-467.

Silvertown, J., Franco, M., Pisanty, I. [and others]. 1993. Comparative plant demography - relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. *Journal of Ecology* 81: 465-476.

Tolvanen, A., Schroderus, J., and Henry, G.H.R. 2001. Demography of three dominant sedges under contrasting grazing regimes in the High Arctic. *Journal of Vegetation Science* 12(5): 659-670.

Ulanova, N.G. 2000. Plant age stages during succession in woodland clearing in central Russia. In *Vegetation science in retrospect and perspective*. Uppsala: Opulus Press: 80-83.

Ulanova, N.G. 2006. Restoration dynamics of vegetation after clear cutting and catastrophic blowdown of spruce forests in south taiga (European part of Russia). Moscow: Moscow State University, 434 p. Doctor dissertation.

Ulanova, N.G., Demidova, A.N., Klochkova, I.N. [and others]. 2002. The structure and dynamics of a woodreed Calamagrostis canescens population: a modelling approach. *Journal of General Biology* 63: 509-521. In Russian.

Welling, P., Tolvanen, A., Laine, K. 2005. Plant traits: their role in the regeneration of alpine plant communities in sub-arctic Finland. *Journal of Vegetation Science* 16 (2): 183-190.

RESTORING BROADLEAVED FORESTS IN SOUTHERN SWEDEN

Magnus Löf

Abstract—Restoration of broadleaved forests in southern Sweden is a key-issue for many threatened species but also for sustainable timber production and social values. Afforestation with broadleaves using planting or direct seeding is one way of restoration. Rehabilitation using nature-based silviculture or conversion from Norway spruce to broadleaves is another example. In most cases, restoration of broadleaved forests is expensive. Therefore there is an urgent need for new cost-efficient regeneration methods. It is almost impossible due to incomplete knowledge of past forest states, climate change and economical aspects to re-create the forests to its original state. Instead, a broader conception of restoration allowing more diverse goals and a pragmatic approach including economical aspects for the private forest owner, would be more successful.

Conversion of natural habitats into agricultural land or degraded ecosystems is a great threat to biodiversity (Dobson and others 1997). In Europe and southern Sweden, humans have transformed the major part of the previous temperate broadleaved forests into monocultures of crops or conifers (Nilsson 1997, Kenk and Guehne 2001). Economical and practical forestry justifications underlie the present situation. In the 18th and 19th century, the formerly mixed broadleaved forests were overexploited for agricultural use, litter harvesting, grazing and cutting for fuel (Spiecker and others 2004). In addition, an urgent need for timber, as a consequence of the process of industrialization promoted the need for fast growing timber. During the last 200 years, conifer tree species such as *Picea abies* L. Karst and *Pinus sylvestris* L. were chosen both for reforestation and afforestation for several reasons, namely a rapid rate of growth, ease of establishment, little tending requirements, and lastly it was not browsed. Today, only 0.2 % remains of the central European temperate broadleaved forests in something that can be called a natural state (Hannah et al. 1995). It is one of the most degraded ecosystems in the world.

Table 1—Standing volume by tree species (Anonymous 2006a) and estimated annual utilization, plus share that is imported, of roundwood from broadleaved tree species in Sweden (fuelwood excluded) (Nylinder and Woxblom 2005). N/A means data not available.

Tree species	Standing volume, % of total	Round wood utilization, 1000 - m^3	Import, %
Conifer tree species	80.4		
Betula spp.	11.3	5 700 - 6000	60 - 75
Populus tremula	1.4	600 - 800	40 - 50
Alnus spp.	1.3	50 - 70	< 1
Quercus spp.	1.0	200 - 250	10 - 25
Fagus sylvatica	0.6	500 - 600	60 - 70
Salix spp.	0.5	N/A	N/A
Fraxinus excelsior	0.1	12 - 15	10 - 30
Others	3.4	N/A	N/A

Sweden is covered with relatively uniform coniferous forests (Table 1). Tree species that formerly dominated the forests in southern Sweden such as *Fagus sylvatica* L., *Fraxinus excelsior* L. and *Quercus* spp. make up only small parts of the total standing volume. Following major storms in southern Sweden in 1999, 2005 and 2007, conversion of coniferous stands to more natural broadleaved stands have become discussed (Karlsson and Lönnstedt 2006). Due to the millions of fallen trees, blockage of the roads and breaks in the power and telephone lines, numerous people and businesses had extensive problems for several weeks after the storm. Traditionally and until the storm, the forestry and timber based businesses provided safe and sound local employment for countryside people. The impacts of the storm resulted in numerous financial and mental consequences. Many forest owners lost a large part of their forests, i.e. the result from their life's investment of work and engagement. Following the storms, discussions about what tree species are most sustainable have been intense between government, industry and forest owners.

In this paper, I compare the different goals for forest management in society and industry and present restoration efforts for increasing the amount of temperate broadleaved forests in southern Sweden. In addition, I discus if the present day strategy is efficient and if there are alternative approaches.

Different Forest Management Goals for Society Compared To Industry

On the national level, the parliament has decided that the environment is equally valuable as forest production for timber, pulp and fuel (Anonymous 1992). For the environment, this means among other things that biodiversity shall be secured. In addition, Sweden has put the signature on several international agreements for protection of biodiversity (Anonymous 2005). Many threatened species depend on broadleaved forests. More than 50% of all threatened species in the forests are dependent on tree species such as *Fagus sylvatica* L., *Fraxinus excelsior* L., and *Quercus* spp. (Berg and others 1994). The area regenerated with broadleaved trees and the area of older broadleaved

Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, Alnarp, Sweden.; magnus.lof@ess.slu.se

forests shall therefore increase (Anonymous 2005).

Forest production was the main goal for forestry until 1993, when environmental issues became equally important (Anonymous 1992). Since the 1940s, successive governments have encouraged land owners to create new forests, and to maximize the productivity of existing forests, through intensive techniques such as using conifer tree species, fertilization, mechanical site preparation, ditching, improved planting stock and the use of pesticides. Annual growth in the productive forests is today 106 million m^3 (Anonymous 2006a). In 1920, it was 60 million m^3 annually. The largest increase is in southern Sweden. Of the productive forest area (Table 1), around 51% is owned by relatively small private forest owners. Around 30% is owned by other private forest owners and larger forest companies or industries. Only 19% is owned by the state. In southern Sweden, more forests are privately owned compared to the northern part of the country. Most forest owners are members in various owner associations, which together with the industry and the large companies value forest production and want to increase it when bio-fuels becomes more important.

Restoration Efforts and Research

Since valuable broadleaved forests in southern Sweden to a large extent were converted to more productive coniferous forests and society feared that it would disappear completely, laws were introduced in 1974 and 1984 to protect them (Löf 2001). Forest owners thereafter had to replace such harvested stands with new forests consisting of the same species. The regeneration costs and silvicultural measures such as thinning are subsidized up to 80 and 50%, respectively. Following these laws, the standing volume of valuable broadleaves has increased and the area has stopped decreasing. Today there are plans to protect 10-15% of the valuable broadleaved forests in Sweden from forestry operations (Andersson and Löfgren 2000). However, small amounts of new valuable broadleaved forests have been established during the last 25 years (Löf and others 2007). Some areas were established through afforestation between 1990 and 1995, when high amounts of subsidies were offered. After major storms 1n 1999, 2005 and 2007, and the possibility to get subsidies up to 50% of the regeneration costs, only scattered restoration activities has been put into practice.

General problems, from the forest owner perspective, are the high regeneration costs and the low productivity of most broadleaves compared to conifer tree species. Normal costs are of approximately €1200 - €2000 ha-1, but for valuable broadleaves the cost for regeneration may be as high as €6500. In addition, the rotation period is often twice as long compared to conifer tree species. To increase the share of broadleaves in the forests, governmental organizations have practiced advice, guidance and information campaigns as methods. They have been relatively successful in terms of highlighting the importance of biodiversity but less successful for the implementation of broadleaved silviculture and restoration. The Forestry Board, which is the responsible governmental organization on forest land, has both environmental and productivity goals that should be implemented at the same time amongst forest owners. Probably, the advice in different directions confuses most forest owners and results in a conservative management approach. Another underlying problem is the low competence in both silviculture and restoration of broadleaves. This is a shortcoming characteristic of forest owners, forest managers, and forest researchers in Sweden. Most applied forest research has been conducted on conifer tree species (Löf 2001) and little restoration research has been done (Anonymous 2006b).

Applied forest research on broadleaves has during the last ten years been concentrated on cost-effective methods for regeneration such as direct seeding (Löf and others 2004, Madsen and Löf 2005), natural regeneration (Karlsson and Nilsson 2005), conversion of *Picea abies* L. Karst stands to broadleaves (Oleskog and Löf 2005) and on cost-effective stand management (Karlsson and others 2006). However, little of this research has developed into new practical methods. Only a little research has been carried out concerning restoration measures in existing broadleaved stands. A classical approach of research information has been used, including excursions, conferences, demonstration experiments, publications of leaflets and web-pages.

Discussion and Conclusions

European temperate broadleaved forests used to cover much larger areas than they do today. The conifer forests have in many cases proven to be unstable and suffer when exposed to climate extremes such as wind throws, drought damage, and associated bark beetle attacks. In addition, these forests have led to changed or decreased biodiversity. In southern Sweden, a restoration of the natural broadleaved forests is an important key to a more sustainable forestry. However, a change in practical forestry is not easily achieved.

The efficiency of governmental subsidies, advice and information campaigns towards forest owners can be questioned. Only small areas of valuable broadleaved forests have been restored through afforestation and conversion of conifer plantations. Also the results from forest research and research information may be questioned. Most applied forest research has been focused on ways to achieve increased production in already existing conifer stands. Therefore, education of foresters and forest owners are theoretically biased towards conifers, something that is difficult to change over short periods of time. Moreover, recently disseminated research information concerning possible cost-effective methods for broadleaves has not been implemented in practical forestry.

Most information from governmental organisations and research concerning ways for management of broadleaves have been focused on changed silviculture with little or no attention to cost-effective methods for improved economy for the forest owner. Instead, subsidies have been used and more or less voluntary withdrawal of the management intensity has been an imperative necessity to achieve any silviculture of broadleaves. Although it is almost impossible due to incomplete knowledge of past forest states, climate change, and economical aspects to re-create former broadleaved forests to their original state, the conservation policy has aimed towards protected forests without intervention by humans.

The demand for hardwood timber is high, but only small amounts are felled in the Swedish forests (Table 1). Instead large quantities are imported. One reason may be that the small scattered broadleaved stands are difficult to handle from a logistic perspective resulting in high costs. However, this should not be difficult to solve with modern technique. Probably, more attention to economical incentives for silviculture by forest owners should favor also restoration. A pragmatic approach, allowing diverse goals of silviculture and economical aspects also in broadleaved forests,

Literature Cited

Andersson, L., Löfgren, R. 2000. Sydsvenska lövskogar och andra lövbärande marker. Rapport 5081, Naturvårdsverket, Stockholm. 172p. (In Swedish)

Anonymous. 1992. Prop. 1992/93:226. En ny skogspolitik. Riksdagen, Stockholm. (In Swedish)

Anonymous. 2005. Bevara arter – till vilket pris? Formas fokuserar 6. Formas, Stockholm. (In Swedish)

Anonymous. 2006a. Statistical yearbook of forestry. Sveriges Officiella Statistic. Skogsstyrelsen, Jönköping. (In Swedish)

Anonymous. 2006b. Biologisk mångfald – en kunskapsöversikt over befintlig forskning och kunskapsbehov i milömålsarbetet. Report no. 2. Formas, Banders GotAB, Stockholm, Sverige. (In Swedish)

Berg, Å., Ehnström, B., Gustafsson, L., Hallingbäck, T., Jonsell, M., Weslien, J. 1994. Threatened forest plant, animal and fungus species in Sweden - distribution and habitat preferences. *Conservation Biology* 8: 718-731.

Dobson, A.P., Bradshaw, A.D., Baker, A.J.M. 1997. Hopes for the future: Restoration ecology and conservation biology. *Science* 277: 515-522.

Hannah, L.; Carr, J.L.; Lankerani, A. 1995. Human disturbance and natural habitat: A biome level analysis of a global data set. *Biodiversity and Conservation* 4: 128-155.

Karlsson, M.; Nilsson, U. 2005. The effects of scarification and shelterwood treatments on naturally regenerated seedlings in southern Sweden. *Forest Ecology and Management* 205: 183-197.

Karlsson, M., Johansson, U, Ekö, P.M. 2006. Establishment and early growth of mixed beech and spruce stands. In book of abstracts from IUFRO conference Beech silviculture in Europe's largest beech country. 4 – 8 September 2006, Poiana Brasov, Romania. p 70-72. Report available at University of Brasov, Faculty of silviculture and forest engineering.

Karlsson, B., Lönnstedt, L. 2006. Strategiska skogsbruksval: Analys av två alternativ till trakthyggesbruk med gran. Arbetsrapport nr 609, SkogForsk, Uppsala. (In Swedish)

Kenk, G., Guehne, S. 2001. Management of transformation in central Europe. *Forest Ecology and Management* 151: 107-119.

Löf, M. 2001. Uthålligt skogsbruk i ädellövskog. Rapport 19, Skogsvetenskapliga fakulteten, SLU, Uppsala. (In Swedish)

Löf, M., Thomsen, A., Madsen, P. 2004. Sowing and transplanting of broadleaves (*Fagus sylvatica* L., *Quercus robur* L., *Prunus avium* L. and *Crataegus monogyna* Jacq.) for afforestation of farmland. *Forest Ecology and Management* 188: 113-123.

Löf, M., Madsen, P., Stanturf, J.A. 2007. Restaurering av lövskog – några tankar kring ett nytt skötselkoncept (submitted *Svensk Botanisk Tidskrift*) (In Swedish with English summary)

Madsen, P., Löf, M. 2005. Reforestation in southern Scandinavia using direct seeding of oak (*Quercus robur* L.). *Forestry* 78: 1-10.

Nilsson, S.G., 1997. Forests in the temperate-boreal transition: natural and man-made features. *Ecological Bulletins* 46: 117-139.

Oleskog, G., Löf, M (Eds.). 2005. The ecological and silvicultural bases for underplanting beech (*Fagus sylvatica* L.) below Norway spruce shelterwoods (*Picea abies* L. Karst.). Schriften aus der Forstlichen Fakultät der Universität Göttingen und der Niedersächsichen Forstlichen Versuchsanstalt, Band 139. J.D. Saurländer's Verlag. ISBN 3-7939-5139-1. Frankfurt am Main. 94p.

Nylinder, M., Woxblom, L. 2005. Industrial utilization of hardwood in Sweden. Paper presented within COST Action E42: Growing Valuable Broadleaved Tree Species. Thessaloniki, Greece. Available at www.valbro.de.

Spiecker, H., Hansen, J., Klimo, E., Sterba, H., Skovsgaard, J.-P., Teuffel, von, K. (Eds.) 2004. *Norway Spruce Conversion – Options and Consequences.* EFI Research Report 18, Brill Academic Publishers, Leiden, Boston, USA. 269p.

ESTIMATION OF THE CURRENT FOREST LANDSCAPE STATE AND DYNAMICS USING A TOPOGENETIC FOREST COVER CLASSIFICATION

Vera A. Ryzhkova

Abstract—Development of methods of assessment of the current forest cover state and successional dynamics is an ecological research priority. Accomplishing this task through the use of ecological theory and knowledge of vegetation community interactions with forest growing environments will permit us to assess and predict effects of external factors on ecosystems. This task can be approached based on a topogenetic forest vegetation classification, which was developed in Russia and is used by Russian ecologists and forestry specialists. A classification of the forest growing environments and the associated vegetation types was developed for southern Yenisei Mountain Range and a GIS-based vegetation dynamics map was built for a study area representative of the subtaiga and southern taiga forest zones along Yenisei River in Krasnoyarsk Region, Siberia. Forest regeneration dynamics were analyzed in a range of environmental conditions. Using this classification ensures a valid inventory is available of natural and human-caused forest cover disturbances when conducting forest treatments.

Continuously increasing anthropogenic impacts have resulted in a sharp decrease in areas occupied by native undisturbed ecosystems. Many climax ecosystems have been disturbed and shifted from equilibrium to succession over the past 50 years (Isakov and others 1986, Mirkin 1985, Odum 1975). Inventory and estimation of the current dynamic stages of various vegetation communities should be based on a classification reflecting their distribution and genesis trends that allows prediction of their future development. Forest inventory and classification is the major part of this task, as numerous forest ecosystems have been disturbed by external factors, including human influences. Such a classification is strongly needed for southern taiga ecosystems, most of which are experiencing the severest anthropogenic stress.

A topogenetic (from Greek *genesis* – origin, i.e. based on origin in similar topographic condition) approach developed for mountain forests of the Russian Far East (Ivashkevich 1933, Kolesnikov 1956) allows building forest classifications that reflect vegetation community regeneration in different environmental (site) conditions. This approach considers forest diversity as an aggregate of forest development phases. Forest environment and forest vegetation are the major factors controlling this process. Based on these two factors, forest sites are identified within a study area that are similar in topographic location, having the same combination of mesorelief elements, and, as a result, the same environmental effect on vegetation growth. All stands occurring within a relatively uniform area are common in genesis, i.e. they are considered to be the age-stages of a forest stand that is native under the conditions of interest. A regeneration series built of native and secondary stand types called "forest type" is the core unit of the topogenetic forest cover classification. According to the topogenetic principle, the entire diversity of vegetation communities is classified not by continuously changing outward characteristics (e.g., species composition), but by similarity of site conditions, genesis, and development trends of vegetation communities. This classification reflects characteristics of spatial and temporal dynamics of the major structural forest cover units (i.e., forest types), as well as genesis characteristics and development stages of forest communities. This permits prediction of vegetation succession trends and rates.

Study area and methods

The study was conducted in Predivinsk forest district, Krasnoyarsk Regions (57º 00´N, 93º30´E) located in the south of the Yenisei Mountain Range in Central Siberia. According to the forest zone classification developed by Smagin et al. (1977), this area falls within the Yenisei subtaiga and mountain taiga forest province. The vegetation cover is comprised by woody species characteristic of dark-needled taiga and subtaiga. Mixed fir/Siberian pine/spruce forests prevail in the Yenisei Mountain Range (Lapshina et al. 1971). These dark conifer taiga forests are characterized by polydominant stand canopies contributed mainly by fir, with spruce and Siberian pine (in someplaces Scots pine and larch) being permanently present. Deciduous species proportions vary greatly (from 10-20 to 100% of a stand), which is attributable to the fact that they usually occur during post-fire and post-logging forest regeneration periods, as well as to aging-caused stand changes. There are 6-7 dominant species whose contributions to stand canopy vary depending on forest growing conditions (i.e. forest environments).

Fcologist, V.N.Sukachev Institute of Forest, Siberian Branch, Russian Academy of Sciences. Akademgorodok, Krasnoyarsk 660036 Russia; email vera@ksc.ksn.ru

The study forest area is markedly diverse in composition, structure and regeneration dynamics of vegetation communities comprising it. They are heavily disturbed by both natural and human factors. Different native vegetation age stages have big areal extents covering a range of forest growing environments (Lapshina et al. 1971). These forest communities were classified using topogenetic principles. In order to construct vegetation regeneration series, we used a method of spatial-temporal series (Alexandrova 1964), also called a method of spatial-temporal analogies (Isakov et al. 1986). By this method, the stands of different ages currently existing under relatively similar site conditions are arranged into a temporal series, which is analogue to an age series and allows us to track stand regeneration over a fairly long time interval. Thus, a vegetation regeneration series is, in essence, a spatio-temporal series that permits us to hypothetically look at the current state of the analogous stand as being a potential state in the future of the stand under study. The key criterion for combining stand types into regeneration series is similarity of site conditions.

Results and conclusions

Using the above principles and methods, a classification of the forest environments and the associated vegetation types was developed for the study area typical of plain and low-mountain southern taiga forests found along Yenisei River. To do this, topo-ecological transects crossing the study area were built using topographic maps and the orographic arrangement of the study area was analyzed. Hierarchical forest environment classification units (i.e., geomorphological forest environment complexes, groups of forest vegetation types and forest environment types) were identified based on these transects, as well as geomorphologic maps, field data, and archived information. Seventeen forest types (or regeneration series) (6 Scots pine-dominated, 5 mixed fir/spruce, 3 fir/Siberian pine/spruce, and 3 spruce/fir in river valleys) associated with certain forest environment types were identified. Each forest type was characterized by a certain dominant/ co-dominant woody species ratio and productivity level (or site class) characteristic of each succession stage.

A vegetation dynamics map was developed for Predivinsk forest district using GIS technologies and the map legend was based on the above classification. This map consists of several layers, each of which shows spatial occurrence of one of the topogenetic vegetation classification units - stand types, forest types (i.e., vegetation regeneration series), forest type groups, or geomorphologic forest type complexes. This database provides information on the classification units for each contour in the map. The information on stand types (age stages) found in each forest type includes the following basic parameters of the canopy and subcanopy layers, the major woody species regeneration, and ground vegetation cover: species composition, age, productivity, standing crop, and ground vegetation cover diversity indices. The parameters of the forest growing environment (relief elements, soils, and rocks contributing to soil formation) supporting each forest type are also provided.

This topogenetic classification is a critical tool for obtaining valid estimates of the current forest condition and succession trends. Succession characteristics were identified for different forest growing environment types. Within each forest type, this classification showed whether or not native stand development occurred with stand replacement, allowed us to describe woody species composition at early stages, and to identify the major species growth trends and changes of dominant and co-dominant overstory species standing crops in different forest environments. The study products can be useful in developing principles of sustainable forest management, including vegetation cover monitoring, forest restoration decision-making, assessment of site suitability for planting forest of a desirable species composition, and in many other areas.

Acknowledgements

This research was supported by the joint Russian-American Project on Sustainable Forest Management in Central Siberia. The author gratefully appreciates USFS International Programs financial support, which made this presentation possible.

Literature cited

Alexandrova, V.D. 1964. *Vegetation Classification*. Leningrad: Nauka Press. 275 p.

Ivashkevich, B.A. 1933. Forests of the Russian Far East and their future use. *Khabarovsk: The Russian Far East* OGIZ. 168 p.

Isakov, Yu.A., Kazanskaya, N.S., Tishkov, A.A. 1986. *Zonal Characteristics of Ecosystem Dynamics.* Moscow: Nauka Press. 149 p.

Kolesnikov, B.P. 1956. *Siberian Pine Forests of the Russian Far East.* Moscow-Leningrad: Nauka Press. 261 p.

Lapshina, E.I., Gorbachev, V.N., Khramov, A.A. 1971. Vegetation and soils of Yenisei Mountain Chain. In: *Vegetation On The Right Bank Of Yenisei River.* Novosibirsk: Nauka Press: 21-66.

Mirkin, B.M. 1985. *Fundamentals of Today's Phytocenology*. Moscow: Nauka Press. 137 p.

Odum, Yu. 1975. *Fundamentals of Ecology.* Moscow: Mir Press. 740 p.

Smagin, V.N., Iljinskaya, S.A., Korotkov, I.A., Nazimova, D.I., Novoseltseva, I.F., Cherednikova, J.S. 1977. Forest vegetation zoning in Siberia. In: Proceedings of the first all-union workshop on the USSR forest fund zoning. Krasnoyarsk: V.N. Sukachev Forest Institute Press: 8-11.

HOW MANY SPECIES SHOULD BE MIXED AND HOW MUCH GENETIC DIVERSITY IS NEEDED?

Markku Larjavaara

Abstract—The number of species mixed in forest rehabilitation is normally discussed separately from issues of genetic diversity. However, intra- and inter-specific variability both influence conservation values of the rehabilitated stand, risks and value of products produced similarly. Therefore I discuss here tree diversity in general including both species and genetic components. Diversity of trees in forest rehabilitation enhances biodiversity conservation, decreases risks in the production of timber and non-timber forest products and increases natural regeneration in the rehabilitated forest. The productivity and the value of the products produced can be either increased or decreased. However, increasing tree diversity always complicates forest management and therefore monocultures are favored for timber production.

Benefits of Tree Diversity in Forest Rehabilitation—If the aim of forest rehabilitation is to conserve biodiversity, it is obvious that maximizing inter- or intra-specific diversity of trees planted, sown or naturally regenerated is vital. The justification for biodiversity conservation is well presented in numerous publications (e.g., Frankham and others 2002, Pregernig 2006), which focus on the economic values of diversity such as potential use in agriculture and the pharmaceutical industry, or on ethical and aesthetic concerns. It is often stressed that biodiversity should be conserved in order to enable natural evolution, however it is equally important to emphasize that without intra-specific diversity, natural evolution is impossible.

A higher number of tree species increases the number of ecological niches and has also been shown to increase the number of associated species such as understory plants (Kanowski and others 2003) and animals (Wunderle 1997). Therefore planting numerous tree species on a site not only conserves more trees but other organisms as well.

While biodiversity conservation confers benefits at the global level, most impacts of tree diversity in forest rehabilitation are local. Similarly as foraging animals that benefit from diverse forests also millions of humans rely on the wide range of food, medicinal plants or other products they can gather from forests. For smallholders collecting for their own use, it is better to be able to harvest small quantities of numerous products than an abundance of just one or two.

A greater diversity of trees considerably decreases the risks associated with forest rehabilitation. For example, inter- or intra-specific variability in tolerance to biotic and abiotic stresses increase the proportion of dying trees with mild stresses but decreases the proportion impacted by severe stress and in turn the risk of total failure. This is beneficial as the value of a living tree is normally the higher the less there are trees remaining.

Diversity can also decrease the risk of tree mortality or stagnation as a result of spatially spread agents (Vehvilainen and others 2006). Pests or pathogens requiring proximity to host trees cannot infect trees surrounded by non-host trees belonging to a species or genotype that is not susceptible (Linden & Vollbrecht 2002, Chokkalingam and others 2006).

The more diverse a forest is, the more random the pattern of dead trees after a disturbance. In a monoculture, a spreading disturbance such as disease or fire could kill a cluster of trees from one area and leave other areas untouched (Preisler 1993). The spatial pattern could be similarly aggregated after a non-spreading disturbance such as drought if there is variability in edaphic conditions. The more diverse the forest is the more random is the pattern of dead trees and the less harmful the disturbance will be even if proportion of dead trees is the same. This is because surviving individuals that benefit from the increased availability of resources are more numerous in a more random mortality pattern. In fact, their spatial pattern can be similar to that of individuals removed in anthropogenic thinnings.

The risks related to uncertain values of timber and non-timber forest products are lower in diverse stands containing a large range of products. In addition, the composition of diverse stands can be changed by selectively thinning only certain species or genotypes if their value drops unexpectedly.

Plant ecology theories suggest that competition between individuals of the same species is more intense than competition between individuals of different species (Hooper and others 2005).

Bioversity International, Serdang, Malaysia; m.larjavaara@cgiar.org

Between species, there are differences in the ratios in which nutrients (Hiremath and others 2002), water and light are used and their uptake or absorption can vary spatially at different levels. Therefore the production of a mixture of trees is often higher on average than that of monocultures (Atta-krah and others 2004). In the same way, intra-specific diversity could also increase productivity of tree stands.

It is obvious that the functional variability resulting from inter-specific diversity is much greater than of intra-specific diversity as the benefits of diversity are dependent on the extent of functional variability. However, self-incompability and inbreeding depression are restricted to low intra-specific diversity. Genetically similar plants such as siblings of some species cannot produce seeds due to self-incompatibility, making regeneration in an isolated stand with low intra-specific diversity impossible (Byers & Meagher 1992). Even if seeds are produced, their quantity or quality may be reduced or the viability of the new generation significantly altered as a result of inbreeding depression (Darwin 1876). In addition, inter-specific diversity increases the sustainability of rehabilitation: the more tree species present with the potential to reproduce, the higher the likelihood that viable undergrowth will develop.

Disadvantages of Tree Diversity in Forest Rehabilitation

Although the benefits of forest tree diversity in forest rehabilitation are numerous, a majority of the world's tree plantations are monocultures (Carle and others 2002), and many are established with little intra-specific diversity (Zheng & Ennos 1999). One of the reasons for this is that planting a monoculture with only one strongly bred or naturally adapted and genetically narrow variety enables use of the best material whereas increasing diversity inevitably requires the inclusion of inferior materials. Even if a mixed stand performs better on average any of its components individually, it can be outperformed by a monoculture of a highly bred variety (Lamb and others 2005, McKay and others 2005).

Inter-specific diversity also complicates forest management (Hooper and others 2005). Management procedures, starting from seed handling, are different for different species. Existing research is often focused on economically important tree species with well-developed monoculture management regimes (Hooper and others 2005). The possible combinations of species for mixtures are innumerable and optimal management is dependent on the proportions of trees in the mixtures – simply having a stable mixture and keeping all the species alive can be challenging, especially if some species grow faster than others (Erskine and others 2005).

As already stated, diversity is beneficial to communities harvesting for their own use as for them the marginal value of a forest product decreases with increasing quantity harvested. However when products are harvested for sale, their marginal value often increases with increasing quantity. For example, assuming the same timber market price for all species, it would be more profitable to harvest a monoculture than harvesting numerous species in quantities too small for efficient harvesting, transporting and marketing. Even if the marginal value of a product decreases with increasing quantity, it might be preferable to focus on producing one or a few products using a monoculture if their value is significantly higher than products obtained from other tree species.

Acknowledgements

I want to thank N.H. Nghia, Anto Rimbawanto, Lex Thomson, Enrique L. Tolentino and Hope Traficanti for discussions and comments.

Literature Cited

Atta-krah, K, Kindt, R., Skilton J.N., Amaral, W. 2004. Managing biological and genetic diversity in tropical agroforestry. *Agroforestry Systems* 61: 183-194.

Byers, D.L., Meagher, T.R. 1992. Mate availability in small populations of plant-species with homomorphic sporophytic self-incompatibility. *Heredity* 68: 353-359.

Carle, J., Vuorinen, P., Del Lungo, A. 2002. Status and trends in global forest plantation development. *Forest Products Journal* 52.

Chokkalingam, U., Pulhin, J.M., Carandang, A.P., Peras, R.J.J., Lasco, R.D., Natividad, M.Q. 2006. Outcomes and sustainability: lessons from the ground. In: U. Chokkalingam, A.P. Carandang, J.M. Pulhin, R.D. Lasco, R.J.J. Peras, and T. Toma (eds.) *One Century Of Forest Rehabilitation In The Philippines: Approaches, Outcomes And Lessons.* Center for International Forestry Research (CIFOR), Bogor, Indonesia.

Darwin, C. 1876. *The Effects Of Cross and Self-Fertilization in the Vegetable Kingdom*. John Murray, London.

Erskine, P. D., Lamb, D., Borschmann, G. 2005. Growth performance and management of a mixed rainforest tree plantation. *New Forests* 29: 117-134.

Frankham, R., Ballou, J.D., Briscoe, D.A. 2002. *Introduction to Conservation Genetics*. Cambridge University Press, Cambridge, UK.

Hiremath, A.J., Ewell, J.J., Cole, T.G. 2002. Nutrient use efficiency in three fast-growing tropical trees. *Forest Science* 48: 662-672.

Hooper, D.U., Chapin, F.S. III, Ewel, J.J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A.J., Vandermeer, J.,Wardle, D.A. 2005. Effects on biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological Monographs* 75: 3-35.

Kanowski, J., Catterall, C.P., Wardell-Johnson, G.W., Proctor, H., Reis, T. 2003. Development of forest structure on cleared rainforest land in eastern Australia under different styles of reforestation. *Forest Ecology and Management* 183: 265-280.

Lamb, D., Erskine,P.D., Parrotta, J.A.. 2005. Restoration of degraded tropical forest landscapes. *Science* 310: 1628-1632.

Linden, M., Vollbrecht, G. 2002. Sensitivity of Picea abies to butt rot in pure stands and in mixed stands with Pinus sylvestris in southern Sweden. *Silva* Fennica 36: 767-778.

McKay, J.K., Christian, C.E., Harrison, S., Rice, K.J. 2005. How local is local?: a review of practical and conceptual issues in the genetics of restoration. *Restoration Ecology* 13: 432-440.

Pregernig, M. 2006. Biodiversity in national forest and environmental policy. In: T. Geburek and J. Turok (eds). *Conservation and Management of Forest Genetic Resources In Europe* 13-32. Arbora Publishers, Zvolen, Slovakia.

Preisler, H.K. 1993. Modeling spatial patterns of trees attacked by bark-beetles. *Applied Statistics* 42: 501-514.

Vehvilainen, H., Koricheva, J., Ruohomaki, K., Johansson, T., Valkonen, S. 2006. Effects of tree stand species composition on insect herbivory of silver birch in boreal forests. *Basic and Applied Ecology* 7: 1-11.

Wunderle, J.M. Jr. 1997. The role of animal seed dispersal in accelerating native forest regeneration on degraded tropical lands. *Forest Ecology and Management* 99: 223-235.

Zheng, Y.Q. Ennos, R.A. 1999. Genetic variability and structure of natural and domesticated populations of Caribbean pine (*Pinus caribaea* Morelet). *Theoretical and Applied Genetics* 98: 765-771.

SOUTH SIBERIA MOUNTAIN FOREST-TUNDRA LANDSCAPES IN THE CONTEXT OF CLIMATE CHANGE

Viacheslav I. Kharuk and Sergey Im

Abstract—The mountain forest-tundra landscapes of Sayan and Altai Mountains, Siberia is formed by Siberian pine (*Pinus sibirica*), fir (*Abies sibirica*) and larch (*Larix sibirica*). These trees, due to harsh climate conditions, regularly grow as prostrate forms ("krummholz"). We found that during the last decades those prostrate forms were transforming into arboreal forms. Moreover, an expansion of Siberian pines, larch (and, to a lesser extent, fir) into the mountain tundra zone has been observed. Sparse stands are transforming into closed stands. The regeneration established mainly during the last ~15 yr (with maximum in the last years of the 20th century and beginning of the 21st century). At higher elevations on moister slopes most regeneration was Siberian pine (up to 70,000 stems ha^{-1}), whereas at lower elevations it was fir. On drier slopes larch regeneration dominated. Trends observed since the 1930s included an increase in radial increment through the mid 1950s, followed by a decrease until the middle of the 1980s. A strong positive trend in apical and radial increments was observed after the mid-1980s. These changes correlate with observed increase of summer temperatures. The temperature increase of 1Cº allowed regeneration to propagate at elevation of ~ 150 m. The correlation with precipitation is positive on snow-deficient slopes (mainly southern exposures), and negative where snow excess is observed; the last is due to the delay of the vegetation period, which was caused by the increased snow cover, eventually increasing during the period of snow melting. In the context of actual and predicted climate trends, we expect these transformation of mountain forest-tundra landscapes will be observed: a propagation of regeneration along an altitudinal gradient, a shifting tree-line, and transformation of krummholz into arboreal forms, with increasing stand closure.

Sukachev Institute of Forest, Krasnoyarsk, Russia, E-mail: kharuk@ksc.krasn.ru

MAINSTREAMING BIODIVERSITY CONSERVATION IN RESTORATION OF PRIVATE FORESTS FROM NORTHERN WESTERN GHATS, INDIA

Jayant Sarnaik, Archana Godbole

Abstract—The Western Ghats, a chain of mountains along the western coast of India, has been identified as one of the 25 mega-biodiversity hotspots of the world. The northern Western Ghats cover the coastal districts of Maharashtra - Thane, Raigad, Ratnagiri and Sindhudurg. It has been observed that deforestation and over-extractive uses of forests are two major threats to the biodiversity and forest ecosystems in this region. The situation is critical in Ratnagiri and Sindhudurg since a majority of forestlands (respectively 99.2% and 89%) are privately owned and decisions on forest use are entirely undertaken at the village level in these districts. Problems such as soil erosion, land slides, loss of biodiversity, and water scarcity due to unsustainable forest management affect approximately 50,000 people from 450 villages from this region. Thus once biodiversity rich forests have been converted to degraded forest landscape nearing ecological disaster. The present discussion throws light on issues and challenges related to, and strategies for ecological restoration of private forests from this area. The communication stresses the need to accord higher priority to biodiversity conservation in eco-restoration of forest landscapes. The observations made during our organization's decade-long work on traditionally protected forest patches –Sacred groves reveal that many rare and endemic tree species viz. *Hydnocarpus pentandra, Saraca asoka*, once abundant in this region, are vanishing from the private forest landscapes. The data collected during an extensive survey of 20 villages by AERF researchers about the health of watershed forests from this region showed that there exist either denuded hills or plantations of exotic species like *Eucalyptus* and *Acacia* sp. on degraded forestlands which have caused irreversible damage to the different forest ecosystems. This paper discusses the approach, various tools and mechanisms required to achieve bio-diversity conservation through restoration of degraded private forests from northern Western Ghats.

Strategies for achieving biodiversity conservation in India have been largely restricted to establishing protected areas, launching flagship programs to protect wild life species like the tiger and devise policies, acts and rules in order to observe the conditions of international treaties such as the Convention on Biological Diversity (CBD). This has led to total apathy among the civilians and government officials about the importance of biodiversity on the one hand and indiscriminate use of natural resources by the rural poor on the other. As a result many ecologically sensitive and important regions of India from biodiversity perspective are nearing ecological disaster.

The western coastal districts of the state Maharashtra, India viz. Raigad, Ratnagiri and Sindhudurg which cover the northern western Ghats, are identified as one of the 25 mega-biodiversity hotspots of the world, and serve as ideal examples of what happens if protected areas do not exist and people are perpetually poor and ignorant about the surrounding natural wealth in an ecologically sensitive area. Mass deforestation of private forests is a common feature in these districts. The private forests form the major component (about 90 %) of the total forest cover of this region. These generally belong to an individual or a village and are periodically sold for small personal needs and/or village needs to timber merchants. Severe degradation of the ecology, loss of valuable biodiversity, fall in groundwater levels, soil erosion and frequent landslides are the consequences of this practice. Indirectly it has led to loss of traditional knowledge associated with valuable biodiversity such as medicinal plants and migration of young people to metropolitan areas in search of better livelihood options, making the forests more vulnerable for overexploitation.

Monoculture plantations of *Acacia* sp. and *Eucalyptus* sp. as a part of afforestation programs by the social forestry department has helped these invasive and thirsty species to spread fast in this region drying up watersheds. Thus it is extremely imperative to initiate participatory restoration of private forests in this area for reestablishing the forest ecosystem, its services and simultaneously linking it to livelihoods of rural poor through integration of biodiversity.

For the last couple of years there is an increasing awareness among the international funding agencies, NGOs and governments of developed countries about the need to integrate biodiversity

Applied Environmental Research Foundation (AERF), C-10, Natya Chitra Co-op Hsg. Society, Pune-411029, Maharashtra, India; email aerf@vsnl.com

conservation beyond protected areas and in other economic sectors. The prominent reasons for this shift in thinking and approach could be a) climate change, b) moderate success in achieving biodiversity conservation solely through establishment of protected areas, or c) serious difficulties faced by the international environmental organizations and governments who have been the signatories of this treaty in achieving the objectives of the CBD by 2010 (Huntley and Petersen 2005).

A few years ago, the Ministry of Environment and Forest undertook an ambitious project to formulate a National Biodiversity Strategy Action Plan (NBSAP) supported by the Global Environment Facility. A series of stakeholders' workshops were conducted, opinions sought, regional meetings were held for development of an all-inclusive strategy to protect biodiversity for a country which has one of most diverse ecosystems in the world. The whole effort resulted in a document which seems to exclusively target policy makers. It has created neither the awareness among the real stakeholders (i.e., resource owners) nor any impact at the grassroots level. The Joint Forest Management initiative which tried to involve local people for sustainable management of forest resources has been successful in only one state in India. Thus it only shows that a lot needs to be done for achieving participatory conservation of biodiversity.

Our organization's efforts over the last decade to conserve the traditionally protected forest patches – Sacred groves from Ratnagiri district has met with considerable success. Over this period we developed a mechanism for participatory conservation of 10 sacred groves from this region. Sacred Groves are known as treasure houses of local biodiversity and cutting of trees is considered taboo. These institutions play a crucial role in socio-cultural activities of the village and are maintained by the village body. The interactions with villagers during the project activities revealed the lack of knowledge about plant diversity. It was understood that there is a need for continuous awareness generation about the importance of biodiversity and long-term intervention is necessary to create a positive impact. Though the sacred groves' conservation is successful in some villages, these institutions have survived due the traditional belief system. With the increasing developmental pressures and waning belief system, threats to these ecosystems have also increased. Thus it was felt that a landscape-level approach was needed to arrest the degradation of forest ecosystems and achieve biodiversity conservation at large-scale.

The approach and methods used to develop strategies for mainstreaming biodiversity conservation in restoration of private forests in northern Western Ghats are discussed in the following sections.

Our Approach

The Applied Environmental Research Foundation (AERF) carried out a biodiversity assessment study in about 20 villages from Ratnagiri district with an objective to assess the status, composition and structure of forests found on private lands, which would ultimately help in ecological restoration of these valuable resources. Ratnagiri district is one of the coastal districts of Maharashtra, which forms a narrow strip running from north to south along the western coast of India. It lies between $16^0 31'$ to $18^0 04'$ North latitude and $73^0 02'$ to $73^0 52'$ East longitude. Over 85% of the land surface in Ratnagiri district is hilly. About 75% of the total cultivable land is left fallow in this hilly area where shifting cultivation was practiced a decade ago. These have developed into good quality secondary forests now.

Before commencing on fieldwork and data collection, a combination of secondary data and consultation was used for site selection and detailed assessment. Satellite images of the district along with land use distribution and population data was used to select areas for further sampling. A report published by the Institute of Agriculture Extension and Management, Hyderabad (2002), categorizes the district of Ratnagiri into 6 agro-ecological zones viz. north and south coastal zones, north and south plateau zone, and the northern and southern section of the Western Ghats. This scheme was incorporated into this study and representative patches of forests were selected for the assessment. Consulting experts, local people as well as visual estimation of vegetation density was used for site selection.

Based on this a minimum of three sites were selected per ecological zone. At each site an assessment was undertaken whereby 25m x 25 m quadrates were laid at 500 m intervals; the sampling strategy was therefore systematic. Species composition, density, as well as measurements of forest structure were taken along with observations of forest health such as soil type, litter depth, slope and sightings of rare bird and/or animal species. As a result of these data, the status of forests within private lands was assessed. This method was adopted in accordance with guidelines laid down for prioritizing Important Plant Areas (IPA) by Plantlife International.

In addition to this, four indicator species were selected for the study. These species were all slow-growing climax forest tree species: *Antiaris toxicaria, Hydnocarpus pentandra, Saraca asoca* and *Strychnos nux-vomica*. All four species are climax forest species and therefore appropriate to indicate the status of the private forests of the region. During the assessment, presence, density and population structure of these species was documented. Measurements of extent of regeneration and dispersal distances were used to depict a population recruitment curve for the four species. Forests are dynamic ecosystems and measures of regeneration and dispersal are appropriate snapshots of the dynamics that occur within private forest plots. Sacred groves form an important component of the forest landscape within the region. An assessment of forests within the 6 ecological zones also resulted in the identification of sacred groves within each zone.

Sacred groves are traditionally protected forest patches. In a rapidly degrading landscape these groves are probably the only remnant patches of climax vegetation. These sites potentially form important reference sites for restoration of private forests. A similar assessment of sacred groves was also undertaken following the methodology and sampling design discussed earlier. The study was not limited to ecological studies and was complemented by socio-economic investigations through semi-structured interview schedules. It was essential to learn along with an understanding of forest status, the current use, management or rather mis-management of the forest lands as well as the driving forces behind forest lands such as market forces, resource demand and economic status of the landowner and local communities. In addition to this, traditional tenure systems as well as management regimes also come into play which ultimately determines the status of forests within these lands. The combination of ecological as well as social science research techniques proved to be an appropriate strategy for the current study, the results of which have been furnished in the following section.

Results and Discussion

The biodiversity assessment study of private forests revealed some uncomfortable truths. Neither the timber merchants nor the forest owners knew the conservation value of IUCN Red List species *Saraca asoka* and *Hydnocarpus pentandra*. Small but healthy populations of these trees were cut and sold as timber when the AERF research team revisited the test plots for taking periodic observations. It was also observed during the study that about 70% of the forest patches selected for study was exposed to severe degradation and climbers have occupied most of the tree canopy. The villagers were not aware about the medicinal importance of trees from the area. Moreover not many people were in a position to identify more than 5 trees in this biodiversity rich region. Local people's perception about forests was restricted to a woodlot. Discussions with local villagers were held regarding participatory management of private forests. It was concluded that following strategies will play key roles in restoration of private forests and biodiversity conservation at landscape level in this region.

a) **Capacity building of the local people**--Local people should be properly trained to identify local plants as well as nursery techniques should be taught to them for propagation of indigenous trees.
b) **Development of NTFP based rural enterprise**--Non-timber forest products such as medicinal plants, dye plants, honey and resins are abundantly available in this region. Thus a rural enterprise based on NTFP could lead to diversification of forest use and create livelihood options to the forest owner.
c) **Management agreements**--Private forests are sold to the timber merchants for paltry amounts in this region. These forests could be leased from the forest owner by offering suitable compensation. Tools such as selective felling, rotational harvesting and sustainable collection of NTFPs could be used to generate income while keeping the forest structures intact from the same resource. In this manner, a mechanism for participatory restoration of private forests could be evolved.

Conclusion

It is a globally accepted fact that biodiversity conservation outside protected area is difficult and complex task. In order to make biodiversity conservation participatory, it has to be linked with livelihood issues of the forest owners. Restoration of forest landscape will be successful if sustainable forest management could offer attractive economic returns to the forest owners. Site specific approaches need to be developed while following the global guidelines so that a win-win situation could be arrived at both for policy makers and the practitioner.

Acknowledgments

We would like to thank our colleagues at Applied Environmental Research Foundation Mr. Sameer Punde and Sanjay Pashte for their valuable input.

Literature Cited

Huntley B., Petersen C. 2005. Mainstreaming biodiversity in production landscapes. Working paper 20.November 2005. Global Environment Facility. 1818 H Street NW, Washington DC 20433 USA.

THE ROLE OF VARIOUS TYPES OF ARTIFICIAL FOREST IN SOIL AND WATER CONSERVATION IN SOUTH CHINA

Billy C. H. Hau

Abstract—Forest plantations are replacing natural forests worldwide. This study reviewed primary research papers published in China from 1994 to 2004 on soil and water conservation capability of plantation forests in South China. The aim was to understand the potential impact of replacing or compensating natural forest loss by artificial plantations in the region. The three most common plantation forests in South China are monocultures of Masson Pine *Pinus massoniana* (Pinaceae), China Fir *Cunninghamia lanceolata* (Taxodiaceae) and the bamboo *Phyllostachys heterocycla* cv. Pubescens (Gramineae). Whilst the review showed that the soil erosion index of derelict land was some 4.5 to 58 times higher than that under vegetation (shrubland, plantation or natural forest), plantation forest cover on the landscape scale is a poor reflection of the extent of soil erosion control. For example, despite high forest cover in Hunan (51%) and Jiangxi (53%) Provinces, soil erosion in forests in these two provinces was comparable to or even higher than on farming terraces. This is attributable to the uniformity and smoothness of the forest ground substrates of monoculture plantations and the removal of the existing vegetation cover (grass and shrubs) prior to tree planting in China. In the extreme cases, sites were burnt deliberately prior to reforestation. Soil erosion in the first year after planting can reach 8,000 ton km^{-2} and soil erosion will require 3 to 5 years to slow down. Most studies showed that litter productivity, which contributes to a forest's ability in soil amelioration, was also generally lower (6-75%) in China Fir, Masson Pine or bamboo plantations than in natural forest. The canopies of bamboo, pine or fir plantations have been found to intercept (25-40%) less rainfall than those of natural forest. In summary, polyculture plantations, whether native or exotic, are better in soil and water conservation in South China.

Department of Ecology & Biodiversity, The University of Hong Kong, Pokfulam Road, Hong Kong; email chhau@hkucc.hku.hk

REHABILITATION OF DAMAGED LANDSCAPE OF OPEN CAST COAL MINE SPOIL IN A DRY TROPICAL ENVIRONMENT OF INDIA: AN IMPLICATION OF FOREST RESTORATION

A.N. Singh

Abstract—The mining industry is next to agriculture in India in terms of economic importance. Coal is one of the main energy sources for electricity generation in India; therefore, coal mines are still in operation because of energy needs. Due to mining operations, significant areas of tropical forests are damaged directly by coal mines, and indirectly by the placing of huge amounts of overburden or mine spoils on un-mined surfaces. Mine spoils are physically, chemically and biologically inhospitable for any plant growth and natural recovery is a very slow process. Therefore, conversion of such habitats into forest ecosystems is a challenging issue for ecological restoration. Thus, to accelerate natural succession, this study was conducted on the aspects of rehabilitation of coal mine spoils through dense plantations of certain woody species: *Albizia lebbeck, A. procera, Tectona grandis* and *Dendrocalamus strictus*. The selected species are indigenous and possess varied ecological characteristics. Two species were short-stature legume trees (*A. lebbeck* and *A. procera*), one is a slow growing timber tree (*T. grandis*) and the last a fast growing woody grass (*D. strictus*). The objectives of the present study were to quantify growth, biomass, net primary production (NPP), and nutrient dynamics in the plantations and to assess the impact of plantations on restoration of biological fertility. Growth in height and diameter, accumulation of biomass and NPP in different tree components and the herb layer, N and P deposition and release were measured up to 6-yr of age for *A. lebbeck, A. procera,* and *T. grandis* and up to 5-yr of age for *D. strictus.* Results indicated that biomass accumulation and nutrient storage increased with age of plantations on mine spoils but also varied between species. Redevelopment of soil biological fertility of mine spoil was strongly integrated with vegetation growth and nutrient cycling, suggesting strong evidence for plant-soil relationships. An organo-mineral-horizon was built-up in the developing soils of coal mine spoils at least at the initial stage of plantation establishment.

Department of Botany, Panjab University Chandigarh-160014, INDIA, Email: dranand1212@gmail.com

ECONOMIC IMPLICATIONS OF COMMUNITY- BASED FOREST MANAGEMENT PROGRAM AS A STRATEGY FOR FOREST LANDSCAPE RESTORATION IN THE PHILIPPINES

Leni D. Camacho[1], Sofronio C. Camacho[2] and Floribel D. Paras[2]

Summary—The study looked into the economic implications of Community-Based Forest Management program (CBFM) as a strategy used in restoring degraded uplands in the Philippines as the case of CBFM in the Province of Quirino, Philippines. In the past, reforestation efforts had little impact in restoring the landscape and greenery of the country by having programs that did not involve local communities in planning and decision-making. The enactment of Executive Order 263 mandated the implementation of CBFM as the national strategy for rehabilitation of forests in partnership with local communities. Here, the involvement of upland communities encompassed reforestation activities but also allowed the people to contribute in landscape restoration through agroforestry. Thus, it is interesting to look into the implications of CBFM since it has significant economic impacts on the participants who are the key stakeholders and will greatly affect the success of the program.

The study was undertaken in five sites in Quirino Province, namely Baguio Village, Don Mariano Perez, Cabugao, Anak and Asaclat. A primary survey and a series of interviews with CBFM participants were conducted in the areas which were conducted from October to November 2002 and May 2003. There were 60 respondents chosen based on the number of active participants in the respective sites. A pre-tested questionnaire was used in the interview complemented with socioeconomic, demographic, farm and other relevant data. Secondary data were gathered from past researches in the area. Officials of the communities, leaders of various associations and local residents were also interviewed and consulted.

Opportunity cost and contingent valuation (CVM) methods of data analysis were used. The economic implications of devoting the area to reforestation under the CBFM program were evaluated by estimating the opportunity costs incurred to the local residents as a result of the project. It determined the extent to which these costs could become a potential constraint to reforestation and verified the benefits from reforestation. The results of the analyses guides in making reforestation to become a viable and economically efficient investment. The net present values (NPV) of opportunity costs were also computed, which represents the change in income of the local residents because of the reforestation activities in the area. Likewise, the CVM was also used to determine how the upland farmers value their stay in the area. The method estimated the willingness to accept incentives to give up the area.

Using economic criteria, CBFM was found to be a very effective strategy for landscape restoration in both forest protection and conservation areas. It was also effective in helping develop the local upland community. Results of agroforestry data analysis indicated that farming activities done by the community while waiting for the tree crops to mature provides additional income, financial support, livelihood alternatives, improved farm management, and other production inputs.

Meanwhile, analyzing the feasibility of CBFM through CVM indicated that in the long run it is profitable to join the program because the number and variation of benefits derived from it is greater than the option of not joining the program. Reforestation activities provided participants of the program the permission to use resources within the area legally, giving them additional employment and extra income, and providing opportunities for financial support through their respective Peoples's Organizations (POs).

From the results of the study, it has been noted that constraints to the implementation of CBFM can be political, organizational, and human in nature. Indefinite or unclear benefit-sharing

[1] Department of Social Forestry and Forest Governance, College of Forestry and Natural Resources, UPLB, College, Laguna, Philippines; email- lcamacho@laguna.net
[2] Forestry Development Center, CFNR, UPLB, College, Laguna, Philippines.

mechanisms of the program potentially hinder a harmonious relationship among CBFM stakeholders and should therefore be clarified and agreed upon by all parties concerned. Also, the suspension of resource use permits of CBFM areas brought about by changing policies of administrators cause demoralization among the project participants. If policy makers want to maintain the enthusiasm of the people for the program, this political issue should be addressed. Organizational problems within the PO also hinder the success of the project usually because of internal problems such as the equitable distribution of employment opportunities and unpaid reforestation wages. Finally, weak financial management, farm recording and bookkeeping of cash and non-cash production inputs and outputs impede development of individual farms and POs. Technical assistance and attentive monitoring to the POs should be done to help them in this matter.

CONSERVATION RELAY: PRIVATE SECTOR PARTICIPATION IN RESTORATION OF DEGRADED FOREST LANDSCAPES IN MT. MAKILING, PHILIPPINES

Emmanuel R.G. Abraham[1], Leilani A. Castillo[2], Yong Kwon Lee[3], Su Young Woo[4], Don Koo Lee[5], Youn Ho Jang[6], Jose O. Sargento[2] and Amelita C. Luna[7]

Abstract—This paper presents a private sector volunteer-based strategy for initiating and sustaining forest restoration efforts in Mt. Makiling, Philippines that evolved within the last decade. The strategy, dubbed "conservation relay." is a process where various private sectors carry out and support restoration efforts in sequential time periods, attending an area from its degraded status to a condition favoring natural restoration processes. From 1993 to 2006, about 830 individuals belonging to 14 companies/groups contributed to the rehabilitation of 31.5 hectares of degraded forest areas in Mt. Makiling. Recent research on the impacts of these efforts in one of the sites showed substantial improvement in vegetation cover, species composition microclimate, and soil conditions that now favor natural regeneration processes.

Mt. Makiling is a small mountain ecosystem covering about 5,907 ha located approximately 65 km southeast of Manila on the south-central part of Luzon Island, Philippines. About 70% of the mountain was reserved by the government as an outdoor training laboratory for natural resources management and nature study since 1910. In 1909, when the UP College of Agriculture (now University of the Philippines Los Baños) was first established, much of the area surrounding its forested core was degraded (Brown 1919). By the late 1970s, many of these areas were successfully reforested primarily through the efforts of faculty, students and staff of the university (Sargento and others 1999). However, degraded areas still persisted in other sites, particularly on its southwestern slopes.

Increased environmental awareness in the early 1990s heightened stakeholder participation in efforts to rehabilitate these degraded areas. This was the decade where private sector participation in forest restoration efforts became significant as various modes of partnership were explored and carried out (Torres and Aparejado 1999). This paper presents how the private sector participated in the restoration of three degraded areas on the mountain, including the largest contiguous grassland patch. It presents the basic framework of a strategy dubbed as "Conservation Relay"--"a corporate ecosystem restoration strategy that initiates as well as builds on earlier restoration efforts to start-up and sustain the rehabilitation of process of a degraded area. It is like a race where the baton--representing material, financial or manpower inputs--is passed from one cooperating stakeholder to another through time, until a degraded area is fully rehabilitated" (Oruga 2004). Some biophysical impacts of the restoration efforts are also presented.

Materials and Methods

Available records of private sector participation in forest restoration efforts in Mt. Makiling between 1990 and 2006 were compiled, reviewed and analyzed. The analysis was supplemented by personal knowledge of some of the authors who were part of these efforts. Site specific studies that assessed impacts of restoration efforts were conducted from 2002 to 2006.

Results and Discussion

Within the period covered by the study, private companies and groups carried out reforestation in three degraded areas of Mt. Makiling: Sitio Kay Inglesia and Sitio Palanggana on the southwestern flank of the mountain, and Sitio Paliparan on the northeastern side. The first two sites were contiguous patches of grassland areas covering about 16 ha and 10 ha, respectively. The third site consisted of small patches of grasslands that collectively covered 5.5 ha. The private sector volunteer-based strategy often involved ordinary employees of pharmaceutical and manufacturing companies (e.g. Novartis, DuPont, EPSON, etc) as well as socio-civic organizations. These companies or groups brought their staff to Mt. Makiling to plant trees on an annual basis and provided financial resources to maintain and protect the plantation between plantings.

[1] Institute of Renewable Natural Resources, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines; email- erg_abraham@yahoo.com
[2] Makiling Center for Mountain Ecosystems, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines
[3] Korea Forest Service, Daejeon, 302-70, Korea
[4] Department of Environmental Horticulture, College of Natural Sciences, University of Seoul, 90 Jeonnong-Dong, Dongdaemungu, Seoul, 130-743 Korea-
[5] College of Agriculture and Life Sciences, Seoul National University, Seoul,151-921 Korea
[6] Korindo, Korindo Bldg., MT. Haryono, Kav. 62, Jakarta, DKI Jakarta, Indonesia-
[7] Office of the Coordinator for Research, Extension and Linkages, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines;

After Sitio Kay Inglesia was extensively burned over in April 1990, local stakeholders protected it from fire and the private sector carried out reforestation efforts from 1993 to 1997. Additional plantings, maintenance and exclusion of fire continued thereafter. As of 2006, only a few small patches of grasslands remained although most of these were already planted with young seedlings or were being invaded by more tree species. Wildlife such as wild boars, monkeys, and birds has been sighted. The 13-year restoration effort covered a total of 16 ha and involved more than 200 individuals from five companies/groups which spent an aggregate of at least PhP 950,000 (USD 19,000 at PhP 50/USD). Research further showed that the tree plantations improved site qualities. Jang and others (2004) found that the Acacia plantations had higher total nitrogen content and dehydrogenase activities compared to the grassland patches. Lee and others (2006) also found that the Acacia plantations promoted natural regeneration, improved soil enzyme activity and microclimate (air temperature, soil temperature and relative humidity) and decreased the variation of these factors. Forest restoration efforts in Sitio Palanggana was carried out from 1999 to 2003 as part of a privately funded research on the use of indigenous forest tree species for rehabilitating watershed areas. When private funding ceased, a private corporation picked up the baton and continued restoration efforts thereafter using the private sector volunteer-based approach. As of 2006, three groups and about 200 individuals participated in reforesting a total of 10 ha of degraded forest land at the cost of about PhP 650,000 (USD 13,000). In Sitio Paliparan, about 5.5 ha of degraded areas were rehabilitated by 390 individuals from seven companies/groups over an 11-year period, costing about PhP 680,000 (USD 13,600). The duration of private sector participation ranged from less than a year up to 5 years and was generally in sequential time periods.

The results showed that the private sector volunteer-based strategy provided much-needed fiscal and manpower resources in rehabilitating degraded areas in Mt. Makiling. By initiating and sustaining restoration efforts, site conditions of degraded areas improved and favored more successful natural restoration processes. The strategy also exposed many individuals from private non-forest sectors to forest restoration activities and in the process, increased their environmental awareness and commitment. The study showed the potential effectiveness of conservation relay to carry out forest restoration efforts in degraded areas especially when resources to do so are limited.

Literature cited

Brown, W.H. 1919. *The Vegetation of Philippine Mountains*. Bureau of Science Publication No. 13. Manila: Bureau of Printing. 434 p.

Jang, Y.H., Lee, D.K., Lee, Y.K. [and others]. 2004. Effect of *Acacia auriculiformis* and *Acacia mangium* plantation on soil properties of the forest area degraded by forest fire on Mt Makiling, Philippines. *Journal Korean Forest Society* 93(4): 315-323.

Lee, Y. K., Lee, D.K., Woo, S.Y. [and others]. 2006. Effect of *Acacia* plantations on net photosynthesis, tree species composition, soil enzyme activities, and microclimate on Mt. Makiling. *Photosynthetica* 44(2):299-308.

Oruga, J.A. 2004. Saving a fairy's abode. The Philippine Starweek 18(47):4-5.

Sargento, J.O., Abraham, E.R.G., Aparejado, L.A. 1999. Reforestation performance with Philippine tree species in *Mt. Makiling Forest Reserve.* In: Torres, C.S., Tan, E.M., eds. *The Mt. Makiling Forest Reserve: Development Initiatives and Management Experiences.* Quezon City: Makiling Center for Mountain Ecosystems: 80-95. In cooperation with: Mt. Makiling Reserve Area and Laguna de Bay Commission; Office of the President.

Torres, C.S., Aparejado, L.A. 1999. Partnership modes in reforestation and rehabilitation of the Mt. Makiling Forest Reserve. In: Torres, C.S., Tan, E.M., eds. *The Mt. Makiling Forest Reserve: Development Initiatives and Management Experiences.* Quezon City: Makiling Center for Mountain Ecosystems: 103-113. In cooperation with: Mt. Makiling Reserve Area and Laguna de Bay Commission; Office of the President.

DEVELOPING GUIDELINES FOR FOREST RESTORATION IN THE PHILIPPINES

Rex Victor O. Cruz[1], Lucrecio L. Rebugio[1], Don Koo Lee[2], Wilfredo M. Carandang[1], Enrique L. Tolentino, Jr.[1], Nathaniel C. Bantayan[1]

Abstract—For over four decades policy, institutional and technological imperfections and deficiencies have limited the success in restoring degraded forests in the Philippines putting in jeopardy the attainment of sustainable forest management. This paper outlines a conceptual approach for a more systematic and deliberate program to restore degraded forests in the Philippines. The paper identifies the guidelines for the preparation of appropriate action plan that will cover the full range of dimensions and facets of forest restoration with the ultimate goal of attaining greater success in restoring degraded forests. The discussion includes the need to categorize the various degraded forests in terms of existing conditions, goals of restoration and modes of restoring the degraded lands. Among the menu of guidelines, the role of clear legal foundation, participation of local communities, local governments and other stakeholders, and the adoption of integrated and holistic planning framework are highlighted.

Rationale—Restoration of degraded forests is a key to sustaining the capacity of forests to perform a myriad of ecological, socio-cultural, and economic functions. Increasing utilization of the forests for various purposes has diminished the ability of the forests to supply goods and services vital to healthy and progressive communities. Years of harvesting timber and other forest products along with the use of forest lands for agriculture and other alternative uses left behind vast tracts of forests with altered vegetation cover that is usually unable to perform fully the functions of pristine forests. When vegetation cover is removed or altered in any way the forests become dysfunctional, which when prolonged can have devastating impacts to the environment and the economy of the country. As a corrective measure, forest restoration becomes critically essential in bringing the degraded forests back into the state of being able to perform its normal functions.

The Philippine government has made numerous attempts to restore vast degraded forests. However policy, institutional and technological imperfections and deficiencies limited the success of past initiatives in restoring degraded forests into functional states, hampering the efforts to minimize the ill-effects of degraded forests and putting in jeopardy the attainment of sustainable forest management goals. This proposal responds to the call for a more systematic and deliberate program to restore degraded forests in the country. The proposal is to lay down guidelines for the preparation of appropriate action plan that will cover the full range of dimensions and facets of forest restoration with the ultimate goal of attaining greater success in restoring degraded forests.

Definition of Key Terms

Deforestation and Forest Degradation—Forest degradation can take many forms, and be manifest at many scales. Degradation occurs when unnatural events cause perturbations to natural processes that compromise ecological integrity. As defined by Serna (1986), degradation involves the reduction in, or impairment of, the capability of a forest area to produce wood due to the influence of outside factors, particularly human activities. He added that degradation involves no diminution of the area but only a decrease in the productivity of the resource. This definition is quite narrow and limited.

Grainger (1988) put forward the concept of vegetation degradation which he defined as a temporary or permanent reduction in the density, structure, species composition or productivity of the vegetation cover. Grainger (1996) further identified three main causes of degradation: extraction (e.g., selective logging which may be followed by either tree planting or managed natural regeneration), forest damage resulting from natural or indirect human causes like drought or pollution, and clearance followed by managed regeneration, planting or interrupted succession.

In tropical environments, large-scale, intense forest degradation is a relatively recent phenomenon, following rapid population growth and consumer demand for tropical timber products by developed nations (House 1997). Tropical forests are now undergoing such changes at rates that are unprecedented, the results of which are fragmentation, species and community losses, and climate change. Deforestation is an extreme case of degradation. Deforestation is defined as

[1] College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna 4031 Philippines; email-rexcruz@yahoo.com
[2] Seoul National University, Seoul, Korea

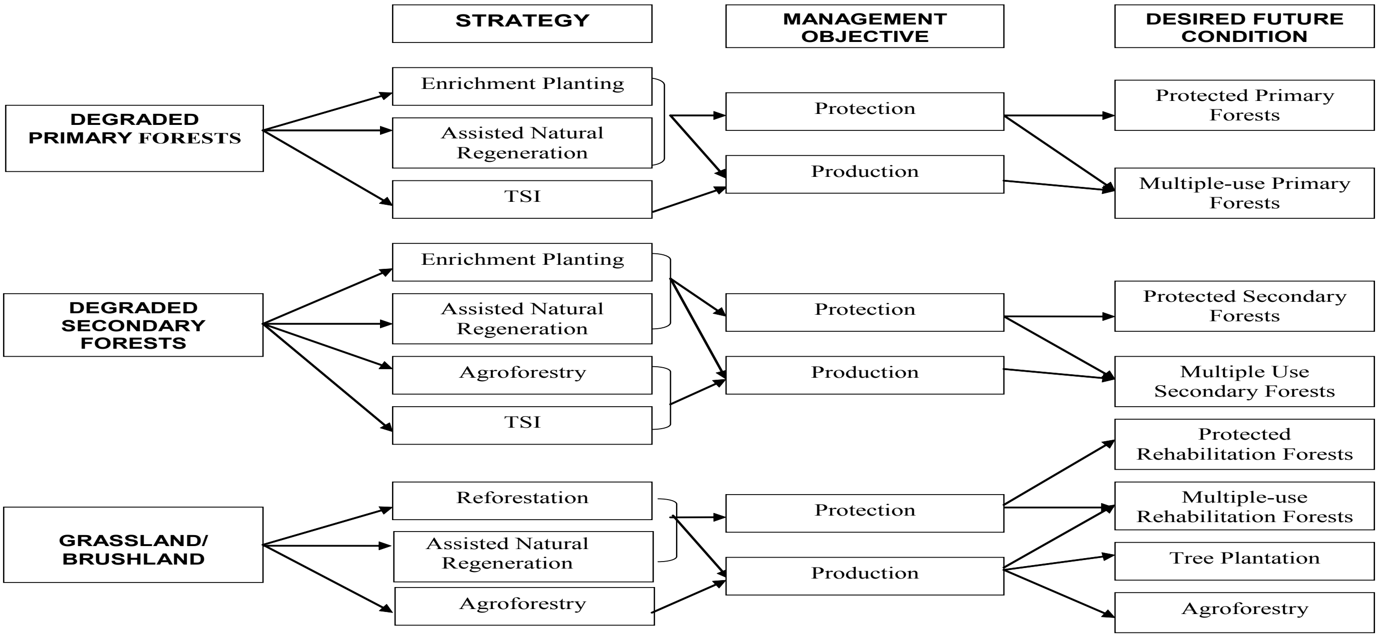


Figure 1. Common modes of forest restoration in the Philippines.

the temporary or permanent clearance of forest for agriculture or other purposes (Grainger 1996). It may temporarily or permanently reduce the density of the vegetation cover to zero.

Major physical indicators of forest degradation include the nature of vertical structure, the density of the stand, species composition, and productivity. The vertical structure of a degraded forest may lack some of the layers that are characteristic of a primary or old-growth forest. Logging, a common cause of degradation, usually removes the dominant and emergent trees.

The density of trees in a degraded forest may be characterized in terms of canopy closure, canopy quality, fragmentation, tree density, and biomass density. Degraded forests tend to exhibit more gaps in the canopy as compared with undisturbed forests that may also contain gaps due to natural causes like lightning and tree mortality. Logging removes large trees and produces significant gaps. In terms of canopy quality, leaf cover in a degraded forest can be highly abnormal. Over-logging may produce open forests as in savannahs. The reduction of the overall density of trees decreases biomass density.

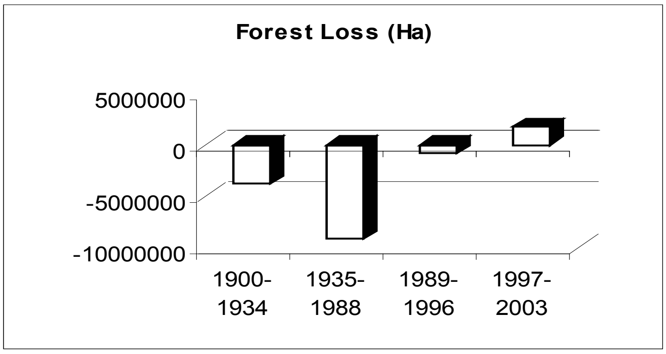


Figure 2. Rate of forest loss in the Philippines

In most degradation cases, the large trees removed are usually replaced by a bushy forest with smaller trees. Human impacts may fragment a former homogeneous spatial distribution of an undisturbed forest, resulting in a complex mosaic of undisturbed forest, degraded forest, gaps and clearances. Even if substantial patches of undisturbed forest remain, forest cover in the entire area is clearly degraded.

Finally, degradation can lead to a temporary or long-term change in species composition. Extraction of commercial timber species, together with the growth of the secondary species, and the planting of monocultures or even a mosaic of species mixtures commonly lead to degradation of species composition. These will likely have adverse consequences on biological diversity within the forest and change its productivity, i.e., the net biomass accumulation in a young secondary forest is higher than in a primary forest.

Replacement, Rehabilitation and Restoration of Degraded Forest Lands—The development of degraded forestlands may follow a number of courses. Lamb (1994) and Bradshaw (1987) described the crucial differences between these options. First, there is reclamation or replacement of a degraded forest ecosystem, which implies recovery of the basic productivity and physical stability of the site by establishing new vegetation in place of the original one. In the tropics, the resulting vegetation association is often simpler but more productive. It could also be simpler and less productive. Seriously degraded areas may offer opportunities for the establishment of industrial tree plantations, oftentimes using exotic species that are more versatile and grow more rapidly than the native vegetation.

In a strictly theoretical sense, restoration of a degraded forest ecosystem aims to put back what was in the area before degradation took place. This includes plant and animal components, and the full range of ecological processes leading to the recovery of ecological integrity of the area. It is the most ambitious, technically challenging and expensive development option but is the most ecologically appropriate. Pragmatically, however, restoration of degraded forests can be viewed as a package of strategies for transforming degraded forests into certain sequence of desired future conditions. In

Region	Closed Forest	Open Forest	Mangrove Natural	Plantation	Total
REGION 04-B	484866	604246	57567	48465	1195144
REGION 02	503149	604473	8602	33621	1149845
CAR	384877	246848	0	40595	672320
REGION 03	226241	304215	368	58671	589495
REGION 13	64729	431832	26731	0	523292
REGION 08	36473	410111	38781	34483	519848
REGION 11	177503	240986	2010	536	421035
REGION 12	126385	218858	1350	2641	349234
REGION 10	107071	226400	2492	1530	337493
REGION 04-A	117162	161165	11346	0	289673
REGION 06	105873	104686	4600	49355	264514
ARMM	106319	96661	45786	1580	250346
REGION 01	37723	117217	151	34710	189801
REGION 09	29652	126790	22279	3474	182195
REGION 05	50618	90284	13499	2075	156476
REGION 07	2231	43026	11770	17842	74869
NCR	0	2790	30	0	2820
TOTAL	2560872	4030588	247362	329578	7168400

Source: FMB 2004

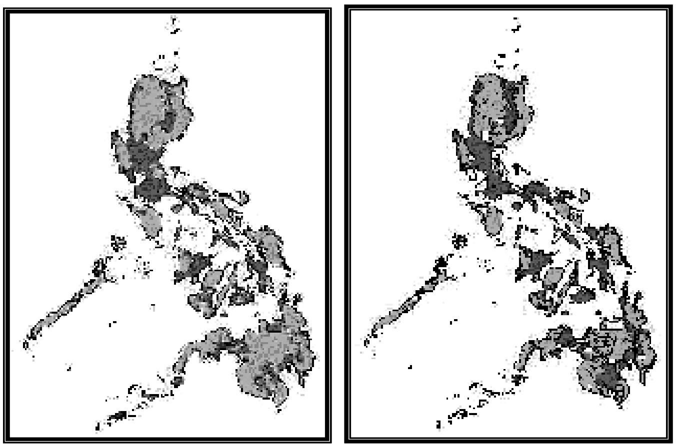
Table 1. Forest cover of the Philippines,

this sense, forest restoration can be interpreted as a combined method for replacement, rehabilitation and restoration. As such, restoration can be varied in terms of objectives, conditions of degraded forests and the desired conditions as shown in Figure 2. The selection of restoration strategies is determined by the condition of forests or vegetation cover of the area (i.e., primary forests, secondary forests or grassland/brushlands), the management objective (i.e., protection or production), and the desired condition of the degraded forests (i.e., protected, production or multiple-use forests).

In-between replacement and restoration is the concept of rehabilitation. In this case, some attempt is made to replace the most obvious components of the original forest. These are usually the tree layers comprised of some of the original tree species. But the choice as to the tree species or combination of tree crops is oftentimes limited. This is restoration that is not completely successful, so to speak. Forest rehabilitation aims to provide for more than mere physical stabilization of the site, but falls short of restoration of the pre-degraded site. In most cases, any further re-establishment of the original forest elements including the fundamental ecological processes is incidental or accidental.

Rehabilitation can be looked at as a compromise between what is relatively easily achieved and what is ultimately desirable. Lamb (1994) asserted that there are often valid economic and social imperatives that dictate at which point along the degraded forest development continuum from reclamation to restoration a particular project is aimed. With the rate at which destruction of the tropical forests is going on, and with extinction rates increasing in magnitude compared with the background rate over geological time (Wilson 1988), and with a growing global appreciation of biodiversity conservation (McNeely 1996), there is renewed interest in forest restoration.

Rehabilitated lands may yield more income than restored lands. However, the true value of restored lands is determined by how society views the cost of protecting rare species, and the indirect returns of the "ecosystem services" (Westmann 1977) restored lands will provide. The cultural, scientific and intrinsic values of restored lands are



General land cover map of the Philippines [Black = forest use; Gray = non-forest use]

Land classification map of the Philippines [Black = forestland; Gray = non-forestland]

Figure 3. Land cover and land classification map of the Philippines.

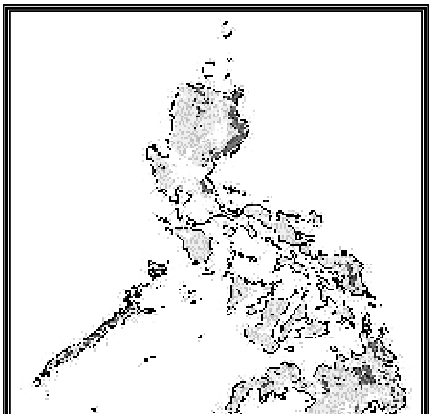


Figure 4. Forest lands that are used for non-forest purposes.

the highest where intrinsic value means value for its own sake, not associated with human benefit. Restoration may be more costly to implement initially, but it results in ecosystems that require less maintenance input in the long term, are more stable, and have higher species diversity.

Methodology

The content of this paper is based largely on the synthesis of results coming out of the various studies conducted by the ASEAN Korea Environmental Cooperation Project in the Philippines (AKECOP) particularly the studies on the and biophysical and socioeconomic dimensions of forest restoration and the State of the Art Review of Forest Restoration in the Philippines (Rebugio and others 2005) that covered vast amount of restoration plans, program and project documentations and other documents related to forest restoration in the Philippines. To enrich the substance of this paper numerous published research results and technical papers such as the ITTO Guidelines for the Restoration, Management and Rehabilitation of Degraded and Secondary Tropical Forests (2002) and the Manual for the Application of Criteria and Indicators for Sustainable Management of Natural Tropical Forests (ITTO 1999) were also reviewed. Comments generated from several forums where the early drafts of this paper were presented provided further enrichment to the guidelines.

Results and Discussion

Background Information

Land use and land cover of the Philippines— In general, the main indicator of success in restoration activities and biodiversity conservation is forest resources. Of the world's 3,870 million ha of forests, 56 % are tropical and subtropical (FAO 2001). In Asia, there is an estimated 548 million ha of forests of which 432 million ha are natural forests and 116 million ha are plantations. In the Philippines, 5.789 million ha are forests of which 0.753 million ha are forest plantations. This has increased to 7.168 million hectares (with 0.33 million ha of plantations) based on the latest satellite data (Table 1). From 1900 until 1996, the Philippines lost 14.9M ha of tropical forests (Figure 1) with a recovery of about 1.8M ha.

Degraded Forests of the Philippines—Of the 30 million ha comprising the total land area of the country, it is estimated that 53% (or 15.88 million ha) belong to forestlands while the rest are A&D lands (Figure 3) [forestlands - black color and non-forestlands - gray color]). The irony is that while the policy on land classification has been in place for the past 80 years, the line that separates the forestlands from the A&D lands does not exist on the ground (Bantayan and Arche 2003). Figure 4 shows the general land cover of the country expressed in terms of areas under forest cover (black color) and areas that are under non-forest use (gray color).

Based on estimates about 65% of forest lands in the country is degraded with either inadequate forest cover or no cover at all that is roughly broken down as follows: degraded old growth or primary forests is about 1.9 M ha, secondary forests is around 2.8 M ha, about 2.4 M ha is brushland, 2 M ha is grassland, and the rest is either cultivated or plantation areas.

Development of Guidelines for Forest Restoration in the Philippines—Indeed the vastness of degraded forests in the country can be attributed to the inefficiency in the utilization of forest resources mainly due to absence of strong will as much as perhaps the inadequacy in skills to carry out logging and other forest uses in an environmentally safe manner. But in matters pertaining to restoration of degraded forests, it seems fair to mention that the will to undertake restoration has been strongly exhibited in many programs launched between 1960 and today. Records will show that billions of pesos have been invested to restore degraded forests in various parts of the country. Unfortunately the same records will show that the areas successfully restored are disproportionately low compared to the investments sunk into the different restoration programs. As bad as it looks the few successful restoration stories that can be told along with many failed attempts at restoring degraded forests promise realistic hope that forest restoration in the Philippines can be improved and shove Philippine forestry closer to the path of sustainability. Out of these vast experiences in restoration, lessons can be learned and developed into guidelines for improving the current modes of forest restoration that are at best disorganized, largely intuitive, and lacking in the solid foundation that science provides.

The proposed guidelines for forest restoration in the Philippines were based particularly on the review of state-of-the-art of forest restoration in the Philippines (SOAR) together with the results of various studies undertaken through the ASEAN-Korea Environmental Cooperation Project in the Philippines and on selected existing local and international guidelines.

Review of the State-of-the-Art of Forest Restoration in the Philippines—Selected key results of the SOAR are briefly described below.

Policy Gaps—Pervasive weak enforcement (and monitoring) of laws and regulations governing forest restoration and forest protection limited the success of many restoration programs including but not limited to selective logging system and various social forestry programs. Policy on selection cutting in the Philippines is well known internationally as one of the best there is and yet, the degradation of almost all logging concession areas testify to the lethargic enforcement of the policy (FDC 1996). Social forestry policies in the Philippines are likewise hailed as models after which social forestry projects in other countries are patterned but the inadequate implementation of the policies failed to prevent the abuse of resource use permits never before granted to local communities.

Inadequate resource allocation for research, information and technology generation (seed production areas, biotechnology, etc.) has not facilitated the science and information-based policy and management decision making process for forest restoration. The limited resources for undertaking researches in general have stifled the generation of knowledge and technology essential to effective forest restoration. In addition, the limitation in financing created an imbalance between basic and applied research as well as between the short- and long-term studies, providing insufficient opportunities to shift from intuitive to more information-based decision making.

Inadequate incentives for restoration particularly of protected areas have rendered many forests vulnerable to degradation and have made the restoration of degraded forests in protected areas virtually impossible. The policy to withdraw protected areas from intensive use of even the occupants of the protected areas requires the provision of sufficient incentives for these people to remain in the protected areas without imperiling the sustainability of the forests. While such incentives as the permission to remain in the protected areas and assignment of areas that can be used for multiple production purposes are in place, additional incentives are needed to enable these occupants to have a decent life without degrading the forests.

Management Modalities—Most of the programs were conceptualized and carried out as sector initiatives without strong cross sector linkages. Instead of undertaking restoration as an integral element of sustainable forest management, many restoration programs were implemented as stand alone initiatives. Many reforestation projects for instance were undertaken outside of an integrated management and development plan for a watershed, forests or even for a political unit, alienating the projects from stakeholders outside of the project implementation structure.

Formulation and planning of most restoration programs in the past were characteristically more an intuitive than an analytical process rendering the programs prone to errors of judgment of planners and decision makers. Planning lacked sufficient grounding on clearly defined problems, priorities, goals and desired future condition distinct to a particular site making the selection of appropriate restoration strategies highly improbable. As a result restoration prescriptions tended to be more generic instead of custom-fit to the peculiarities of one site to another that resulted to the little success in many reforestation programs undertaken in the past decades.

Highlights of AKECOP Research Results—The Philippine Forest Restoration and Biodiversity Conservation project, under the AKECOP, was conceived to generate information and technologies that would be useful in the restoration of denuded and degraded forestlands in the Philippines that is estimated at around 5 million ha. Started in the middle of 2001, AKECOP conducted a total of 17 studies in its two research sites: the La Mesa Dam Watershed in Rizal Province and the Makiling Forest Reserve of the College of Forestry and Natural Resources, UP Los Baños in the province of Laguna. These studies include the assessment/characterization of the various bio-geophysical and socio-economic-cultural conditions prevailing at the research sites; establishment of field trials on forest restoration strategies; generation of baseline information on hydrology and carbon stocks; development of integrated database and geographic information system on Mt Makiling biodiversity and other research activities.

Objectives—In line with AKECOP's long term vision, AKECOP-Philippines regional research aimed to generate information base for developing sustainable models for restoring natural forest and rehabilitating degraded forest lands in the Philippines. It is also aimed at sharing restoration research information among collaborating scientists in the region. Lastly, AKECOP- Philippines Project intended to develop a comprehensive biodiversity decision support system with particular emphasis on plant species and genetic resources in the Philippines, particularly in the Mt. Makiling Forest Reserve.

Research Activities—To realize the above objectives, several studies were identified for implementation following the framework shown in Figure 5. Four studies focused on the assessment of the current state of resources in the study sites. These are: 1) assessment of soil resources, 2) assessment of microclimate conditions, 3) assessment of hydrologic processes, 4) assessment of carbon stocks, and 5) socio-economic characterization.

Five studies on the various restoration strategies for natural forests and grasslands were implemented, namely: 1) appropriate silvicultural treatments for the effective revegetation of open patches within a natural forest, 2) assisted natural regeneration as an effective technique of rehabilitating marginal grasslands in the Philippines, 3) rehabilitation of degraded lands through accelerated pioneer-climax species (APCS) strategy, 4) rehabilitation of degraded lands through short rotation forestry

(SRF) species-based agroforestry system and 5) ecophysiology of indigenous tree species planted in degraded sites.

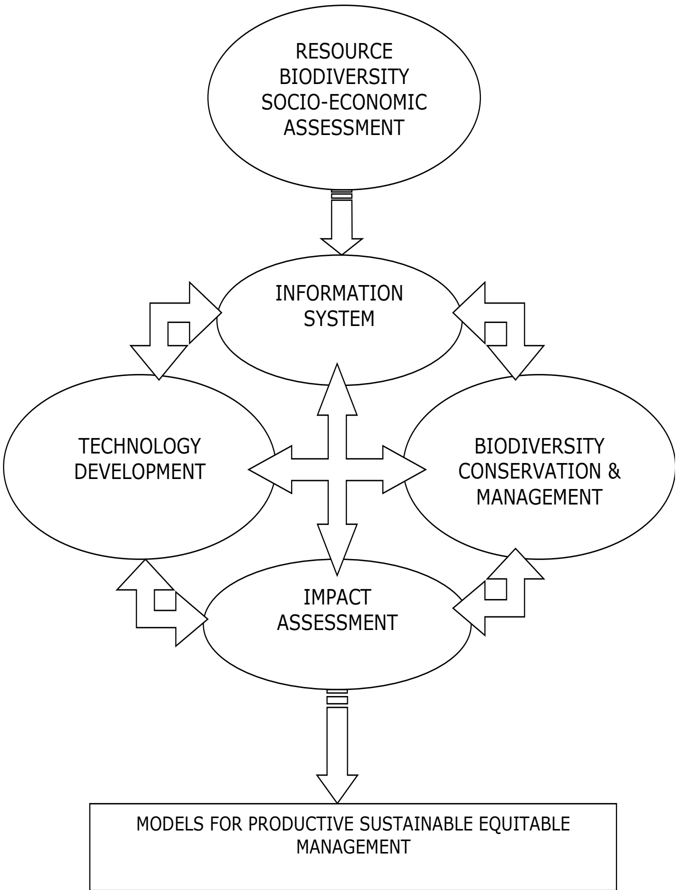


Figure 5. General Framework for the Philippines-Korea Forest Restoration and Biodiversity Program.

Finally, two major studies on biodiversity decision-support system for the Mt. Makiling Forest Reserve, Philippines, namely the Makiling Forest Reserve biodiversity assessment and conservation. This involves generating checklists and updating a bibliography for Mt. Makiling and the conduct of conservation biology studies on endangered species, particularly *Rafflesia manillana (Rafflesiaceae)* and 2) Makiling Forest Reserve biodiversity information system. This involves the compilation of existing remotely sensed data/maps (satellite images/maps, aerial photographs) for two sub-watersheds of Mt. Makiling; grid-based mapping of land cover and land-use of the two sub-watersheds based on existing data (will serve as basis for establishing ground truth plots mentioned earlier); implementation of the protocol for GIS database establishment for the two subwatersheds and development of a comprehensive spatially-referenced database and information system using IKONOS satellite map or NAMRIA Landsat map of Mt. Makiling.

Key Results and Outputs
Below are the salient outputs of the various studies undertaken by AKECOP-Philippines.

1. State of the Art Review of Forest Restoration in the Philippines.
2. Biodiversity and of Plant Genetic Resources of the Philippines: A State of the Art Report.
3. Development of GIS-based Restoration Map of the Philippines.
4. ANR with slashing appears as a promising technique for restoring degraded secondary and primary forests that could accelerate growth of regenerants.
5. Regeneration is more vigorous and diverse in open patches than along edges of secondary forests.
6. Removal of lianas and woody climbers enhances the growth of regenerants but the effects on succession process was not known.
7. Different species possess varying potential for forest restoration. Some species are good for replacing the lost forest cover, some are superior as soil conditioners, some species are good for conserving soil and water, some for restoring lost biodiversity, some for reducing soil erosion and others for improving microclimatic conditions.
8. Common species for restoration were classified based on their efficiency in using water based on studies of seedlings planted in the nursery.
9. Ecological impacts of restoration will not always be positive and readily observable such as the impacts on soil properties and hydrologic processes. This suggests the need for long term observation and study to ascertain the impacts of restoration on the ecology of the area being restored.
11. Socioeconomic study on agroforestry and reforestation in CBFM areas reveal potential strategies to generate substantial economic benefits for the communities along with the improvement of the physical conditions of the area.
12. However, the absence of mechanisms for equitable sharing of benefits and the uncertainty of ability to utilize timber and other resources in the CBFM areas continue to limit the effectiveness of agroforestry and reforestation.
13. Water users fee appear to be a realistic mechanism for generating funds for rehabilitating watersheds that is acceptable to resource users
14. Awareness on the part of the users of forests resources such as water tend to enhance the willingness of stakeholders to contribute to the effort of restoring degraded forests

Guidelines

Cross-cutting Principles
Establish Clear Legal Basis and Strong Political Will—The interest and commitment of actors and players from the highest to the lowest

level of an implementing agency or institution is critical to the success and effectiveness of any restoration project. Particularly important is the political will of key policy and management decision makers at various levels of administration that should manifest into high priorities and adequate support given to forest restoration. The political will required is one where nothing and no one can stand in the way of enforcing policies that will provide sufficient enabling environment for local communities, government agencies, the private sector and other stakeholders to carry out sustained forest protection and restoration program until the last hectare of degraded forests is brought back to a desired state. Anything short is but paying lip service that spells failure from the beginning. Key actions required are:

1. Provide enabling and motivating mechanisms for the different actors and players in restoration efforts
2. Conduct policy assessment on what policies work and what don't work
3. Institute policy and institutional reforms to improve the implementation of various restoration methods
4. Embark on massive and persistent IEC campaign to increase awareness of policy and decision makers as well as key stakeholders on the prospective values of restoring degraded forests to the environment, daily life and local and national economy
5. Encourage participation of local communities, LGUs, private sector and other stakeholders.

The Government Alone Cannot Do All the Needed Restoration Work—local communities, LGUs, private sector and other stakeholders in the forefront should be encouraged and enlisted as major players in forest restoration. It is essential that programs for building their capability should be set in motion along with appropriate incentive and motivating mechanisms. This will require among others:

1. Capability building program to elevate the technical skills of the local communities, LGUs, private sector and other stakeholders in carrying out forest restoration and related activities
2. Financial assistance program that will bring about sustainable improvement of the financial position of local communities
3. Land and resource property rights systems that will promote positive participation of local stakeholders over the long-term
4. Fertilization of local/indigenous knowledge and practices and its potential application in forest restoration.

Integrated And Holistic Resource Assessment, Planning And Implementation—Restoration of degraded forests should be integrated with management and development plans at the local and regional levels. It cannot be carried out apart from the scheme of natural and socioeconomic planning and management at the larger scale such as the municipal, provincial, regional and national scale. As an integral part of bigger plans, mobilizing resources and support to restoration is usually facilitated. More importantly, success of restoration program integrated with development plans at the broader scale can be enhanced by promoting greater complementation with related programs such as livelihood development and IEC and by minimizing conflicts with competing programs such as real estate development and land conversion. Likewise, restoration must be carried out considering the full range of multiple benefits from restored forests such as soil and water conservation, carbon sequestration, biodiversity conservation, livelihood creation, timber and non-timber forest products. Among others the key actions needed are:

1. Development of models for integrating forest restoration with plans at the larger scale (municipal, provincial, regional, national level)
2. Documentation of success stories, best practices and accounts of gains and benefits of restoration program integrated with larger plans
3. Development of mechanisms for encouraging LGUs to invest in forest restoration
4. Development of tools and procedures for integrated resource assessment and planning
5. Facilitate integration of forest restoration with existing comprehensive land use plan for a particular watershed, LGU or any other land management unit
6. Carry out valuation of potential benefits/services from restored forests and related assessment studies such as of carbon sequestration potential of various forest types or vegetation cover types
7. Forest restoration goals and strategies must be defined on the basis of full assessment of the current site conditions and what is deemed as the best combination of uses for the area considering the physical, biological and socioeconomic concerns.

Equitability and economic and financial viability—The appropriate balance between ecological and economic benefits from restoration must be sought to succeed. The cost of restoration must be justified by the total economic benefits that can be realized from its implementation. A relevant issue is on who will shoulder the cost of restoration and how to distribute the benefits among several beneficiaries. Traditionally, the government provides the financing for forest restoration. Considering the huge amount of money needed to fully restore degraded forests, non-traditional modes of financing restoration must be explored. Emerging schemes of charging fees for environmental services rendered by the forests to end users such as water use-fees should be carefully examined. Key actions required include:

1. Development of models and documentation of actual valuation of the total economic benefits that accrue to society from the implementation of forest restoration strategies
2. Explore innovative modes of financing various restoration strategies especially those intended for protection forests or protected areas such as payment for environmental services and carbon trading
3. Enhancement of the economic and financial viability of restoring protected areas by creating opportunities for income generation
4. Forest restoration should be guided by science

Knowledge and information-based decision making—One of the basic foundations of successful restoration initiative is a thorough understanding of the ecological and silvicultural dimensions of various restoration strategies as they relate to the characteristics of the degraded areas and the restored state desired. It is essential that the formulation and implementation of forest restoration programs be based on appropriate knowledge on ecology and silviculture. Key actions required are:

1. Typological classification of all degraded forests and forest lands based on physiographic, climatic, biological, social and economic features
2. Ecophysiology of plants and animals originally and currently found in the degraded areas must be clearly understood
3. Selection of appropriate plant species for restoration must be guided by site suitability, economic and ecological objectives
4. Environmental impacts of various restoration strategies must be fully understood
5. Continuous monitoring of restoration initiatives must be carried out with active participation of stakeholders and using acceptable criteria and indicators
6. Facilitate the growth of science through research in various aspects of forest restoration and promote the integration of research results in the formulation, implementation and monitoring of forest restoration.

Guidelines for Restoring Degraded Primary and Secondary Forests

Enhance the Natural Regeneration Process of the Forests—Measures that facilitate self regeneration should be given high priority. These include measures that minimize the limiting effects of such factors as fires, poor soil condition and typhoons on natural regeneration. Key actions needed are:

1. Identification of key stress factors that limit natural regeneration including extreme climate events, infertile soil, pests and diseases, weeds, illegal activities, fire and others
2. Application of tree growth enhancing measures such as use of mycorrhizae and nitrogen-fixing bacteria
3. Application of soil conditioning measures to improve fertility
4. Prompt control of weeds, pests and diseases along with discriminate removal of vines, lianas and invasive species that compete with preferred species
5. Strict monitoring of and taking decisive actions on illegal activities.

Enhance Biodiversity and Multiplicity of Functions Through Restoration—Restored forests that have more biological and functional diversity provide greater ecological as well as economic benefits than forests that are less diverse. Biologically diverse forests are known to be more stable and less prone to stress factors related to pests and diseases. Diverse forests are also known to effectively perform ecological functions such as soil and water conservation. It is therefore essential that restoration of degraded primary and secondary forests be designed with provisions for measures that enhance biological and functional diversity. Key actions related to this are:

1. Restoration strategies and objectives related to biological and functional diversity should be based on thorough inventory of existing vegetation as well as on past vegetation in the area along with information on wildlife and the physical and socioeconomic profiles of the area
2. Growth and development of species native or originally found in the area should be enhanced. Introduction of new or exotic species to the area should be done judiciously especially if restoration aims to recover the pre-disturbance condition of the forests
3. Enhance the knowledge and skills of the local stakeholders on biodiversity assessment and related measures to maintain biodiversity
4. Promote use of non-traditional species through market development measures such as research on product processing, substitutability and financial viability, and IEC
5. Regular monitoring of biodiversity and ecosystem functions of the area should be carried out to facilitate prompt adaptation to existing and emerging problems, threats and opportunities

Guidelines for Restoring Grassland and Brushland

Cost-effectiveness And Social Acceptability—Assessment of the best use of grasslands and brushlands should be based on comprehensive assessment of the physical, biological, ecological and socioeconomic considerations in the area. It is ideal that restoration of grasslands and brushlands is pursued as the best use option of the area based on cost-effectiveness, social acceptability and other key parameters. Key actions needed are:

1. Assessment and classification of grasslands and brushlands based on physical, biological and socioeconomic parameters. Land capability classification and land use suitability assessment need to be performed to determine what the best land use option is for the degraded areas considering the preferred ecological and economic goals of the stakeholders
2. Identification of stakeholders who can make long term commitment to the restoration of grasslands and brushlands. It is essential that the primary responsibility to undertake restoration should rest on a particular individual or agency with capability will and motivation to mobilize resources required for the restoration works at hand
3. Favorable policy environment, long term security of tenure and other essential enabling and motivational mechanisms should be provided to those who are willing and capable to commit to long-term restoration of grasslands and brushlands
4. Encourage local communities to undertake restoration of grasslands and brushlands by providing appropriate capability building program not only on the technical aspects of restoration but also on engaging in a variety of livelihood projects
5. Identification and assessment of onsite limiting factors including problematic soil conditions, fire hazards, extreme climate events, and topography to determine suitable measures for enhancing site quality and measures for adapting to adverse site conditions.

Provision of Adequate Stock of Quality Planting Materials—The success of attaining the objectives of restoring grasslands and brushlands largely depends on the quality of planting materials. Suitability to the site is important to the growth and development of planted materials. Equally critical are the health, vigor and genetic character of planting materials to be used for restoration. The key actions below are therefore essential:

1. Identification of areas suitable as sources of quality planting materials. This will include full characterization of the physical and biological features of the potential areas across the country to cover as much biogeographic zones there are and developing a databank system to contain all the information related to the different areas
2. Implement a system for inspection and certification of quality seeds and other planting materials to insure that only quality planting materials are used for restoration purposes
3. The full potential of biotechnology and other emerging technology must be explored to facilitate the production of sufficiently available quality planting materials
4. Assessment of ecophysiological and silvical behaviors of indigenous and exotic species to facilitate the selection of species suitable to specific areas and restoration objectives.

Conclusion

The widespread failure of reforestation projects across the country is a symptom of deficiencies in policies, information, technology and competencies that are essential to successful forest restoration. For many years forest restoration in the Philippines has been limited in many cases by weaknesses in policy implementation. In other instances policy and management decision making processes have been constrained by the insufficient knowledge and information base rendering forest restoration initiatives ineffective. These are evident from the records of the performance of many restoration projects as well as the experience of many technicians and practitioners. As discouraging as this may seem, dissection of the underlying factors constraining forest restoration and of the factors that facilitated successful restoration albeit few and isolated cases, reveal a promising path towards a more effective restoration program in the Philippines. With religious adherence to a set of basic principles consistent with many of those used in few successful restoration areas in the Philippines and in many other areas elsewhere, successful restoration of the vast areas of degraded forests is not remote.

Literature cited

Bantayan, N.C., Arche, R.V. 2003. Evaluation of forest and natural resources data and information flow in the Philippines. Information and Analysis for Sustainable Forest Management. Linking National and International Efforts in South and Southeast Asia. EC-FAO PARTNERSHIP PROGRAMME (2000–2002). Printed and published in Bangkok, Thailand.

Bradshaw, A.D. 1984. Ecological principles and land reclamation practices. *Landscape Planning* 11:35-48.

FAO. 2001. *State of the World's Forests*. Food and Agriculture Organization. Rome.

FDC. 1996. Impact Assessment and Policy Implications of Timber License Agreement (TLA) Cancellation/Expiration. Forestry Development Center, College of Forestry, University of the Philippines Los Banos, College, Laguna, Philippines. pp28.

FMB. 2004. *Forestry Statistics*. Forest Management Bureau. Department of Environment and Natural Resources. Visayas Avenue, Diliman, Quezon City, Philippines.

Grainger, A. 1988. Estimating areas of degraded tropical lands requiring replenishment of forest cover. *International Tree Crops Journal* 5(1/2).

Grainger, A. 1996. Degradation of tropical rainforest in Southeast Asia: taxonomy and appraisal. In Eden, M. J. and J. T. Parry (eds). *Land Degradation in the Tropics: Environmental and Policy Issues*. Pinter and the Commonwealth Foundation, London.

House, A.P. 1997. Ecological processes in tropical forest rehabilitation. In Proceedings of an International Workshop on BIO-REFOR. Brisbane, Australia.

ITTO. 1999. *Manual for the Application of Criteria and Indicators for Sustainable Management of Natural Tropical Forests. Parts A, B and C.* International Tropical Timber Organization. Yokohama, Japan. Pp 46.

ITTO. 2002. ITTO *Guidelines for the Restoration, Management and Rehabilitation of Degraded and Secondary Tropical Forests.* International Tropical Timber Organization. Yokohama, Japan. Pp 84.

Lamb, D. 1994. Reforestation of degraded tropical forest lands in the Asia-Pacific Region. *Journal of Tropical Forest Science* 7:1-7.

Mc Neely, J.A. 1996. Economic incentives for conserving biodiversity. In: Szaro, R.C. and Johnston, D.W. (eds) *Biodiversity in Managed Landscape: Theory and Practice*. Oxford University Press. New York. p647-655.

Rebugio, L.L., Cruz, R.V.O., Carandang, W.M., Tolentino, E.L., Jr., Dela Cruz, L.U., Lasco, R.D., Visco, R.G., Dizon, J.T., Pulhin, F.B., Dalmacio, R.V., Bantayan, N.C., Calderon, M.M., Camacho, L.D. 2005. Forest Restoration in the Philippines: A Review of Research and Development Initiatives. UPLB College of Forestry and Natural Resources and the ASEAN-Korea Environmental Cooperation Project, College, Laguna, Philippines. pp163.

Westmann, W.E. 1977. How much are nature's services worth? *Science* 197:960-964.

Wilson, E.O. 1988. The Current state of biodiversity. In: Wilson, E.O. (ed) *Biodiversity*. National Academy Press. Washington, D.C. pp218.

ROLE OF MICROENVIRONMENT FOR RESTORATION ON FOUR TROPICAL SPECIES IN THE LA MESA WATERSHED, PHILIPPINES

S.Y. Woo[1], D.K. Lee[2], Y.K. Lee[2] and W. M. Carandang[3]

Abstract—Seedlings of four tree species (*Bischofia javanica, Dracontomelon dao, Erythrina orientalis,* and *Pterocarpus indicus*) were planted in flat and sloping grassland in plantation sites established in May 2002 in the La Mesa watershed, Philippines. Tree growth and net photosynthetic rate (PN) were monitored. The height, diameter at the root collar, and PN of the four species grown in the sloping grass site were larger than those of seedlings grown in the flat grass site. In addition, soil moisture contents in the sloping grass site were higher than those of the flat grass site. Growth of the four species was probably strongly associated with microenvironments (e.g. air temperature) in both tested sites.

[1] Department of Environmental Horticulture, University of Seoul, Seoul 130-743, Republic of Korea; email-wsy@uos.ac.kr
[2] Department of Forest Sciences, College of Agriculture and Life Sciences, Seoul National University, Seoul, 151-921, Republic of Korea
[3] Institute of Agroforestry, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines.

POST-FIRE RESTORATION OF OAK-KOREAN PINE FOREST WITH *RHODODENDRON MUCRONULATUM*

T. A. Komarova[1], L. A. Sibirina[1], L. Ya. Ashchepkova[2], D. K. Lee[3], H. -S. Kang[3]

Abstract—Some regularities of transforming the plant communities in the course of post-fire successions in the meso-xeric oak-Korean pine forest with *Rhododendron mucronulatum* of the South Sikhote-Alin Mountains were considered. All wood species were analyzed to compare density, basal area, and importance value. Only two species (*Pinus koraiensis* and *Quercus mongolicae*) had higher indices of importance value in different stages of post-fire succession. Natural thinning was more intensive during the first 10-20 years after fire among pioneer species (*Betula, Populus, Salix*). The number of young plants of *Pinus koraiensis* and deciduous species (*Quercus mongolicae, Tilia taquetii, Acer mono*) increased with time in contrast to pioneer species.

The xeric and meso-xeric *Rhododendron mucronulatum*-oak-Korean pine forests, which grow on steep and dry slopes, have the greatest fire hazard. The fire season begins here just after snow melt in spring and continues through late autumn. Effects of forest fires on timber stands and post-fire development of aspen-birch and deciduous–Korean pine forests in Russian Far East were studied by many scientists, but none of them explicitly explored the variation in fire severity on post-fire stand dynamics. Our goal is to analyze subsequent stand development after fire across a range of fire severity in *Rhododendron mucronulatum*-oak-Korean pine forests.

Materials and Methods

Research was conducted from 1983 to 2006 in the north-western part of the South Sikhote-Alin mountains (43° 09′- 44° 01′ N and 133° 09′-134° 03′ E) within Sokolovka and Izvilinka River basins (tributaries of the Ussuri River) on 18 sample plots 0.25 ha each, which underwent wildfires of various intensity from 2 to 220 years ago. Nine permanent plots were chosen for long-term monitoring in Verkhneussuriisky Biocoenotic Station, located in Pravaya Sokolovka River basin within an altitudinal range of 440-1000 m a.s.l. These plots were inventoried with time intervals of 1-5 years. During each inventory, density (trees ha^{-1}) and basal area (m^2 ha^{-1}) were defined for each wood species. The sample plots were researched for quantitative participation of each plant species. The DBH of all trees was measured. Undergrowth, shrubs and lianas of different size (divided into 10-50 cm size-classes) were counted in two 50 m by 4 m subplots in each plot. Scientific names of all species are referenced from the "Vascular Plants of Soviet Far East" (SPb:Science. Vols. 1-8 1985-1996).

The importance value was defined for each wood species by following five size categories: overstory (trees >12.0 cm DBH), midstory (1-12.0 cm DBH), large understory (<1 cm DBH and >150 cm height), middle understory (51-150 cm height) and small understory (<50 cm height). The importance value indices (I_J^t) were calculated for eight wood species J in each inventory (t) of sample plots as follows:

$$I_J^t = \sqrt{\sum_{i=1}^{5} \log_0 (n_{iJ}^t) \times \left(\frac{n_{iJ}^t}{S_i} \right)^2}$$

where n_{ij}^t– number of wood plants of i size categories of j species, $S_i = \sum_{i=1}^{k} n_j^t$ - total quantity of i size category of all wood species, $\log_0 (n_{iJ}^t)$ – decimal logarithm of i size category of j species in inventory t.

Results and Discussion

The studied post-fire communities occupy slopes of various aspects and on tops of the crests up to 500-700 m a.s.l. Such plots are usually exposed to heavy insolation and violent temperature fluctuations, as well as the impact of strong winds blowing off tree waste and loosened ground litter. In this connection, the soils are thin, with little horizon

Stand characteristics	Sample plots						
	42-1984	42-1984	102-2005	14-1986	42-1988	44-1989	44-1989
Year after fire	6	11	23	60	130	≈ 200	≈ 220
Number of stems (ha)	12025	7096	5786	2160	1752	1756	2144
Basal area (m^2 ha^{-1})	10.02	12.53	13.19	23.7	31.62	38.89	48.58
Volume (m^3 ha^{-1})	33.79	61.5	73.1	188.8	230.7	324.9	401.7
Average height (m)	4.0	5.3	6.2	12.9	14.5	17.3	17.9
Average diameter (cm)	3.5	4.7	5.4	11.8	15.2	16.8	16.9

Table 1. Comparison of sample characteristics of stands in the course of the post-fire succession.

[1]Russian Academy of Sciences, Far East Branch, Vladivostok, Russia; email-sibirina@ibss.dvoiru [2] Far East University, Vladivostok, Russia; [3] Seoul National University, Korea.

differentiation, cobble-filled, and oligotrophic; organic matter composition scarcely exceeds 10% and the pH of upper soil horizons was 4.8-5.2. The timber stands are usually site class IV, dominated by *Pinus koraiensis* and *Quercus mongolicae*. In the shrub layer there are in addition to *Rhododendron mucronulatum*, small abundances of *Euonymus pauciflora, Philadelphus tenuifolius* and *Corylus mandshurica*. Poorly developed herbaceous cover is dominated by mesoxerophytic oligotrophic sedges (*Carex vanheurckii, C. pseudosabynensis* and *C. nanella*) and herbs (*Iris uniflora, Viola orientalis, Fragaria orientalis*). The floristic composition of the plant communities on the 9 permanent plots included 72 seed vascular plant species; 14 wood species, 13 shrub and liana species, 45 species of herbs and sub-shrubs.

The development of a new generation of trees depends in large part on fire intensity and area of burn. Autumn fires are characterized by long-term ground fires that sometimes transfer to crown fires. This autumn fire occurred in October 1982 on the top part of the steep southern slope, at the elevation of 650-670 m. Before the fire, the forest consisted primarily of *Pinus koraiensis* and *Quercus mongolicae* with some *Tilia taquetii, Betula platyphylla, Picea jezoensis* and *Abies nephrolepis*. The crown fire caused considerable disturbance to tree crowns. Tree trunks were burnt up to 16-18 m high and only some individuals of *Quercus mongolicae* survived. These stands were last disturbed by an intensive forest fire 130 years ago. Changes in timber stand characteristics along the successional gradient after intensive ground and crown fires are considered in inventories of four permanent plots (table 1).

The general trend of succession after intensive fires is connected with an increase in species diversity in all stands, besides tree density, considerably varying at the different species in the course of successions. Among wood species only *Quercus mongolicae* have higher indices of importance value in the different stages of post-fire recovery process after intensive ground fires (Figure 1).

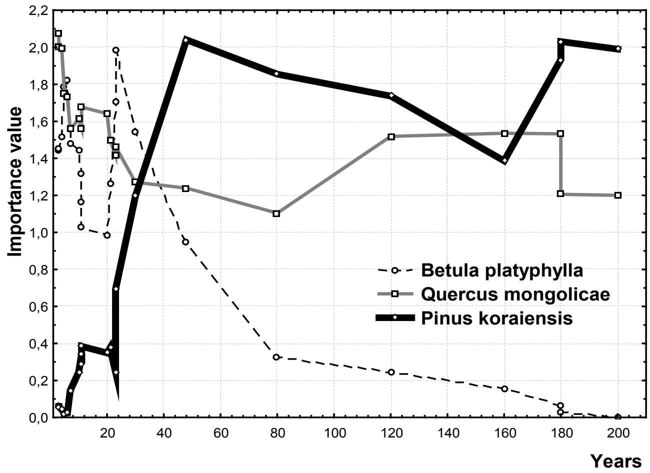


Figure 1. Changes in importance value of three wood species during reforestation succession after intensive fires in the Rhododendron

Pinus koraiensis has small abundance and importance value indices in the first stages of succession after intensive ground fires, but it can dominate in the understory, midstory and overstory after light fire with the partially preserved standing timber. Forty to fifty years after intensive fires, comparatively high indices of importance value for *Pinus koraiensis* were registered. The main secondary forest forming species are *Betula platyphylla* and *Populus tremula*. As accompanying species, there are *Salix caprea, S. taraikensis* and *Padus maackii*. Indices of importance values for pioneer species primarily varied in the restoration process after intensive fires. As crown closure gets denser, the competition for space, light, moisture, etc. increases between young trees. The weak plants are suppressed by stronger ones and die in the process of self-thinning. The most intensive self-thinning process occurred for the first 10-20 years after fire among pioneer species (*Betula, Populus,* and *Salix*) with a significant decrease in number of these species occurring. So, 23 years after crown fire on the permanent plot 42-1984, viability was maintained only by 2.4% of *Betula costata* plants, 7.5% of *B. platyphylla,* 17.6% of *Populus tremula* and 35.4% of *Salix caprea* plants. In contrast to active self-thinning of pioneer wood plants, we observed an increase in quantity of young plants, characteristic for the later stages of successions. Thus, by 23 years after crown fire on the research plot, the number of *Tilia taquetii* increased by 11.4 times, *Pinus koraiensis* by 22.1 times and *Acer mono* by 44 times. However, the number of *Quercus nongolica* decreased to 0.8 times.

Acknowledgements

This research was supported by a grant from Korean Science and Engineering Foundation (KOSEF) "Cooperative research for development of useful natural resources and restoration of degraded ecosystems in Northeast Asian regions" and "Overseas laboratory program Korea Research Foundation (KRF-2005-212-F00002)"

ASSISTED NATURAL REGENERATION (ANR) AS AN EFFECTIVE TECHNIQUE OF REHABILITATING MARGINAL GRASSLANDS IN THE PHILIPPINES

W. M. Carandang and R. F. Paelmo

Abstract—The study was primarily conducted to determine the effectiveness of Assisted Natural Regeneration (ANR) as a rehabilitation technique for degraded grasslands in the Philippines. Specifically, it aimed to (1) determine the rate of growth of natural regeneration resulting from ANR treatments; (2) assess species diversity through time; and, (3) evaluate the effects of ANR on soil moisture. The experiment was carried out in a Randomized Complete Block Design with four replications. Three ANR treatments namely lodging, slashing every month, and slashing every other month were tested against a control where no ANR treatments were undertaken. The ANR treatments did not produce any significant effect on recruitment (number of species and number of regenerations by species) or height growth of regeneration during the first year of observation. However, survival of the existing regeneration in the area was significantly affected by the ANR treatments. At the end of the second year, the regeneration height increments as well as soil moisture content were significantly influenced by the ANR treatments while the population and number of species were not. Monthly slashing of the host vegetation yielded the tallest regeneration. The least mortality of regeneration was observed in the lodging and slashing every other month treatments. While there were no significant differences among the treatments in terms of the number of regeneration, the highest occurred in plots where lodging was undertaken. The control plots yielded the highest soil moisture content through time while the plots slashed monthly had consistently the lowest soil moisture content.

Grasslands, of which cogon (*Imperata cylindrica*) is the dominant vegetation, abounds in the Philippines. Estimates place the area covered by these grasslands at 1.18 M ha (Lasco 1998) which are mostly unproductive lands. If these areas are not subjected to grassland fires, they can naturally and gradually return to forested ecosystems. This, however, will occur over a very long period of time. The occurrence of such natural succession could even be hindered by forces of climate change. It is now generally recognized that global warming is causing prolonged dry seasons which increase the frequency of grassland fires, render the soil drier and creates adverse conditions which make natural tree revegetation more difficult. There is a need to hasten the re-establishment of forest vegetation in such marginal and degraded grasslands. Assisted Natural Regeneration (ANR) is considered as one of the most viable ecological approaches towards attaining the objective of revegetating these degraded lands with trees.

ANR, a forest rehabilitation technique based on the ecological principle of succession, utilizes natural processes and promotes the regeneration of indigenous species. Moreover, ANR is known to be effective in restoring and enhancing biological diversity and ecological functions within the target ecosystem. Regenerated forests through ANR are known to be more biologically diverse than those reforested through conventional techniques. There are better chances of restoring original vegetation and ecosystem functions and processes, and soil disturbance is minimal. On the social side, ANR is said to be labor-intensive, the implementation of which can provide employment to the upland communities. In the process, indigenous knowledge can thus be promoted. Given these benefits, however, there is still a dearth of information on the physiological responses of young seedlings when exposed to ANR treatments as well as the impacts of the ANR treatments on the environmental conditions in the area. For instance, Walpole (2004) has discussed the implications of ANR to the conservation of plant genetic resources and concerns on appropriate management schemes when such is implemented particularly in community based forest development programs.

The implementation of ANR in the country started in the 1980s (FAO 2004). However, there is as yet limited adoption of this rehabilitation technique in the Philippines. Fortunately, the ANR implementation in the country has been given a boost with the issuance of a policy support in the form of Memorandum Circular No. 17 issued by the Department of Environment and Natural Resources in 1989 prioritizing the application of ANR in the development of watersheds, protection and production forests in the Philippines (DENR 1989). This study sought to contribute more knowledge about ANR to amplify its potentials in the rehabilitation of grasslands in the Philippines and in the tropics in general. Specifically, the study

Institute of Agroforestry, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, 4031 Philippines; email-wm_carandang@yahoo.com

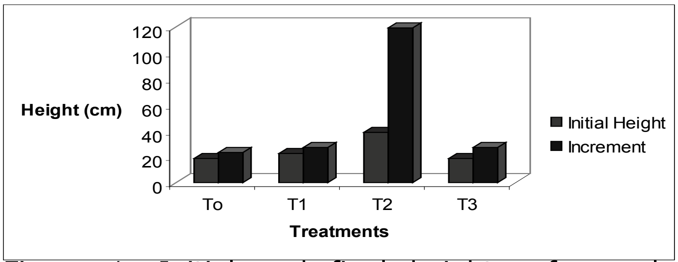


Figure 1. Initial and final heights of sample regeneration one year after establishment of experimental plots.

aimed to: determine the growth rate of natural regeneration resulting from ANR treatments; assess the species diversity through time; and evaluate the effects of ANR on soil moisture.

Materials and Methods

The study was conducted at a portion of the La Mesa Watershed in Quezon City, Philippines. ANR plots within the cogon grassland patch were laid out in a Randomized Complete Block Design (RCBD with four replications. The following were the treatment: (a) T_o- control; (b) T_1 - lodging or pressing every month (cogon grass was not slashed but trampled on); (c) T_2 - slashing monthly and; (d) T_3 - slashing every other month. The number of broadleaf tree species was counted in each plot. Some of the regeneration stems enumerated were

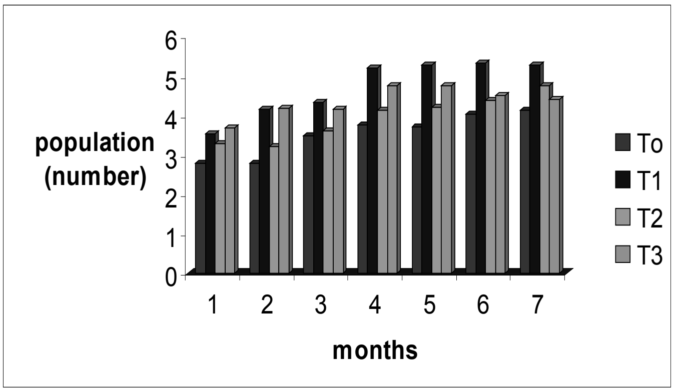


Figure 2. Total number of regeneration stems after two years as affected by the different ANR

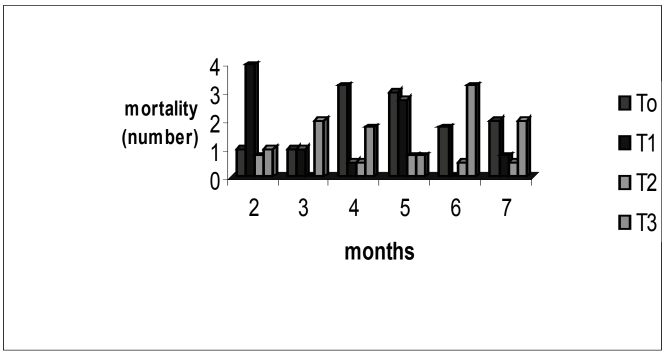


Figure 3. Number of dead regeneration stems as affected by ANR treatments during the first seven

sampled and tagged for height measurements on a monthly basis. Prior to the conduct of the treatments

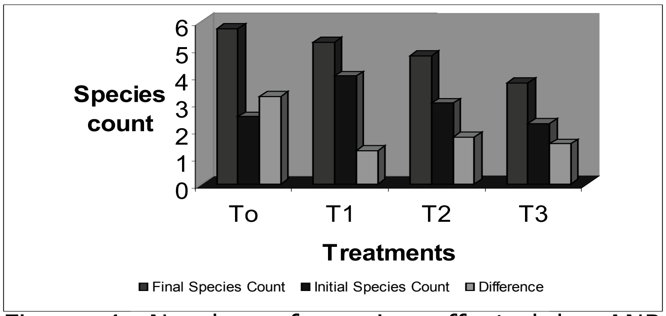


Figure 4. Number of species affected by ANR treatments after two years.

(lodging and slashing) height measurement was made and new regeneration stems were noted and tagged. Mortality rates among regeneration stems were also determined during the first seven months of the implementation of the study. Soil moisture was also measured using a soil moisture meter.

Results and Discussion

Height Growth—The tallest regeneration was obtained from the T_2 plots (slashing monthly, 7.78 cm) while the shortest regeneration was among the T_3 plots (slashing every other month). However, the differences in height among the sample plants were not significantly different during the first year of observation. After the second year, significant differences on height of the sample plants were observed (Figure 1). Still, the tallest regeneration was observed among the regeneration in the T_2 plots. Seedlings in the T_2 treatment also exhibited the fastest growth. The monthly slashing of host vegetation could have freed the regeneration from competition. The decomposition of the slash has resulted in an increase in the organic matter and other essential nutrients, which may have caused in the increased height of the seedlings in these plots.

Population—There were no significant differences

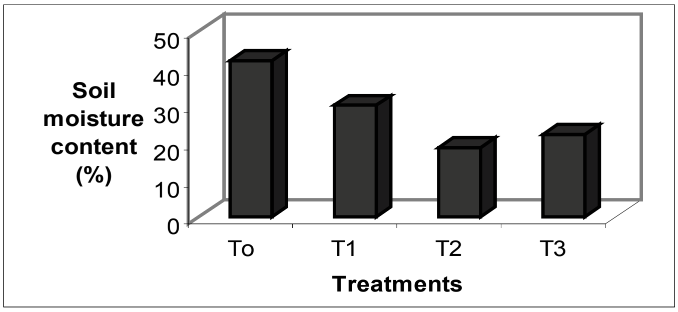


Figure 5. Soil moisture content as affected by ANR treatments.

observed in the total number of regeneration stems among treatments two years after the start of the study (Figure 2). The lodged plots (T_1) consistently had the highest population (total number of seedlings) throughout the whole duration of the study. The host vegetation in the control plots may have caused significant light attenuation on the surface soil which in turn could have prevented the germination of the seeds of tree species yielding a relatively lower population count. On the other hand, slashing could have adversely affected seed germination with the undue exposure of the surface soil rendering the immediate environment of the seeds drier most of the times. These conditions could have resulted in the low number of regeneration stems in the control and the plots that were slashed. The results obtained were in contrast to the two-year study of Pajar and Tomas (2000) where blanket brushing without cultivation gave the highest number of regeneration stems.

Rate of Survival—Except in the second and fourth month, survival of regeneration did not differ significantly (Figure 3). Mortality, however, was less in all the treatments compared with the control, with the exception of those plots subjected to lodging. For the first two treatments, the weed canopy could have provided protection to the smaller seedlings of trees against desiccation during the dry season, similar to the observation made by Hardwick and others (2000). The lesser competition for soil and atmospheric resources in the slashing treatments could probably account for the higher survival rates. The persistence of the host vegetation could have smothered the regeneration in the control plots as well those whose grass vegetation was pressed. The initial pressing too could have resulted to the tree regenerations being lodged in the process, ultimately leading to their death. Pressing as an ANR treatment then is to be done only when regeneration stems are quite visible already and can adequately be marked on the ground. Mortality was noted to be high only during the initial months of the first year of the study and tended to level off as time progressed. These observations provide further merits to the conduct of ANR treatments in the successful rehabilitation of grasslands.

Species Count—While the treatments resulted to insignificant differences at the end of the study period, the highest number of species occurred in the control plots (Figure 4). The number of new species that emerged was likewise highest in these plots. Lodging resulted in the least number of new emerging species after the treatments. It is worthwhile mentioning however that there was an increasing trend in the number of species observed in all the treatments through time. Given a longer time perhaps differences in species accretion will become significant. The decreasing mortality of regeneration as observed previously is an indication of improving site conditions within the ANR area. Such improvement can likewise bring about the regeneration of more tree species increasing the diversity of plants in the area through time. This, however, will be dependent on the occurrences of mother trees in the surrounding areas.

Soil Moisture Content—Moisture content was significantly highest in the control plots (42.02%) while the lowest (18.6%) was determined in the plots that were slashed monthly (Figure 5). The continuous vegetation cover in both the control and lodging plots conserved the soil moisture through reduced soil evaporation. Uddin and Sajise (1997) opined that on ANR plots where lodging was done, grasses and weeds were kept in place, dying and decomposing slowly thus absorbing a lot of moisture during rainy days. On the other hand, the removal of the soil cover through slashing continuously exposed the soil resulting in reduced soil moisture.

Conclusion

The application of ANR treatments produced significant effects on height growth of regeneration in the experimental area as well as on the moisture content of the soil. The reduction in competition due to the removal of competing host vegetation during slashing may have been responsible to the increased height growth of tree regenerations. The non-removal of host vegetation was deemed responsible for the maintenance of moisture in the soil in the ANR area. However, there were no profound influences on the number of regenerations and the species count in the area over a period of two years. But given the observed trends in these two parameters, it is not surprising that ANR treatments can bring about enhancement of existing tree species in the ANR area.

Overall, lodging and slashing as ANR treatments have been found to be beneficial for encouraging growth of existing regenerations of broadleaved species in tropical areas in the Philippines. Both can be prescribed when regeneration is highly visible already and can be avoided during the conduct of the operations. The frequency of slashing though will have to be adjusted considering the prevailing climatic conditions in the area.

Acknowledgments

The study was part of the Forest Restoration Research Program of the ASEAN-Korea Environmental Cooperation Project (AKECOP) – Philippines which was funded by the ASEAN-Korea Environmental Cooperation Unit (AKECU) of the National Instrumentation Center for Environmental Management, College of Agriculture and Life Sciences, Seoul National University, Korea. The ABS-CBN Foundation – Bantay Kalikasan allowed the use of a portion of the La Mesa Watershed for the conduct of this study.

Literature Cited

DENR. Memorandum Circular No. 17, Series of 1989. Prioritizing Application of Assisted Natural Regeneration in the Development of Watershed Protection and Production Forest. Policies, Memorandum and Other Issuances in the National Forestation Program. Vol. II, NPCO, DENR, Diliman, Quezon City, Philippines.

FAO. 2004. Advancing ANR in Asia and the Pacific. RAP publication 2003/19. http://www.fao.org/publications/dr2003-19

Hardwick, K., Healey, J.R., Blakesley, D. 2000. Research needs for the ecology of natural regeneration of seasonally dry tropical forests in Southeast Asia. In: Elliot, S., Kerby, J., Blakesley, D., Hardwick, K., Woods, K. and Anusarnsunthorn (eds.). *Forest Restoration for Wildlife Conservation*. Chiang Mai University, pp.165-180.

Lasco, R.D. 1998. Management of Philippine tropical forests: implications to global warming. *World Resources Review* 10(3):410-418.

Pajar, P.P. and Tomas, W. G. 2000. Enhancing the production potential of assisted natural regenerations. *Canopy International* 26(1): 3-11.

Uddin, A.S. and Sajise, P.E. 1997. Comparative analysis of assisted natural regeneration (ANR) and conventional reforestation in New Bataan, Davao condition: Part I. Vegetation analysis and seedling performance. *Ecosystems Research Digest* 1(2): 3-20.

Walpole, P. 2004. Ten aspects of ANR in the Asia-Pacific Region. http://www.fao.org/DOCREP/004/AD400E/ad400eo5.

GROWTH, BIOMASS ALLOCATION AND WATER-USE EFFICIENCY OF TWO-YEAR-OLD SIBERIAN LARCH (*LARIX SIBIRICA* LDB.) SEEDLINGS FROM DIVERSE SEED SOURCES OF MONGOLIA

Batkhuu Nyam-Osor[1], Don Koo Lee[1], Yeong Dae Park[2], Jamsran Tsogtbaatar[3]

Abstract—The rehabilitation of degraded forests in Mongolia showed very low success and the total area of successful reforestation represented only 5% of the total degraded forest. One of the reasons for such poor results may be attributed to the low quality of planting stock due to the poor quality of seeds. The objective of this study was to examine growth, biomass allocation and water-use efficiency of two-year-old Siberian larch seedlings from diverse seed sources of Mongolia. We found out that there were significant differences in growth, biomass allocation and water-use efficiency among the seed sources at two growing conditions. Source No.6 (Huvsgul) and Source No.8 (Turag) showed higher shoot length, root collar diameter, root length, needle length, biomass accumulation, and proportion of biomass to roots at open nursery and greenhouse nursery conditions, respectively. The Source No.1 (Ovorkhangai) had the lowest performances at both growth conditions. On the other hand, seedlings grown at greenhouse nursery conditions had more intensive growth and accumulated more biomass compared to seedlings grown in the open nursery conditions. But proportion of biomass to roots of open nursery grown seedlings was higher than that of greenhouse grown seedlings, which may suggest that a more promising survival rate can be expected after field transplanting.

Siberian larch (*Larix sibirica* Ledeb.) is the most important and widely distributed timber tree species in Mongolia. Its success can be explained by its broad tolerance in moisture, temperature, and soil requirements. Pure natural stands and open woodlands of Siberian larch now occupy almost 60% of the total closed forest area in Mongolia. Siberian larch, single-species stands appear in the most favorable habitats both in steppe and mountain tundra (Savin and others 1978). Hence, it has been widely used for reforestation and afforestation activities in Mongolia. But reforestation success was very low, and survival rate of planted seedlings were between 30% and 60%, seldom reaching 50%. Consequently, the total area that has been successfully replanted represented only 5% of the total forest lost (World Bank 2002). At present, 150,000 ha of forests need to be rehabilitated but on average only 5,000 ha are being planted each year (Tsogtbaatar 2004). The main reasons for the poor result of the plantations were lack of compatibility between sites and species, nursery systems with outdated techniques that are poorly equipped, poor site preparation, poor quality of planting stock due to poor seed and nursery techniques. No seed orchard was available and forest plantations on grazing land often were resented by herders (JICA, FMC and MNE 1998).

The objective of this study was to investigate seed source differences in growth, biomass allocation and water use efficiency in two-year-old Siberian larch seedlings from diverse seed sources of Mongolia. The results maybe useful for understanding drought-resistance variations of studied seed sources and selecting the most promising seed sources for reforestation of degraded forest lands in Mongolia.

Materials and Methods

Seed and Seedling Materials—Seeds of Siberian larch (*Larix sibirica* Ledeb.) were collected from natural stands of eight different geographical locations in Mongolia between 2002 and 2004 (Table 1). Laboratory tests of seed quality were conducted by the International Rules for Seed Testing (ISTA). Seeds were examined for quality by purity, weight of 1,000 seeds, a germination test, seed viability by soft x-ray photography, and a tetrazolium test.

Seeds of different sources were sown in May 2005 in open and greenhouse nursery beds at the Dambadarjaa Nursery (N47°59′15″, E106°57′31″) belonging to Forest Experimental Station of Institute of Geoecology, Mongolian Academy of Sciences.

Measurement of Growth and Biomass Allocation—Seedling emergence was monitored and 50 seedlings from each seed source were selected for measurement of growth parameters. Proportional allocation of biomass to root and shoot was assessed at the end of growing season. Thirty healthy seedlings per seed source were harvested for dry weight determination. The biomass of each shoot and root parts weighed separately and biomass allocation to roots was expressed as the root weight ratio (RWR=root dry weight/ total seedling dry weight) (Cregg 1993). Relative

[1] Department of Forest Sciences, Seoul National University, Seoul, Republic of Korea; email-nbatkhuu@biology.num.edu.mn
[2] Center for Forest Disturbance Science, USDA Forest Service, Athens, GA, USA
[3] Institute of Geoecology, Mongolian Academy of Sciences, Mongolia

No	Seed source	Collection date	Lat (N)	Long (E)	Alt (m)	Temp (^{0}C)	Prec (mm)
1	Ovorkhangai	2003, Sept	46.49	102.15	1700	-1.8	296.2
2	Zavkhan	2003, Aug	47.38	96.32	1658	-6.3	225.7
3	Tuul river	2003, Sept	47.59	108.00	1843	-3.3	250.7
4	Mongon	2003, Sept	48.12	108.30	1450	-2.73	281.5
5	Binder	2004, Sept	48.37	110.34	1100	-1.26	327.1
6	Huvsgul	2002, Sept	49.38	100.1	1275	-1.3	235.5
7	Uvs	2003, Sept	49.39	94.24	1200	-3.36	146.5
8	Turag	2003, Sept	51.17	100.49	1700	-1.3	231.5

Table 1. Description of seed sources used for this study

growth rate was calculated as (Tjoelker and others 1993): $RGR=(lgH_2-lgH_1)/(T_2-T_1)$ where H_1 and H_2 are heights at time beginning and end of sampling period while T_1 and T_2 are the dates of sampling.

Measurement of Net Photosynthetic Rate (Pn), Transpiration Rate (E) and Determination of Water Use Efficiency (Wue)—Light-saturated net photosynthesis (Pn) was measured with the LI-6400 portable photosynthesis system (LI-COR Inc., USA) from June to August 2006 to evaluate monthly variation. Three seedlings from each seed source were selected for measurement in every month. PPFD (photosynthetic photon flux density) was set at 0, 50, 100, 200, 400, 700, 1,000, 1,500, 1,800 and 2,000 μmol m-2s-1 and the mean and standard error values of Pn were plotted against specific PPFD values. Each series of PPFD was maintained for at least five minutes to stabilize change of PPFD.

To calculate and compare WUE of each seed sources, 10 seedlings were sampled from each seed sources and measured for net photosynthesis (Pn) and transpiration rate (E). Airflow through the analyzer was adjusted to maintain leaf

Source	Open nursery			Green house nursery		
	DF	MS	F value	DF	MS	F value
Root collar diameter	7	3.59	6.99**	6	12.84	11.93**
Shoot length	7	41019.02	35.94**	6	61063.96	33.45**
Root length	7	13304.02	14.98**	6	7562.64	0.37ns
Current year shoot length	7	38504.77	33.37**	6	42701.76	27.65**
Needle length	7	359.98	13.09**	6	480.87	10.66**
Relative growth rate	7	0.71	35.67**	6	0.16	17.01**

ns- Non significant, * - significant difference at 0.05, ** - significant difference at 0.01

Table 2--ANOVA for growth of two-year-old Siberian larch seedlings grown from diverse seed sources at different nursery conditions (n=50)

temperature at 25°C and relative humidity near ambient levels (ranged from 50~60%) during measurement. Each measurement of Pn and E was taken at the 1,500 μmol $m^{-2}s^{-1}$ light intensity as an average light intensity during the daytime period and instantaneous WUE was calculated by dividing photosynthetic rate by transpiration rate as follows (Wang, 2001):

WUE(μmol CO_2/mmol H_2O) = Pn / E where
Pn-net photosynthesis (μmol CO_2 $m^{-2}s^{-1}$)
E-transpiration rate (mmol H_2O $m^{-2}s^{-1}$)

Data Analysis

All statistical tests were computed using a statistical software package (SAS program, SAS Institute Inc., NC, USA 2000). The differences in growth between experiments were determined by analysis of variance. Duncan's multiple range test (DMRT) was used for multiple comparisons.

Source	Open nursery			Green house nursery		
	DF	MS	F value	DF	MS	F value
Shoot biomass	7	0.44	12.14**	6	3.66	10.63**
Root biomass	7	0.23	7.03**	6	1.82	8.44**
Needle biomass	7	0.18	9.97**	6	1.38	12.03**
Total biomass	7	2.43	10.39**	6	18.62	10.38**
Root weight ratio	7	0.05	14.51**	6	0.05	22.33**
Root to shoot ratio	7	1.52	13.92**	6	0.88	20.76**

ns- Non significant, * - significant difference at 0.05, ** - significant difference at 0.01

Table 3. ANOVA for biomass allocation of two-year-old Siberian larch seedlings grown from diverse seed sources at different nursery conditions (n=50).

Results

Growth performance—All measured growth traits were significantly different among seed sources except for root length in green house grown seedlings (Table 2). Mean shoot length of the seedlings was 94.14 mm and 209.38 mm at open nursery and greenhouse nursery, respectively. Sources No.6 (Huvsgul) and No.4 (Mongon) showed the best shoot growth (168.8±12.41 mm and 267.82±11.67 mm) at open nursery and green house nursery conditions, respectively, whereas Source No.1 (Ovorkhangai) had the lowest (40.15±5.28 mm and 35.34±8.32 mm) performances. Mean root collar diameter had an average 3.17 mm and 4.22 mm at the open nursery and greenhouse nursery grown seedlings, respectively. Sources No.6 (Huvsgul) and No.8 (Turag) showed the best growth in (3.88±0.21 mm and 5.24±0.38 mm) whereas Sources No.1 (Ovorkhangai) and No.7 (Uvs) had the lowest (2.85±0.13 mm and 2.85±0.09 mm) performances. Relative growth rate was significantly different (p<0.0001) at both nursery conditions among seed sources. Mean relative growth was 1.62 mm^{-1} day and 1.93 mm^{-1} day

Source	Open nursery			Green house nursery		
	DF	MS	F value	DF	MS	F value
Net photosynthesis (Pn)						
Months	2	244.41	18.13**	2	1171.878	81.04**
Seed sources	7	168.865	12.53**	6	68.875	4.76**
Months*Seed sources	14	38.215	2.84**	12	66.876	4.62**
Transpiration rate (E)						
Months	2	81.028	101.84**	2	268.629	1078.94**
Seed sources	7	60.813	76.43**	6	5.429	21.81**
Months*Seed sources	14	37.64	47.31**	12	4.589	18.44**
Water use efficiency						
Months	2	33.664	68.97**	2	26.336	46.81**
Seed sources	7	3.106	6.36**	6	4.769	8.48**
Months*Seed sources	14	1.4	2.87**	12	2.261	4.02**

ns- Non significant, * - significant difference at 0.05, ** - significant difference at 0.01

Table 4. ANOVA for monthly variation in net photosynthesis, transpiration rate and water use efficiency in two-year-old seedlings of Siberian larch.

at open nursery and greenhouse nursery grown seedlings, respectively. Sources No.6 (Huvsgul) and No.4 (Mongon) had intensive growth rate at both nursery conditions whereas Source No.1 (Ovorkhangai) had the lowest growth rate.

Biomass allocation—Biomass allocation significantly differed among seed sources ($p<0.0001$) at both growth conditions (Table 3). The seedlings grown at green house (mean total dry biomass 2.31g) had accumulated more biomass than open nursery (0.76g). Sources No.6 (Huvsgul) and No.4 (Mongon) accumulated high total biomass (1.35±0.17g and 3.43±0.44g) at open nursery and green house nursery conditions, respectively whereas Source No.1 (Ovorkhangai) had the lowest total biomass (0.29±0.03g and 1.23±0.16g) accumulation at both growth conditions. Proportional allocation expressed as root weight ratio (RWR) and root shoot ratio (RS) differed significantly among seed sources at both growth conditions. Source No.2 (Zavkhan) and Source No.1 (Ovorkhangai) were allocated more biomass to roots, while Source No.5 (Binder) and Source No.4 (Mongon) allocated less biomass to roots at open nursery and green house nursery conditions, respectively. Seed sources which had intensive height growth had accumulated less biomass to roots compared to the slow growing seed sources.

Monthly Variation in Photosynthesis and Water Use Efficiency—Measurement of monthly variation of gas exchange (Pn and E) and water use efficiency showed significant difference ($p<0.0001$) among the seed sources, months, and seed source and months interaction at both nursery conditions (Table 4). Highest photosynthetic rate and water use efficiency were observed in August at both nursery conditions. Among the study seed sources, Source No.4 (Mongon) and Source No.7 (Uvs) showed highest photosynthetic rates (5.6 and 5.4 μmol CO_2 $m^{-2}s^{-1}$) at green house nursery and open nursery conditions, respectively whereas Source No.8 (Turag) showed lowest photosynthetic rate at both nursery conditions. In between two nursery conditions, Pn was higher in green house nursery (4.84 μmol CO_2 $m^{-2}s^{-1}$) than open nursery (3.96 μmol CO_2 $m^{-2}s^{-1}$), when pooled for all seed sources and measured months.

Water use efficiency values of green house grown seedlings were significantly greater than open nursery grown seedlings (3.96 and 3.07 μmol CO_2 $m^{-2}s^{-1}$/mmol H_2O as pooled for all measurements). High WUE was calculated in Source No.5 (Binder) and Source No.3 (Tuul) with 4.53 and 3.62 μmol CO_2 $m^{-2}s^{-1}$/mmol H_2O, at the green house and open nursery conditions, respectively. The lowest WUE values were observed in Source No.3 (Tuul) and Source No.8 (Turag) with 3.52 and 2.25 μmol CO_2 $m^{-2}s^{-1}$ in green house and open nursery grown seedlings, respectively.

Conclusion

Seed examination results showed significant difference among seed sources ($p<0.001$) in all tested variables. Overall mean germination and germination rate were 51% (2.6 to 83) and 34% (1.6 to 59), respectively. The mean viability was 59% and varied from 15% for Source No.3 (Tuul) to 77% for Source No.5, respectively. Mean weight of 1,000 seeds was 6.65±0.14g. The heaviest seed (7.2±0.02g) was shown by Source No.3 (Tuul) and the lightest one (5.96±0.11g) by Source No.8 (Turag). Mean date of seedling emergence was between 22-45 days after sowing and varied from 26% and 33% for greenhouse and open nursery grown seedlings, respectively.

The growth and biomass allocation differed significantly at both growing conditions, the seedlings grown in green house nursery had more intensive growth and accumulated more biomass compared to open nursery grown seedlings. But the proportional allocation of biomass, root to shoot ratio (RS) and relative weight ratio (RWR) was higher at open nursery grown seedlings, which maybe suggest that more promising survival rates can be obtained after transplanting into field conditions.

Monthly variation in net photosynthetic rate, transpiration rate and water use efficiency were significantly different among seed sources at both nursery conditions in all measured months. Generally, all measured physiological parameters gradually increased with measurement months. Seedlings showed highest photosynthetic rate and water use efficiency in August, followed by June and July.

Water is one of the most limiting environmental factors for tree survival and growth in Mongolia. Hence, selecting trees or provenances with improved drought tolerance may represent the best option to improve transplanted tree survival and growth on a large scale.

The results in growth, biomass allocation and water use efficiency were obtained only within short period of time (two growing seasons) and under the same growing conditions. These morphological and physiological characteristics may change after a prolonged period of growth. Therefore, continuous investigations on growth and biomass allocation characteristics including physiological traits are needed for the future on transplanted seedlings under field conditions.

Literature cited

Gregg, B. M., 1993. Seed-source variation in water relations, gas exchange and needle morphology of mature ponderosa pine trees. *Canadian Journal Forest Research* 23: 749-755.

JICA, FMC and MNE. 1998. *The Forest Resources Management Study in Selenge Aimak, Mongolia*. Japan Forest Technical Association (JAFTA), Asia Air Survey Co., Ltd.

[MNE] Ministry of Nature and Environment of Mongolia, 1999. *Forest and Forestry in Mongolia*. Ulaanbaatar, Mongolia.

Savin, E.N., Ogorodnikov, A.V., Semechkin, I.V., Dugarjav, Ch., Korotkov, I.A., 1978. *Forests of the Mongolian People's Republic (geography and typology)*. Nauka, Moskow, 127p. (in Russian).

Tjoelker, M.G., Volin, J.C., Oleksyn, J., Reich, P.B., 1993. Light environment alters response to ozone stress in seedlings of *Acer saccharum* and hybrid *Populus*. I. In situ net photosynthesis, dark respiration and growth. *New Phytologist* 124: 627-636.

Tsogtbaatar, J. 2004. Deforestation and reforestation needs in Mongolia. *Forest Ecology and Management* 201(1): 57-63.

United Nations Development Programme (UNDP). *Biological Diversity in Mongolia.* Ulaanbaatar, Mongolia. 106pp.

United Nations Environment Programme (UNEP), 2002. *Mongolia: State of the Environment*. Ulaanbaatar.

Wang, R. Z., 2001. Photosynthesis, transpiration, and water use efficiency of vegetative and reproductive shoots of grassland species from north-eastern China. *Photosynthetica* 39(4): 569-573.

World Bank. 2002. *Mongolia Environment Monitor*. Ulaanbaatar, Mongolia. 38pp.

RESTORATION OF MT. MAKILING – A BIODIVERSITY HOTSPOT AND ECOTOURISM DESTINATION IN THE PHILIPPINES

Portia Gamboa-Lapitan

Abstract—The Makiling Center for Mountain Ecosystems (MCME), UPLB has long been in the forefront of habitat restoration in Mt. Makiling. The super typhoon Milenyo that hit it in September 2006 has brought back the ecological state and the restoration gains achieved so far in Mt. Makiling to the status it was a decade ago. An area of about 450 ha of the 4,244 ha Mt. Makiling Forest Reserve has landslides scarring almost all sides of the forest reserve. The need for restoration work is made more pressing and urgent with the forecast of more frequent super typhoon phenomena in the years to come.

This paper discusses the following: 1) the status of Mt. Makiling as a biodiversity hotspot and ecotourism destination in the Philippines after super typhoon Milenyo, 2) the program developed to expeditiously restore the ecological state of areas damaged by Milenyo, 3) the interventions for mitigating impact of global climate change in Mt. Makiling, 4) the mechanism conceptualized by which people and institutions can be rallied to support and undertake the restoration work, and 5) the social commitment to which MCME stands by in restoring Mt. Makiling.

Makiling Center for Mountain Ecosystems,UPLB, College, Laguna, Philippines, Email: portialapitan@yahoo.com

FOREST RESTORATION THROUGH MYCORRHIZAL TECHNOLOGIES: CASE OF BUKIDNON FOREST INDUSTRIES, PHILIPPINES

Nelly S. Aggangan[1], Romulo T. Aggangan[2] and Nelson M. Pampolina[3]

Abstract—Reforestation of degraded lands in Southeast Asia is a major objective of many countries including the Philippines. The establishment of exotic fast growing trees, such as eucalypts and acacias, provides an immediate cover and soil stability on grasslands as well as providing a timber resource of considerable economic value. It also provides a nurse crop that will be essential in the restoration of endangered dipterocarp forest in the country. However, for eucalypt and acacia plantations to be successfully established on nutrient deficient soils in Asia, seedlings may require ectomycorrhizal associations specific for eucalypts, acacia and native dipterocarps. This study was conducted to determine nursery and field performance of mycorrhizal and non-mycorrhizal reforestation species: *Eucalyptus urophylla*, *Acacia mangium*, and *Shorea contorta*. Seedlings of *E. urophylla* and *A. mangium* were inoculated with vegetative mycelia of ectomycorrhizal fungi from species of *Pisolithus* and *Scleroderma*. *Shorea contorta* was also inoculated with vegetative mycelia of *Astreus* sp., *Scleroderma* sp. and *Pisolithus* sp. All seedlings had uninoculated counterparts. Seedlings were planted in areas of cogon grass in Manolo Fortich under the auspices of the Bukidnon Forest Industries (BFI), Malaybalay in the province of Bukidnon, Mindanao Island. Bukidnon lies in the ultramafic geologic belt where concentrations of heavy metals are relatively high. The soil in the experimental area contained high levels of chromium and nickel (0.5% - 1%). Throughout the seven years observation period, mycorrhizal-inoculated seedlings gave better growth and greater wood volume than the uninoculated counterpart. Numerous fruit bodies of *Scleroderma* spp. were observed, two years after outplanting. After five more years, other ectomycorrhizal fungi appeared, implying fungal succession dominated by *Scleroderma*, *Thelephora*, *Cortinarius* and *Boletellus*. Similar results were obtained from the mycorrhiza inoculation trials implemented by BFI. Moreover, mycorrhizal-inoculated rooted-cuttings of *S. cortorta* interplanted in a stand of *E. urophylla* grew faster than the un-inoculated counterpart. These results clearly suggested that ectomycorrhizas are a prerequisite for the establishment and growth of eucalypts and acacias to restore degraded dipterocarp ecosystem in the Philippines. Although a limited number of ectomycorrhizal fungal isolates were used in this study, the data presented indicate that the selection of superior isolates, based on specialization for host or habitat, is essential to achieve positive growth responses in the field.

Reforestation of degraded lands in Southeast Asia is a major objective of many countries including the Philippines. The establishment of exotic fast growing trees, such as eucalypts and acacias, provides an immediate cover and soil stability on grasslands as well as providing a timber resource of considerable economic value. Eucalypts and acacias are grown in plantations around the world because of their silvicultural characteristics, economic importance, and environmental values. Dipterocarps are of the same economic importance as eucalypts and acacias. Most dipterocarps require partial shade during their seedling development thus fast growing species such as eucalypts and acacias are planted to provide shade for dipterocarps. Dipterocarps are the climax forest tree species and was the dollar earner for the Philippines a decade ago. However, for eucalypt and acacia plantations to be successfully established on nutrient deficient soils in Asia, seedlings may require ectomycorrhizal associations specific for eucalypts, and acacia. Likewise, the ectomycorrhizal fungi used in the inoculation of eucalypts and acacias should also be compatible with dipterocarps.

The Bukidnon Forest Industries (BFI) is a joint venture between the Philippines and New Zealand governments, in Bukidnon, Mindanao (now being privatized) with the aim of rehabilitating degraded

[1] National Institute of Molecular Biology and Biotechnology, University of the Philippines Los Baños, College, Laguna 4031; Email: nea@laguna.net
[2] Forestry and Environment Research Division, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Los Baños, Laguna 4030
[3] Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Banos, College, Laguna 4031

marginal lands covered mainly with *Imperata cylindrical* (cogon grass). The rehabilitation area was previously a dipterocarp forest dominated by *S. contorta*. It now has been planted with 7,000 ha of *A. mangium*, *E. deglupta*, *Pinus caribaea*, *E. camaldulensis* and other species, with relatively high survival rates and good growth performance (Sy 1998). BFI conducts trials on site-species matching and tree nutrition. The first mycorrhiza inoculation experiments used topsoil from under *Pinus merkusii* and mixed it with the potting medium. Fruit bodies of *Scleroderma* are prevalent under pine plantation at BFI. Later, mycorrhizal tablets containing spores of *Scleroderma* and *Pisolithus* were introduced onto the seedling during pricking. The present technique now is to apply *Scleroderma* spores collected from under *P. merkusii* (1g L^{-1} water) twice until reaching plantable size (3-4 months).

In this paper, ECM fungi *Pisolithus, Scleroderma and Astreus* were used to inoculate *E. urophylla, A. mangium* and the dipterocarp *Shorea contorta*. Likewise, soil from under dipterocarps was used to inoculate rooted cuttings of *S. contorta* which were interplanted with 18- or 36-mo-old *E. urophylla*. The aims were to determine the effects of ECM inoculation and fertilization on tree growth and on mycorrhizal fungi.

Materials and Methods

The experimental site is a cogonal area in Manolo Fortich under the auspices of the BFI, Malaybalay in the province of Bukidnon, Mindanao Island. Bukidnon lies in the ultramafic belt where concentrations of heavy metals are high. The soil is acidic, low in phosphorus (P) and high in nickel (0.5% - 1%) and chromium. The region experiences a short dry season (December to April, precipitation range from 3 to 57 mm mo^{-1}), a long wet season (May to December, precipitation range from 260-370 mm mo^{-1}) and humidity of 94 to 98%. The total average annual rainfall and evaporation are 2,336 and 1570 mm, respectively. December and January are the coolest (mean 25-27^{o}C) and March and April are the hottest (29-30^{o}C) months. The area is generally hilly and mountainous to an undulating rolling landscape (800-1500 masl).

This study was conducted to determine nursery and field performance of mycorrhizal and non-mycorrhizal reforestation species: *Eucalyptus urophylla, Acacia mangium*, and *Shorea contorta* following a Randomized Complete Block Design. Four experiments were conducted. The first experiment was *Eucalyptus urophylla* and *A. mangium* seedlings were inoculated with vegetative mycelia of ectomycorrhizal fungi *Pisolithus* sp. and *Scleroderma* sp. In the second experiment, *Shorea contorta* seedlings were also inoculated with vegetative mycelia of *Astreus* sp., *Scleroderma* sp. and *Pisolithus* sp. In the third experiment, rooted cuttings of *S. contorta* were inoculated with top soil from dipterocarp forests and were interplanted in a 25-mo-old stand of *E. urophylla* established by BFI. All seedlings had uninoculated counterparts. Growth, wood yield, and occurrence of ectomycorrhizal fungi were monitored. The last experiment was to assess the effect of P fertilizer on the occurrence of ECM fungi in the established eucalypt plantations. BFI's standard inoculation technique is to top water the young seedlings with a suspension of spores of *Scleroderma* collected under pine plantations two times within the three-to four-month rearing period in the nursery.

Results and Discussion

Generally, growth of *E. urophylla, A. mangium* and *S. contorta* inoculated with *Pisolithus, Scleroderma* and *Astreus* grew better than their non-mycorrhizal counterpart under nursery conditions. *Astreus* was the most effective growth promoter for *S. contorta* while some strains of *Pisolithus* did not colonize the roots of *A. mangium*. For *E. urophylla*, colonization was high for all the ECM tested.

In the field, *E. urophylla* mycorrhizal with *Pisolithus* and *Scleroderma* gave better growth and greater wood volume than the uninoculated counterpart throughout the seven-yr observation period. Numerous fruiting bodies of *Scleroderma* spp. were observed, two-years after outplanting but no *Pisolithus*. After five-years more, other ECM fungi appeared implying fungal succession.

For the mycorrhiza inoculation trials conducted by BFI, *Scleroderma*, *Cortinarius,* and *Thelephora* were the most abundant ECM fungi under 18-mo-old stand of *E. urophylla*. Application of P fertilizer (0, 100 and 1,000 kg solophos ha^{-1}) had no effect on fungal diversity, fungal biomass, tree growth, or litter production but substantially reduced hyphal length by 31 to 52%.

In the *E. urophylla* plantation where seedlings mycorrhizal with *Scleroderma* or non-mycorrhizal *S. contorta* were interplanted, four ECM fungal species above ground and 18 ECM morphotypes (11 in *S. contorta* and 7 in *E. urophylla* below ground) were observed. From RFLP analysis, it was concluded that some species of *Scleroderma* were able to naturally colonize roots of *Shorea* and *Eucalyptus*, which validated results under laboratory and nursery conditions. Outplanted mycorrhizal *S. contorta* had better survival (33-48%) than non-mycorrhizal plants at 18-months. Mycorrhizal *S. contorta* were 40-46% taller with biomass of 2-3 times greater than the control before outplanting. Eighteen-months after outplanting, height was increased by 26-46% relative to the control. In this experiment, ECM diversity included *Scleroderma,*(Table 1). These results clearly imply that ectomycorrhizas are a prerequisite for the establishment and growth of eucalypts, acacias and dipterocarps in the Philippines. Although a limited number of ectomycorrhizal fungal isolates were used in this study, the data presented indicate that the selection of superior isolates, based on specialization for host or habitat, is essential to achieve positive

Table 1. Abundance and biomass production of ectomycorrhizal fungi under a one- to 18-mo and 19- to 36-yr- old *E. urophylla* plantations established by BFI.

Plantation age (mo)	ECM fungal Species	Aug and Sep 1998		January 1999	
		Basidiocarp per plot*	Biomass (kg ha^{-1})	Basidiocarp per plot*	Biomass (kg ha^{-1})
1-18	Scleroderma	16 ± 8	2.2 ± 0.94	13 ± 8	1.96 ± 1.13
	Thelephora	19 ± 2	0.38 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		May and Aug 1997		June, July and August 1998	
	Cortinarius	3 ± 0	0.31 ± 0.0	2 ± 1	0.07 ± 0.06
19-36	Scleroderma	34 ± 22	2.67 ± 1.75	5 ± 3	2.31 ± 1.41
	Thelephora	4 ± 1	0.15 ± 0.06	32 ± 6	1.11 ± 0.27

Literature Cited

Aggangan, N.S. 1996. Soil Factors Affecting the Formation and Function of *Pisolithus-Eucalyptus Urophylla* Ectomycorrhizas In Acid Soils In The Philippines. Ph.D. Thesis Murdoch University, Perth, Western Australia. 207 pp.

Aggangan, J.S., J.C.O. Bulan, Limos, C.A.S. 2002. Ectomycorrhizal inoculation of *Anisoptera thurifera* and *Shorea guiso* in Philippine Red Soil: Growth and Phosphorus Dynamic. Research Project Philippine Science High School, Diliman, Quezon City. pp 68.

Pampolina, N.M. 2000. Ecology of ectomycorrhiza fungi in eucalypt plantations in Western Australia and the Philippines. Ph.D. Thesis Murdoch University, Perth, Western Australia. 188 pp.

AN INVESTIGATION ON THE METHODS OF RECONSTRUCTION AND RESTORATION OF PEATY SOILS IN THE COASTAL REGIONS OF NOWSHAHR AND CHALUS IN THE NORTH OF IRAN

Eesa Mataji Amirrood[1], Ali Faghih Malekmarzban[2], Saeed Safdari[1]

Abstract—Due to special climatic and geological features and vegetation covering, the coastal area of Nowshahr and Chalus in the north of Iran is among the regions which grant the possibility of accumulation of organic resources and formation of peaty soil in the course of the Quaternary. Organic soils are one of the 12 main categories of soils, called Histosols in the US Taxonomic Classification. A high water table, stagnant water where sweet and salty waters meet, distance from river activities, and hydromorphic trees such as Alnus spp. are among the necessary conditions to form peaty soils in the region. From a geomorphological point of view, the environment in which these soils are formed is between the Caspian Sea and Alborz Mountains. The altitude of this region is about 22 metres above sea level. Alluvial deposits of the Holocene and recent age coastal facies form the geology of the region. A sandy lens containing bivalve shells of the Caspian Sea, at a depth of 5 m in the peaty soils, shows the transitional progress of the sea water when these soils were being formed. The findings which have resulted from laboratory data and studies on the geomorphological conditions of the area, suggest a lowland model for the formation of these deposits. The investigations show that about 6% of the coastal area in Nowshahr and Chalus is covered with peaty soils. The average thickness of these soils is 2 m and the maximum thickness of peat soil in this area is 5.5 m. From a pedological point of view, these soils are unlike many peaty soils in the world as they have a neutral pH. Their percentage of organic materials is approximately 32%, porosity is about 78%, with a specific gravity of 0.32.

According to the international classification, the peaty soils of this region are Histosols, in the suborder of Hemists, Medihemist Great Group and fibric subgroup. Because of the high level of water table and the presence of swamps in this region, many hydrophilous plants grow in this environment. Also some of the migrating birds which fly from Siberia to the southern parts of the Caspian Sea choose these regions in order to pass the cold period of winter. Although the government has banned the use of these peaty-soil-covered lands for various construction purposes, nevertheless due to expensive lands, nice weather and tourism they are buried under tens of tons of gravel and construction materials and filled with buildings. If this procedure goes on, not only the ecological features of the region will be altered but also these economically precious soils will become useless. Previous research determined the value of these soils and their valuable application in different agricultural industries such as the mushroom industry, greenhouses, and supplying organic materials for pistachio and olive trees. In addition, the importance of these soils for recording paleoclimatological and geological events was noted. In fact, these soils have preserved all the past events in themselves and provide us with a regional calendar of the Quaternary period. Due to the reducing conditions prevalent among peaty soils, the rate of spore and pollen destruction is very low, thus these soils can be a good place for determining the genetic reserves of valuable species which once inhabited area. Regarding all these issues, it has been suggested that first, the areas must be kept away from personal manipulation and be declared preserved areas under the care and supervision of the government and research institutes. This will contribute to preventing construction and changed in land use. Second, exhaustive paleoplant and paleoclimatological studies must be conducted in this region in order to gain a better understanding of these soils and their role in preserving the ecologic conditions of the aforementioned areas as a potentially national and international project.

[1] Geology Department at Azad University of Nowshahr and Chalus, Chalus, Mazandaran, Iran. mataji@kohrovan.ir
[2] Environment Administration of Nowshahr and Chalus, Chalus, Mazandaran, Iran.

WILDLIFE DIVERSITY STUDIES AND CONSERVATION EFFORTS IN THE PHILIPPINES

Juancho B. Balatibat

Abstract—Wildlife diversity studies through rapid assessment using transect methods and utilizing different trapping techniques were conducted in different habitat types in various parts of the Philippines. Results showed the presence of considerable numbers of vertebrate wildlife species in the study sites from common to rare and threatened species. Further, endemism was noted as remarkably high, reaching an average of 45% particularly at the watershed areas sampled. In addition, possible new species were also collected from the study sites. The computed Shannon-Wiener Diversity Index for the different study sites indicated relatively high wildlife diversity. El Nido Island in Palawan had the highest species diversity index, ranging from 3.41 to 3.58. The varied habitat types and landscapes in the Philippines contribute to high degree of biological diversity that deserves a concerted conservation effort. These studies further confirm that the Philippines is a biologically rich country and a significant biodiversity hotspot and conservation area in the world.

The Philippines with diverse landscapes is a biologically rich country and is regarded as a significant biodiversity hotspot and conservation area in the world. Per ha, the Philippines probably harbors more diversity of life than any other country on Earth, but its biodiversity is also under tremendous threat of endangerment (Ong et al. 2002). In addition, because of the large number of islands of different sizes and geological histories, the Philippines may have the greatest concentration of island endemism in the world, which makes it one of the best places in the world for ecological and evolutionary studies (Alcala 2002, Catibog-Sinha and Heaney 2006). Conservation International lists the Philippines amongst the top ten "Megadiversity Countries" globally. Major international conservation organizations currently regard the Philippines as one of the top global priorities for conservation action (Oliver and Heaney 1996). Birdlife International, for example, has ranked the country as one of the highest priorities for bird conservation.

Of the more than 1,000 terrestrial wildlife species (576 birds, 172 terrestrial mammals, 101 amphibians and 258 reptiles) recorded for the Philippines, almost half (49%) are unique to this country. Unfortunately, these wildlife resources are continuously under pressure due to loss and destruction of their habitat, over-exploitation, environmental pollution, and the recent global climate change. About 128 endemic wildlife species are under various threat categories (Ong et al. 2002). Conservation efforts for wildlife and other biological resources in the Philippines began in 1987 with the creation of Protected Areas and Wildlife Bureau (PAWB) that received more attention after the country signed the 1992 Convention on Biological Diversity (CBD). These wildlife diversity studies, therefore, may contribute important and reliable data on wildlife from various sites for the implementation of wildlife conservation initiatives throughout the Philippines.

Methodology

Study sites—Rapid inventory and diversity assessment study of wildlife was conducted in different parts of the Philippines. The sampling areas were found in El Nido Island, Palawan; Kaliwa Watershed in Tanay, Rizal; Mountain ecosystems in Tampakan, South Cotabato; Caliraya Watershed in Laguna; and, Angat Watershed in Bulacan. For Kaliwa Watershed and the Mt. Matutum ecosystems, only an avifaunal inventory was conducted.

Sampling techniques—The line transect method for ocular observation of wildlife, mist netting for nocturnal and volant species, and cage-trapping for non-volant species. Known species collected from the mist net and traps were released after proper documentation and measurement. Possible new species were preserved accordingly for further species verification.

Biodiversity measures—Biodiversity parameters such as the Shannon-Wiener Diversity Index, Simpson's Dominance Index, and Species Evenness Index were computed for the various sampling sites using bird-sampling data. Only the data on Shannon are discussed here.

Results and Discussion

Species inventory—In El Nido Island, Palawan, 103 bird species, 24 mammals, 10 reptiles, and 12 frogs were recorded to occur in different types of vegetation (Magsino 2000, Osbucan 2000). Secondary forest had the highest bird species diversity, followed by mangrove vegetation. Palawan is known for its high rate of endemism. Thus, the endemic wildlife recorded in the area included 10 bird species, 6 species of mammals, one species

Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines; email-jbbalatibat@yahoo.com

of reptile, and 2 species of frogs. Among these endemic species the Palawan peacock pheasant (*Polyplectron emhanum*), the Grey Imperial Pigeon (*Ducula pickeringii*) and the Blue-naped Parrot (*Tanygnathus lucionensis*) are endangered species.

Avifaunal inventory at Kaliwa Watershed in Tanay, Rizal recorded a total of 55 species in 31 families found in different plant communities varying from grassland, agriculture, bamboo stand, and secondary forest (Urriza 2004). Among these species, 29% or 16 species are endemic to the Philippines; two species, the Philippine Duck (*Anas luzonica*) and the Philippine Dwarf Kingfisher (*Ceyx melanurus*), are listed as vulnerable (Collar et al. 1999, WCSP 1997).

Bird diversity assessment along different elevation gradients with different habitat types varying from grassland-agroforestry, old secondary growth and mossy forest in Tampakan, south Cotabato mountain ecosystems reported by Duran (2005) listed 55 species constituting 44 genera and 29 families. About 42% of these species are endemic to the Philippines. Three genera recorded in the area (*Phapitreron, Rhabdornis* and *Sarcops*) are also endemic to the country. The grassland-agroforestry area and the mossy forest gave the highest number of bird species, 35 and 34 respectively. During this study, an unidentified frog species, which appears as a new species was collected.

As a requisite for the preparation of conservation and development plant plan for the two watershed areas managed by the National Power Corporation, the Caliraya watershed in Laguna and the Angat watershed in Bulacan, a biodiversity resource assessment was conducted in 2005 and 2006, respectively. The wildlife survey conducted in a 500 ha area at the Caliraya-Lumot Watershed listed a total of 54 species in 45 families including freshwater fishes. The terrestrial wildlife consisted of 27 species of birds, 7 species of reptiles, 4 species of frogs and 4 species of mammals. Wildlife endemism in the area is high at an average of 37%. Endemic birds comprised about 33%, reptiles 29%, amphibians 25%, and mammals 60%. Among the endemic species, Luzon Bleeding-heart Pigeon (*Gallicolumba luzonica*) is categorized as near-threatened. In addition, the Luzon Tarictic Hornbill still abounds in the area. For the Angat Watershed, a total of 66 species belonging to 34 families was recorded from the six transect sites surveyed. It was comprised of 43 species of birds, 14 species of reptiles, 5 species of frogs, and 4 species of mammals. Significantly, a possible new species of frog of the genus *Kaloula* was collected from the water tributary in the area. Furthermore, the endemism level was remarkably high at an average of 45%. Among the groups of wildlife, the mammals and amphibians gave extremely high percentage endemism at 100% and 80%, respectively. The reptiles group had 43% endemic species while the avian fauna had 37%. The two endemic genera, *Phapitreron* and *Sarcops*, are also present in the area. Thus, Angat Watershed area can be categorized as an important Endemic Wildlife Area (EWA) in the Philippines.

Biodiversity indice—Wildlife diversity levels in the different study sites, based on Shannon-Wiener index using bird sampling data taken from an approximately 2-km transect, appeared relatively high. At El Nido Island, species diversity index ranged from 3.41 to 3.58. For the Kaliwa watershed, bird species diversity ranged from 2.00 to 3.44 while in Tampakan mountain ecosystems, species diversity got a low index value of 2.88 and a high value of 3.11. At the Caliraya watershed, species diversity index value averaged 2.43 while Angat watershed gave an average of 2.11. El Nido Island had the highest species diversity followed by the Tampakan mountain ecosystems, then the Kaliwa watershed. Furthermore, the data revealed that lower species diversity index values were obtained from more disturbed and open habitat types. According to Magurran (1988), an area with an index value ranging from 1.5 to 4.0 is considered highly diverse. Thus, the wildlife composition of the different study sites is highly diverse.

Conclusion

Results of these different studies further confirm the biological richness of the Philippines and the presence of high rates of endemism that makes it one of the top megadiversity countries and one of the hottest of the hotspots globally. It also implies that several habitat types and landscapes in the country are Important Biodiversity Areas; even the small island of El Nido, Palawan. Thus, local and international organizations and even the community must strengthen the concerted effort for the conservation and/or protection of threatened wildlife and other biological resources in the country.

Acknowledgment

This paper is a brief compendium of the outputs in my various research involvements. My heartfelt gratitude to Drs. Rex Cruz and Enrique Tolentino of the College of Forestry and Natural Resources, University of the Philippines Los Baños for giving me the opportunity to be involved in the biodiversity resource assessment in Caliraya and Angat Watershed; to Mr. Blas Tabaranza through the Haribon Foundation for the support given to my advisees, Ms. Gina Magsino and Mr. Ivan Osbucan, for their wildlife inventory in El Nido, Palawan; to Dr. Nelson Pampolina and the Southern Mining Company in Tampakan for the support for my advisee, Mr. Neil Duran for his thesis on avifaunal diversity assessment at Tampakan mountain ecosystems, South Cotabato, Philippines; and to Prof. Joey Baril for the help extended to Mr. Rolly Urriza, my thesis advisee, during the avifaunal inventory at the Kaliwa watershed.

Literature Cited

Alcala, A.C. 2002. Vanishing Treasures of the Philippine Rainforest. http://www.fieldmuseum.org

Catibog-Sinha, C.S., Heaney, L.R. 2006. *Philippine Biodiversity: Principles and Practice.* Quezon City:Haribon Foundation for the Conservation of Natural Resources, Inc. 495pp.

Collar, N.J., Mallari, N.A.D., Tabaranza, B.R., Jr. 1999. *Threatened Birds of the Philippines*. The Haribon Foundation/Birdlife International Red Data Book. Makati City. Bookmark. 559 pp.

Duran, N.J.E. 2005. Avifaunal diversity assessment along different elevation gradients of Tampakan Mountain ecosystems and vicinities, South Cotabato, Philippines. College of Forestry and Natural Resources, University of the Philippines Los Baños. Unpublished undergraduate thesis.

Magsino, G.M. 2000. Inventory of avifauna in El Nido, Palawan. College of Forestry and Natural Resources, University of the Philippines Los Baños. Unpublished undergraduate thesis.

Magurran, A. E. 1988. *Ecological Diversity and Its Measurement*. Princeton University Press, New Jersey. 179 pp.

Oliver, W.L.R., Heaney, L.R. 1996. Biodiversity and conservation in the Philippines. *International Zoo News* 432: 329-337.

Osbucan, I.L.R. 2000. Inventory of Amphibians, Reptiles and Mammals in El Nido, Palawan. College of Forestry and Natural Resources, University of the Philippines Los Baños. Unpublished undergraduate thesis.

Ong, P.S., Afuang, L.E., Rosell-Ambal, R.G. 2002. Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan. Department of Environment and Natural Resources, Conservation International Philippines, Biodiversity Conservation Program-University of the Philippines Center for Integrative and Development Studies, and Foundation for the Philippine Environment, Quezon City, Philippines. 113 pp.

Progress Report. 2005. Land-use and ground verification of Caliraya-Lumot Watershed. UPLB-Foundation Inc. and National Power Corporation Funded Project. (Unpublished report)

Progress Report. 2006. Biodiversity resource inventory and assessment at Angat Watershed. UPLB-Foundation Inc. and National Power Corporation Funded Project. (Unpublished report)

Wildlife Conservation Society of the Philippines. 1997. Philippine Red Data Book. Makati City: Bookmark. 262 pp.

FORESTRY PROGRAMS ON ECOLOGICAL RESTORATION IN CHINA

Huaxing Bi

Abstract—Because of some irrational activities of human beings, such as destroying the vegetation and farming on steep sloping land, degeneration of ecosystems is becoming the key environmental problem in China. This affects sustainable economic development and the establishment of harmonious relationships between human beings and the environment. Facing this reality, the Chinese government has been paying much attention to this problem and taking restoration of the ecology as one of the important tasks for national environment protection. Now we have worked out related policies and have implemented many important ecological restoration programs, such as the Natural Forest Protection Program, the Program for Conversion of Cropland to Forests, Key Shelterbelt Development Programs in the Three North Regions and the Middle and Lower Reaches of the Yangtze River; all of these programs have made great progress. This paper gives a summary of the progress of ecological restoration programs in China.

China has a total area of 175 million ha of forestland (fifth-largest in area in the world), and a standing timber stock volume of 12.5 million m^3 of timber (which ranks seventh in the world). Yet despite these figures, China's timber resources remain relatively scarce; its forest area represents only 4% of the world's total, and its standing timber accounts for only 3% of the world's reserves. Its area of reforestation forest cover stands at 18.21% of the total land mass, which is slightly over half of the world average, but only 0.13 ha per capita, which is well below the world average of 0.65 ha. The shortage of vegetation (because of a long history of deforestation, human being's irrational activities, and natural conditions) has made a lot of ecological environmental problems, for example soil erosion. China is now one of the countries with the greatest amount of soil erosion; the area of soil erosion is 3.56 million km^2, which accounts for 37% of the total area of China. In the Loess Plateau, a typical soil erosion area in China, the average soil erosion modulus is 3,720,000 kg km^{-2}. The sediment concentration of the Yellow River is 37.6 kg m^{-3}, 38 times that of the Mississippi River and 49 times the Nile River.

Being an important and effective way for ecological restoration and environment protection, the Chinese government has paid a great deal of attention and greatly has increased investments in soil and water conservation in recent years; there is about 50,000 km^2 of soil erosion controlled each year. However, at least 50 years will be needed for erosion control based on this rate. So, we must speed up erosion control to satisfy the grand goal of building a well-off society in an all-round way. But how do we do that? Depending only on artificial measure is not enough. In recent years, China has produced significant adjustments to the forest ecological construction strategy; one of the important signs is the implementation of ecological restoration. In 2001, some ecological restoration pilot projects were put into effect in the whole nation by the Ministry of Water Resource, China. To restore vegetation, control soil erosion, and promote sustainable economic development, the State Forestry Administration of China has proceeded with some forestry ecological projects and has gotten very great achievements on these projects.

Key Forestry Programs on Ecological Restoration

Natural Forest Protection Program—This program aims at rehabilitation and development of natural forests. The program covers 734 counties and 167 forest industry bureaus in key state-owned forest areas in 17 provinces in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River as well as northeast and Inner Mongolia. Three major objectives are expected to be achieved during the period of 2000-2010. (1) The existing forest resource will be protected in a proper manner. A logging ban is put on commercial harvest of natural forests in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River. The timber output in such key state-owned forest areas as Northeast and Inner Mongolia is adjusted and reduced by 19.905 million m^3, and 94.2 million ha of forest are brought under strict conservation; (2) Efforts are accelerated in developing forest resources. An additional 14.66 million ha of forest and grassland, including 8.66 million ha of forest, are established in the upper reaches of the Yangtze River and the upper and middle reaches of the Yellow River so as to raise the forest cover by 3.72%; and (3) A total of 741,000 redundant forest workers in the program area are properly redirected and relocated.

Beijing Forestry University, Beijing, P.R.China; email-bhx@bjfu.edu.cn

The Program for Conversion of Cropland to Forests—This program targets soil and water erosion in key areas. The program covers 24 provinces (autonomous regions or municipalities). It is expected that 14.66 million ha of cropland will be converted to forest and 17.33 million ha of barren land covered with trees during the period of 2001-2010. Upon completion of the program the forest and grass cover of the program area will be raised by 5%, 86.66 million ha of soil- and water-eroded area brought under control, and 103 million ha of sand-stabilization areas established.

The Sand Stabilization Control Program for Areas in the Vicinity of Beijing and Tianjin—This program targets sandstorms in areas surrounding the capital. The program covers 75 counties, with a total area of 460,000 km^2, in five provinces, including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia. It is expected that during the period of 2001-2010, 2.63 million ha of cropland will be converted to forest, 4.94 million ha of plantations established, 10.63 million ha of grassland harnessed, 113,800 supporting water conservation facilities developed, 23,000 km^2 of catchment managed and 180,000 people relocated for ecological reasons. Upon completion of the program the ecosystems in the vicinity of Beijing and Tianjin will be remarkably improved, with the forest cover reaching 19.44%, an increase of 8.27%.

Key Shelterbelt Development Programs in Such Regions as the Three North and the Middle and Lower Reaches of the Yangtze River—The target of these programs is combating desertification in the Three North region and other ecological problems in other regions. It includes many programs. For example, the 4th phase of the Three North Shelterbelt Program has been initiated, with its focus on combating desertification. It involves 590 counties in 13 provinces in the Three North region. It is expected that 9.46 million ha of land will be afforested and 1.3 million ha of desertified land brought under control during the period of 2001-2010. Upon completion of the program the forest cover in the program area will be raised by a net 1.84%, nearly 11.33 million ha of farmland put under shelter and 12.66 million ha of desertified, salinized and degraded grassland protected and rehabilitated. Key shelterbelt development programs in the middle and lower reaches of the Yangtze River involve relevant areas in 31 provinces (autonomous regions or municipalities). It is expected that 18 million ha of land will be afforested, 7.33 million ha of low-efficiency shelterbelt improved and 37.33 million ha of existing forests properly managed and protected during the period of 2001-2010.

Literature Cited

Fu, B.J., Chen, L.D. 2001. *The Theory And Application Of Landscape Ecology*. Beijing: Science Press.

Peng S.L. 2001. The restoration of degraded ecosystems and restoration ecology. *China Basic Science* (3):18-24.

ECONOMIC EVALUATION OF USING WATER-USE EFFICIENT FOREST LANDSCAPE RESTORATION TREE SPECIES

Leni D. Camacho, Enrique L. Tolentino Jr., Lucrecio L. Rebugio, Sofronio C. Camacho

Abstract—This paper is about ecophysiology and economics. It is an attempt to determine and apply ecophysiological and economic tools for improved species selection for more accelerated forest landscape restoration in the Philippines. Specifically, it compares the ecophysiological characteristics of common forest restoration species, assesses the water-use efficiency of commonly planted landscape restoration species, and undertakes an economic evaluation of the benefits and costs of using different species with relatively higher water use efficiency (WUE) as restoration materials in forest areas. In the absence of empirical data, economic evaluation was based on hypothetical assumptions of comparative water yield through time of different forest restoration species with different WUE if planted in a forest area. Results of an economic evaluation imply that it is wise to invest in the ecophysiological testing of restoration species with a view toward determining those with high value WUE.

The standard method for determining species suitability for most landscape restoration sites in the Philippines is long-term and expensive species trials. Ecohysiological and economic assessments are necessary tools to facilitate and economize selection of appropriate restoration species for the varying conditions in the field particularly adverse sites common in degraded lands.

This paper aims to assess the economic value of environmental benefits of forest restoration using ecophysiological information. It calculates the economic comparative advantage of using restoration species with relatively higher water-use efficiency (WUE) as forest restoration materials in restoration areas. The important information generated from this paper could aid forest managers in deciding the best species for particular restoration sites around the country.

Methodology

Results of a study by Tolentino (2005) on the ecophysiology of some restoration species (*Shorea almon, Hopea plagata, parashorea malaanonan, Anisoptera thurifera* and *Shorea contorta*) were used. Water use efficiency was computed as the ratio of net photosynthesis to transpiration rates. Water use efficiency values were used to compute for the estimated amount of water loss and water retention per tree. Water retention and water loss per tree were estimated based on the amount of water required per kilogram of wood in Kramer and Kozlowski (1979) while the computation of tree biomass was based on the formula by Brown (1977).

Economic evaluation was done based on hypothetical assumptions of costs and benefits, water loss and water absorbed through time of species. The economic assessment techniques used were Net Present Value (NPV), Benefit/Cost Ratio, and Internal Rate of Return (IRR). NPV determines the present-day value of net benefits (gross benefits minus costs) with a predetermined discount rate and time horizon:

$$NPV = \sum_{i=0}^{n} \frac{B_i - C_i}{(1 + r)^i}$$

Where:

B_i = benefits in year i
C_i = costs in year i
r = discount rate (expressed as decimal)
n = number of years (the time horizon)

Benefit/Cost Ratio calculates the ratio of discounted benefits to discounted costs.

$$B/C\ Ratio = \frac{\sum_{i=0}^{n} \frac{B_i}{(1 + r)}}{\sum_{i=0}^{n} \frac{Ci}{(1 + r)}}$$

Where:
B_i = benefits in year i
C_i = costs in year i

Species	Water Use Efficiency (WUE)	Water Absorbed tree^{-1} (gm)	Water Loss tree^{-1} (gm)
Hopea plagata	6.76	232.54	111.46
Shorea contorta	6.26	215.34	128.66
Anisoptera thurifera	4.72	162.37	181.63
Parashorea malaanonan	4.50	154.80	189.20
Shorea almon	3.64	125.22	218.78

Table 1. Water use efficiency (WUE), water absorbed and water loss of five dipterocarp species.

College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines; email-camachold@yahoo.com.ph

r = discount rate (expressed as decimal)

n = number of years (the time horizon)

Internal Rate of Return is a calculation that sets NPV = 0 and solves for i. The resulting IRR could be compared to current interest rates or to the social costs of loans.

$$\sum_{i=0}^{n} \frac{B_i}{(1+r)} - \sum_{i=0}^{n} \frac{C_i}{(1+r)}$$

Results and Discussion

Results of the study showed that the most water-use efficient restoration species tested was *Hopea plagata* with values ranging from 5.56 to 7.11 or an average of 6.78. *Shorea contorta* was second (6.26) and *Anisoptera thurifera* was third (4.72). The least water-use-efficient species was *Shorea almon* (4.72). Water retention per tree ranged from 125.22 gm tree^{-1} (S. almon) to 232.54 gm tree^{-1} (*H. plagata*) while water loss per tree ranged from 111.46 gm tree^{-1} (*H. plagata*) to 218.78 gm tree^{-1} (*S. almon*).

In the absence of empirical data, economic evaluation was used based on hypothetical assumptions of comparative water loss and water absorbed through time of the five restoration species tested for WUE if they had been planted in a degraded restoration area. Economic evaluation of the species based on estimated costs and returns data per ha at an economic rotation of 40 years indicated an IRR ranging from 18 to 20 %. As expected, H. plagata (with the highest WUE) got the highest IRR (20%) followed by S. contorta (19%), while S. almon incurred the least IRR (18%).

Table 2. Economic evaluation of five restoration species based on estimated costs and returns data at an economic rotation of 40 years.

Species	Net Present Value (Pesos)		Benefit Cost Ratio		Internal Rate of Return
	i= 12%	i= 15%	i= 12%	i= 15%	
Hopea plagata	21797	5886	2.020	1.326	20.0
Shorea contorta	21325	5650	1.976	1.309	18.9
Anisoptera thurifera	19770	4871	1.845	1.255	18.9
Parashorea malaanonan	19578	4775	1.249	1.830	18.8
Shorea almon	18710	4340	1.065	1.221	17.9

Summary and Conclusion

The economic importance of ecophysiological studies in improving species selection in forest restoration was elucidated. Results of economic evaluation imply that it is wise to invest in the ecophysiological testing of forest landscape restoration species with a view of determining those with high values of WUE.

Acknowledgement

This research is based on the ASEAN-Korea Environmental Cooperation Project (AKECOP-Philippines) regional research on the ecophysiology of several indigenous tree species. College of Forestry and Natural Resources, University of the Philippines Los Baños.

Literature Cited

Brown, S. 1997. Estimating biomass and biomass change of tropical forest: A primer. Forestry paper 134, Rome: United Nations-FAO.

Kramer, P.J., Kozlowski, T.T. 1960. *Physiology of Trees* McGraw-Hill Book Company. Reprinted and distributed by National Bookstore, Inc. Manila Philippines.

Reyes (1959) as cited in Gumpal, E.C. 1984. A yield prediction model for a cut-over dipterocarp forest in Northern Luzon. Unpublished MS Thesis. UPLB College, Laguna, Philippines.

Tolentino, E.L. Jr. 2005. Ecophysiology of Indigenous Tree Species Planted in Degraded Sites. Final Report of the AKECOP-Philippines Regional Research. CFNR-UPLB, College,Laguna, Philippines.

University of the Philippines Los Baños (UPLB). 1999. The Laguna-Quezon and Laguna Land Grant Master Plan College, Laguna, Philippines.

POST-BURN REGENERATION IN THE FORESTS IN GOSUNG, KOREA

Jae-Hyoung Cho[1], Young-Geun Lee[2], Young-Kul Kim[2], Hyun-Je Cho[3]

Abstract—In the Gosung Fire (3,762 ha) of 1996, 49.4% and 77.0% of deciduous and coniferous stands were severely burned, respectively (Lee and Hong 1998) and then reburned in April 2000. The change of forest ecosystems after fire currently holds considerable interest because fire has an influence on species composition and plant growth in forest ecosystems by changing the floristic composition and the form, distribution, and amount of nutrients. Although there are several studies of early changes in sprout regeneration dynamics after forest fire in Korea, little is known about long-term stand development as affected by fire intensity in Korea (Lee. et al 2002). The objective of this study was to determine the succession of pine forest by sprouting regeneration with the change of time course after forest fires in *Pinus densiflora* stands.

In an attempt to investigate the effects of reburning on the regeneration of burned forests, we established four permanent quadrats in the forests that were damaged by forest fire in 1996 and the other four quadrats in forests that were lightly reburned in 2000 after the first fire in 1996. Species richness in flora has been decreased gradually in all of the eight quadrats and stabilized since 2001; 90 species in 1997, 83 in 1999, 76 in 2001, and 95 in 2006. On the other hand, in the reburned forests, the number of herbaceous plants decreased with time, then increased again 5-yrs after the second fire. This may be due to increase-decrease in the number of light-demanding species. Crown area has increased continuously with time in all of the eight quadrats. But it was dramatically decreased right after the second fire in the reburned forests and then increased again 5-yrs after the second fire. As the two dominant tree species, Mongolian oak (*Quercus mongolica*) and Konara oak (*Q. serrata*) have been competing for growing space. Cork oak (*Q. variabilis*) was tallest and dominated in the sub-tree layer regardless of its low frequency. The number of sprouts per stock has decreased with time; 5.7 in 1997, 2.9 in 1999, 2.1 in 2001, and 1.9 in 2006. The withering of recessive sprouts may give a partial explanation for this result. On the contrary, the number of sprouts per stock in the reburned forests decreased with time before the second fire and then temporarily increased right after the second fire: 5.6 in 1997, 3.1 in 1999, 4.4 in 2001, and 2.2 in 2006. The sprout regeneration dynamics of the three dominant tree species (*Quercus mongolica, Q. serrata, and Q. variabilis*) showed that the major competition layer was shifted from shrub layer to sub-tree layer. Compared with this result, the shifting speed in the reburned forests became slower after the second fire, but restored 5-yrs after the second fire.

Literature Cited

Lee, C.S., Hong, S. 1998. Changes of landscape pattern and vegetation structure in rural area disturbed by fire. *Korean Journal of Ecology* 21:389-399.

Lee, Dowon, et al. 2002. *Ecology of Korea – Forest fires and vegetation responses in Korea* Bumwoo Publishing Company. Korea pp 127-130.

[1] Division of Forest Ecology, Korea Forest Research Institute, 207, Cheongyangni-2 dong dongdaemun-gu, Seoul, 130-712 Korea; email-cjl544@foa.go.kr
[2] Division of Forest Fire, Korea Forest Research Institute, Seoul, Korea
[3] Keimyung University, Daegu, Republic of Korea

STUDY OF LONG-TERM RAINFALL-RUNOFF RESPONSE IN A FOREST CATCHMENT USING TOPMODEL

Hyung Tae Choi, Kyongha Kim, Jae-Hong Jun, Jae-Yun Yoo and Yong-Ho Jeong

Abstract—Hydrologic response is an integrated indicator of watershed condition, and significant changes in land cover may affect the overall health and function of a catchment. In Korea, afforestation areas reached more than 30 % of whole forested areas. The study of rainfall-runoff characteristics of typical afforested catchments needs to develop predictive capabilities and recommendations for management and conservation measures of afforested lands. This paper describes a procedure for evaluating the long-term rainfall-runoff responses on catchment scale. TOPMODEL (Topography-based hydrological model) is applied to a coniferous forest catchment.

The study site considered is a forested experimental catchment (13.6 ha), located in the Gwangneung experimental forest within the Korea National Arboretum. This coniferous forest of *Pinus korainensis* and *Abies holophylla* was planted at stocking rate of 3,000 stems ha^{-1} in 1976. The altitude of the experimental catchment ranges from 160 m to 290 m with a slope from 13° to 35°. The underlying bedrock consists of gneiss and the soil texture is sandy loam. Mean annual precipitation is approximately 1,433 mm.

Long-term stream flow and rainfall data observed from 1982 to 2006 were used to calibrate a hydrological model and analyse long-term rainfall-runoff response. Potential evapotranspiration was calculated by the FAO Penman-Monteith equation using weather information of neighboring national weather stations, and modified by comparison with the actual evapotranspiration data obtained within the study site.

TOPMODEL is a rainfall-runoff model in which distributed predictions of catchment response are made based on a simple theory of hydrological similarity of points in a catchment, originally developed to predict the rainfall-runoff relationship and to describe the spatial pattern of storm flow generation. It has the advantages that the computational burden of the model is greatly reduced relative to a fully distributed model and the number of parameters required to run the model can be kept small, reducing the possibilities of overparameterization. In most cases it has been found that, after calibration of the parameters, TOPMODEL provides good global simulations of stream discharges. The Generalized Likelihood Uncertainty Estimation (GLUE) methodology proposed by Beven and Binley (1992) was been used as a general strategy for model calibration and uncertainty estimation based on the equifinality thesis. The GLUE methodology has now been widely used to model conditioning and uncertainty estimation in a variety of models of complex environmental systems.

The procedure of the GLUE methodology is based upon making a large number of simulation runs of a model with different parameter sets, chosen randomly from the specified ranges for each parameter by Monte Carlo simulation. In total, one million parameter sets were used to make a large number of simulation runs of the TOPMODEL, and the parameter ranges were chosen based on previous studies. The performance of each independent random parameter set is evaluated by a quantitative measure of performance or likelihood measure, and the best parameter sets (the top 1 % of 10,000 sets) were used in analyses.

In this study, we test the feasibility of using widely available data sets for parameterizing hydrological simulation models, and characterize long-term variations and changes of rainfall-runoff responses and model parameter distributions of an afforested coniferous catchment.

Forest Conservation Division, Department of Forest Environment, Korea Forest Research Institute, Seoul, Korea, 130-712; email-choiht@paran.com

LANDCOVER CHANGE OF JEJU-DO ISLAND & CHANGE DETECTION OF *ABIES KOREANA* STANDS AROUND THE PEAK OF MT. HALLA

Jung Hwa Chun, Jong Hwan Lim, and Young Kul Kim

Abstract—Landcover of Jeju-Do Island and *Abies koreana* stands around the peak of Mt. Halla were mapped using Landsat imagery and their spatial changes over time were analyzed. Results showed that Jeju-Do Island has been witnessing the fragmentation of forest area under the continuous pressure of urbanization and industrialization. Change of forest types was also detected due to the reforestation works from 1960s to 1970s. Temporal changes of NDVI values showed that *Abies koreana* stands around the peak of Mt. Halla have been declining over the last two or three decades. The results will provide support for the research on ecosystem structure and dynamics in the context of climate change, and conservation planning to sustain the values of Jeju-Do Island and Mt. Halla forest ecosystem.

The development of landcover map of Jeju-Do, vegetation map of Mt. Halla, and the spatial database in the vegetation monitoring project over the Jeju-Do Island was expected to enhance the understanding of disturbances and dynamics of forest ecosystems. The synergy between field survey and time-series satellite data was expected to improve satellite-based vegetation monitoring, offering more accurate spatial data on vegetation parameters such as the viability or mortality of a certain tree species. *Abies koreana* is one of the important endemic tree species with a limited distribution around the peaks of a few high mountains in Korea. Relatively small population sizes of remaining *Abies koreana* stands that are distributed in isolation increase the possibility that they may be threatened with extinction. The first objective of this remote sensing and GIS work was to detect the landcover change of Jeju-Do Island over time; the second objective was to identify the present *Abies koreana* stands remaining around the peak of Mt. Halla, to describe species composition and map the pattern of the vegetation communities across the study site for continued monitoring in the future, and to detect the change over time.

Materials and Methods

A 115-37 Landsat image provides full spatial coverage of the study site. Two Landsat images from 1975 (MSS) and 2002 (ETM+) were utilized for the detection of landcover change of Jeju-Do Island. Even if the image of 1975 had some noises and low radiometric resolution, we had no choice because the number of older satellite images available is very limited. A single Landsat 7 image of 21 March 2002 was selected to produce a vegetation map. Images available were limited because the site is located around the mountain peak (elevation 1950 m) and hence most of the images were not free of clouds or snow. To detect the change of viability and dieback area of *Abies koreana*, Landsat images from 14 April 1994 April 2003 Landsat 7 image were selected even though some parts of the images were not snow-free, because the image quality was relatively good and free of noise and most of all, two images belonged to the same phenological period of a year. All of the images were geometrically ortho-rectified to the Transverse Mercator coordinate system to less than 0.5 pixel RMS error, utilizing ground control points identifiable in the imagery. Radiometric calibration and subsequent transformation to at-satellite reflectance was performed by utilizing standard procedures of Markham and Barker (1986). Finally, two images for change detection were converted to NDVI grid data using the standard NDVI formula for TM data. The single image for vegetation classification was first fused together with Band 8 PAN layer to enhance the spatial resolution and converted to NDVI and PCA grid data to stack into a single 8-layer image file including original bands except for thermal layers. Due to an initial lack of field data, an unsupervised approach to image classification was employed in this work. In order to recognize the spectral characteristics of the diverse plant communities represented in the satellite imagery, an unsupervised training algorithm (isodata) was run on the 8-layer image to generate appropriate spectral clusters and corresponding signatures. Field surveys were conducted over the study period to gather data on forest condition and pre-clustered spectral classes. Compass and laser distance measuring devices were used together with real time differential GPS (HDOP < 1.5) to identify the location of a certain characteristic. Survey points and the site description data were constructed into spatial coverage and utilized for combining the isodata classes and supervised classification. NDVI grid data of 1994 and 2003 were compared for the change detection of *Abies koreana* stands. The NDVI comparison for whole area of *Abies koreana* stands was impossible because there was remaining unmelted snow partly on the ground. Consequently, the differences of

Division of Forest Ecology, Korea Forest Research Institute, Seoul, Korea; email-chunjh69@foa.go.kr

NDVI between two periods were compared only on the survey points where site status could be described.

Results and Discussion

Classification results were developed into maps showing nine categories of land cover in 1975 and 2002. The main category of quite a big change was the area of urban area. Jeju-Do Island was witnessing the fragmentation of forest area under the continuous pressure of urbanization and industrialization. Also, change of forest types was detected as a result of reforestation work from 1960s to 1970s. Classification results for *Abies koreana* forest were quite reliable according to the comparison with the known survey points. For the survey point where all the trees in the plot were standing completely dead, the surrounding pixels were classified into classes (grassland or bush) other than *Abies koreana* forest stand. Not much change was detected on the whole except for the area showing low NDVI values due to the remaining snow. But on the survey points in snow free area of *Abies koreana* stands, a statistically significant ($p<0.05$) difference between two images was detected. The results will provide support for the research on ecosystem structure and dynamics in the context of climate change, and conservation planning to sustain the biological and other values of Jeju-Do Island and Mt. Halla forest ecosystem.

Literature Cited

Lillesand, T.M., Kiefer, R.W. 2000. *Remote Sensing And Image Interpretation, 4th ed.* John Wiley and Sons, New York, NY,

Markham, B.L., Barker, J.L. 1986. Landsat MSS and TM Post-Calibration Dynamic Ranges, Exoatmospheric Reflectances and at Satellite Temperatures. EOSAT: Landsat Technical Notes, 1: 3-5.

REALITIES OF FOREST LANDSCAPE RESTORATION: THE CASE OF BAROBBOB WATERSHED, PHILIPPINES

Edwin A. Combalicer[1&2], Maricon R. Perez[3], Sangjun Im[1], Marilyn S. Combalicer[1&2], and Sujung Ahn[1]

Abstract—This paper describes the experience in the restoration of the Barobbob Watershed and the implementation of an integrated watershed management approach through community-based forest management. We assessed the land use and associated cover changes in the watershed, and determined the indicators of effectiveness of forest protection strategies based on stakeholders' perspectives. The decentralization of 868.79 ha of Barobbob Watershed including a 439-ha project managed by the Provincial Government of Nueva Vizcaya and Barobbob Watershed Occupants Association, Inc. (BWOA) led to the successful restoration of the forest through people's participation and community ownership approach.

The current land use as a result of enhanced participation between LGU and the community is far better compared to the previous land use because of the increase in productive farm favoring planting of trees. Positive effects of changes in land use were apparent such as decline in the incidence of grassland and bush fire, sustainable supply of quality or potable water in the Barobbob Watershed due to the maintenance of the remaining secondary forest by the association, and increased livelihood opportunities.

The results of interview conducted in determining the importance of the watershed as perceived by the people showed that socio-economic (39%) ranked first followed by biophysical (34%) and institutional framework (27%). This is due to the fact that the current good condition of the watershed largely depends on the management and concern of the residents for the area and its resources. The study found out the issuance of security of tenure and certificate of land ownership strengthened the motivation of the farmers to participate in the conservation program. The co-management arrangement in Barobbob Watershed proved appropriate with the help of the community in the management of its land, timber and water resources. The call for watershed forest restoration and protection is best displayed by enabling social mechanism, community's positive perceptions, and democratic and participatory governance.

Deforestation and forest degradation in the Philippines have altered many of the country's natural forest landscapes. Such a situation has been attributed primarily to the practice of shifting cultivation and conduct of logging whether legal or illegal. Lack of policy implementation worsens the situation. Efforts at restoring the forest landscapes in the country through reforestation have not been sustained and only a few were considered a success.

The landscapes of the Philippines are a mosaic of land uses and may include patches of residual forest and agricultural lands as well as degraded lands. It is rarely possible to reforest a whole area, especially if it is occupied by many farms and people with different customs, religions, and perceptions. In this circumstance, forest restoration might be geared up towards the primary needs of the stakeholders.

This paper aims to 1) showcase the experience in the restoration approach and implementation of an integrated watershed management through community-based forest management, 2) assess the land use and associated cover changes in the watershed, and 3) determine the indicators of effectiveness of forest protection strategies based on stakeholders perspectives particularly on Barobbob Watershed located in the province of Nueva Vizcaya. The case study illustrates that sustainability of watershed requires a management

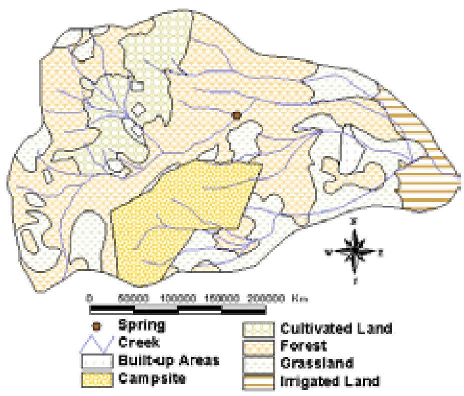


Figure 1. Previous forest landscape pattern (1992) of the Barrobob Watershed.

[1] College of Agriculture and Life Sciences, Seoul National University, Gwanak-gu, Seoul, Korea; email-eacombalicer@yahoo.com
[2] College of Forestry, Nueva Vizcaya State University, 3700 Bayombong, Nueva Vizcaya, Philippines
Isabela State University, Cabagan, Isabela, Philippines

support system. This involves interplay of critical elements such as favorable policy and political environment, enabling social mechanism, and capable and committed actors and players.

Description of the Barobbob Watershed

The Barobbob Watershed is one of the tributaries of the Magat Watershed. The Magat was declared as a forest-reservation area through Proclamation No. 573 on June 26, 1969 because of its great importance to human survival and environmental balance in the region. This watershed has a total area of 868.79 ha and divided into two sub-watersheds namely: Upper Barobbob Sub-watershed (501.28 ha) and Lower Barobbob Sub-watershed (367.46 ha).

The Upper Barobbob sub-watershed has most of the headwaters and numerous small springs that served as sources of potable water. The current 439-ha project is managed by the Provincial Government of Nueva Vizcaya through LGU-Environment and Natural Resources Office (LGU-ENRO) and Barobbob Watershed Occupants Association, Inc. (BWOA) located in the area. Similarly, the Barobbob spring is located at 435 m asl with an average daily discharge rate of 2,700,000 gallons that is more than enough to meet the average daily water demand of approximately 287,250 gallons of nearby areas. As stated in the Annual Report (2000) of the province, this water services is made available to 1,915 households in 19 barangays within the municipalities of Bayombong and Solano, Nueva Vizcaya.

Previous Forest Landscape Scenario—The spatial distribution of previous land uses of the Barobbob Watershed is given in Figure 1. The land uses included the following: 1) grassland (265.76 ha); 2) irrigated riceland (35.43 ha); and 3) secondary forest (567.60 ha). Among the identified land uses, secondary forest occupied the highest percentage, which is 65.33%, while irrigated riceland had the least with 4.08%.

Enabling Social Mechanism—The Upper Barobbob Watershed was declared a protected area in 1992 but squatting of families and settlers, degrading agricultural practices, and illegal logging remained unabated. Thus, the provincial government petitioned for the watershed to be devolved to the province and this was granted in 1992. Ejecting the people or relocating them to other areas did not work as it met some resistance (Agbayani and Tiongson 2003).

The provincial government conducted consultations, consensus building, community mapping, careful planning for the area, and organizational strengthening. The people eventually organized themselves into Barobbob Watershed Occupants Association (BWOA). The provincial government

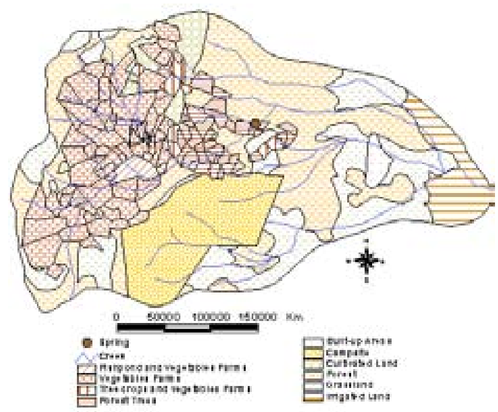


Figure 2. Current forest landscape pattern of the Barrobob Watershed.

entered into a Land Management Agreement with BWOA awarding a 25-year (renewable) tenure to individual members, thus motivating them to join in soil, water, and forest conservation efforts. The squatters have become land managers and the

Land use	Area (*ha*)	Percent of total area
Built-up areas/Residential land	12.40	1.42
Cultivated land	98.66	11.36
Grassland	192.50	22.16
Irrigated ricelands	45.35	5.22
Jamboree site	111.97	12.89
Secondary forest	407.91	46.95
Total	896.79	100.00

Table 1. Area distribution of the current forest landscapes of the Barobbob Watershed.

watershed is now a fire-free and poaching-free zone with improved potable and irrigation water, and more livelihood opportunities.

The Provincial ENRO of Nueva Vizcaya, through a composite management team, became responsible for the daily activities in the watershed. The team is composed of a forester, an agriculturist, a veterinarian, and a representative of the provincial cooperative affairs office to assist farmers with their business activities. The provincial planning and development office is responsible for monitoring the project. The Department of Environment and Natural Resources (DENR) provides resources and services to the provincial government to ensure effective protection, development, and management of the area while LGUs encourage and promote participation of the private sector and entrepreneurs. They also lead and provide assistance to communities, e.g., capability building and empowerment of people's organizations, linkage with institutions, and access to social services, technologies and funds for forest land development and generation of alternative livelihood opportunities. LGUs assistance to CBFM projects includes provision of financial and technical assistance, as well as infrastructure such as farm-to-market roads, water system and irrigation development. They endorse applications to CBFM Agreement between the proponent PO and DENR (GOLD Environment Program 2000, DENR-JICA 2001, Agbayani 2002, Elazegui and Combalicer 2004).

Through the adoption of a collaborative approach, the Barobbob Watershed management project gained nationwide recognition as watershed management model. This watershed received the Galing Pook award of excellence in 1999, being one of the ten outstanding CBFM programs in the country (Agbayani 2002).

Forest Landscape Change

Figure 2 shows the current watershed landscape several years after the awarding of the tenurial agreement to the community residents. The data show that secondary forest still accounts for the major land use (Table 1). Additions to the current land use include cultivated lands covering 98.66 ha (11.36%) either used for agriculture or for orchard/fruit tree plantation. Furthermore, 111.97 ha (12.89%) of the watershed have been set-aside as a Jamboree site. Built-up areas that include residential areas, account for approximately 12.40 ha (1.42%).

A total of 135 families are presently occupying the watershed and working for a livelihood depending on the availability of suitable land areas, forest resources, and its water system. The local communities inside the watershed cultivate the land for agroforestry purposes. Agricultural crops include eggplant, tomato, taro, beans, and rice, among others while tree species include *Gmelina arborea, Swietenia macrophylla*, and *Pterocarpus indicus.* Under the CBFM agreement, the people's organizations are entitled to harvest forest products subject to the approval of the DENR.

The extent of spatial changes and kinds of land uses within the watershed in a span of 10 years resulted to the increase of irrigated ricelands to 9.92 ha. Highly noticeable too is the decrease in the grassland areas and secondary forests to 73.26 ha and 159.69 ha, respectively. The total decrease in area (232.95 ha) for the two land uses is believed to have been comprised of the additional identified current land uses such as the Jamboree site (set aside by law as Boys Scout and Girls Scout camping site), built-up areas, and cultivated lands. Cultivation for agricultural production purposes is not prohibited provided that it is done in moderation and it is in valley areas of the watershed as well as appropriate soil and water conservation practices or measures are employed. The effect of increasing number of occupants coupled with the continuing development and maintenance of the provincial road passing inside the area have also led to the evident increase of built-up areas inside the watershed.

Community's Perception towards Forest Restoration

Based on the results of interviews with some occupants in the area there is an apparent decline in the incidence of grassland and bush fire. Due to the maintenance of its remaining secondary forest by the association, the yield and quality of water in the Barobbob Watershed particularly coming from its spring sources eventually became more sustainable.

An interview was conducted to determine the importance of watershed as perceived by the people. An arbitrary weight equivalent to 100% among the three (3) aspects of the study, namely, 1) biophysical, 2) socio-economic, and 3) institutional framework was allocated. Corresponding ranks for each of the weights given by the respondents were also summarized. Results of interview gave an average weight as follows: 1) biophysical (34%), 2) socio-economic (39%), and 3) institutional framework (27%).

Socio-economic aspect ranked first (39%) due to the fact that the current good condition of the watershed largely depends on the management and concern of the residents for the area and its resources. Such can also be explained by their reasons for planting trees as stated in their MOA, the uses and reasons for protecting the watershed, and the various observed soil and water conservation measures such as bench terracing, small impounding cum fishpond, riprap, and hedgerow planting, which are being applied by the people in their lots.

Biophysical aspect of the watershed ranked second with corresponding average weight of 34%. All respondents considered the importance of the watershed as the main source of potable water coming from the spring for uphill communities and irrigation and domestic purposes for the lowland communities in the municipalities of Bayombong and Solano. The amount of springwater collected, distributed and used largely for domestic and irrigation purposes depend on the residents' capability to protect, maintain, and enhance the productive capacity of springwater resources as well as proper choice of appropriate land uses.

The institutional framework ranked third (27%) which is attributed to the delay in the disbursements of funds allocated to the management and protection of the watershed, unsustainable implementation and monitoring of approved livelihood activities, and mismanagement of some livelihood options given to grantees such as goat-raising, tiger grass production, and fruit tree plantation establishment.

Moreover, interviews with the respondents and focal group discussion conducted among residents of Sitio Pawac revealed that the watershed is best used for domestic purposes followed by irrigation and as a means or source of livelihood. However, it is least perceived as for economic resource conservation purposes.

From the identified land uses, the respondents were further asked of the best land uses where barren or grassland areas can possibly be converted. The identified land uses were sorted as to its primary and secondary best land uses. For its primary land use, most respondents prefer the area to be converted to a tree plantation site. This is followed by agricultural area, forest area, agroforestry area, and protection forest area. Conversion of the area into a forest is their first preference in terms of possible secondary land use. This is followed by agroforestry area, tree plantation or reforestation area, fruit tree area, and agricultural area.

Common to both categories of land uses is their preference of converting bare and/or grassland areas to forest, tree plantation and agroforestry areas. This can give an idea of the respondents' outlook on the possible changes that may be present in the composition of the future landscape of the area.

A Lifeshed to Forest Restoration

The Barobbob Watershed restoration efforts in the province of Nueva Vizcaya mirror the extent of how watershed was addressed to hurdle the different constraints. Nueva Vizcaya is the watershed haven of Region 2 and Barobbob is a 'lifeshed' that provides land and water resources to the low-lying populace. It is being conserved with the premise of managing people first and protecting the people first (Agbayani and Tiongson 2003). When social and economic considerations are clear, participation will easily be harnessed. This was the pivotal factor for the technical, intellectual, social or institutional, and political capital invested in this watershed (Elazegui and Combalicer 2004). The catalyst of devolution efforts was the commitment of the local government unit of Nueva Vizcaya in attaining sustainable watershed management.

Political leadership has played a very vital role in restoring the forest landscape of the watershed. The resourcefulness and responsiveness of local government executives to social, economic, ecological concerns within the watershed paved the way to a range of solutions. LGUs have accorded high prioritization of watershed management in their budget and were able to build on opportunities such as those provided by the Local Government Code and other policy reforms in the forestry/ upland sector.

These undertakings hinged upon holistic approach to a number of considerations such as: enabling policy and other institutional support; forest resources security; forest protection, and socioeconomic and cultural well-being. These are manifested in the development of marginal areas into productive agroforestry farms, protection secondary forests from prevention of forest fires and regeneration of forests and improvement of stocks through enrichment planting.

Conclusions and Recommendations

Based on its biophysical and socio-economic characteristics, the watershed is considered both as important and critical watershed. At present, there exists the need for a holistic management of its natural resources in consonance with the sustainable economic growth and development of the area.

Nature of the resource base determined the type of cooperative management arrangement that was most effective in resource utilization, protection and conservation. The current instruments for co-management arrangement in Barobbob Watershed proved appropriate with the help of the community in the management of its land, timber and water resources.

The expansion of cultivated lands in the watershed was justified by the reasons that farmers grew at their backyards and farm lots a variety of tree and agricultural species basically to meet their direct household needs.

Legal tenurial and economic incentives implemented proved effective in motivating people to undertake sound, long-term forest management. Defining the best type of incentives depending on the need and motivation of local stakeholders was an effective tool to gain interest to the various protection strategies implemented in the watershed.

The call for watershed restoration and protection is best displayed by efforts towards maintaining the integrity of the watershed as a whole, specifically in the management of water for domestic purposes and land resource and its attributes to sustain services derived from the watershed.

The Barobbob Watershed experience generates a number of lessons. The management approach adopted in the province treats watershed as a 'lifeshed' where human concerns are connected with land and water resources. Managing people first, i.e., dealing with their interests in relation to the use of watershed resources, should be the premise in managing the watershed. An effective management support system is essential to ensure that the factors to facilitate watershed management are in place. The competence and motivation of the actors involved to protect watershed resources was very important. One critical role was that of LGUs. The political leadership must be capable of capitalizing on existing policies to augur well for their watershed management initiatives. The LGUs should also harness a participatory approach to managing watershed resources.

Literature Cited

Agbayani, R. Q. 2002. Role of LGUs in watershed management: The Nueva Vizcaya Experience. Paper presented in the 6th Multi-Sectoral Forum on Watershed Management: Unlocking the Keys to Sustainable Watershed Management, November 14-15, Banaue, Ifugao.

Agbayani, R. Q., Tiongson, V. A. 2003. Redeeming the environmental integrity of a watershed haven: Participatory NRM initiatives in Nueva Vizcaya. In *Sustaining Upland Development in Southeast Asia,* edited by R. Serrano and R. Aggangan. Los Baños, Laguna, Philippines.

AFNews. Supporting natural regeneration through management. Vol. IV No. 3. August 1998. http://www.asiaforestnetwork.org/pub/pub26.htm. [Date accessed: November 15, 2006].

Annual Report 2000. Provincial waterworks system report, Province of Nueva Vizcaya.

DENR-JICA. 2001. The master plan study for watershed management in Upper Magat and Cagayan River Basin in the Republic of the Philippines. Interim Report.

Elazegui, D., Combalicer, E. 2004. Realities of the watershed management approach: The Magat Watershed experience. PIDS Discussion Paper Series No. 2004-21. http://dirp4.pids.gov.ph/ris/dps/pidsdps0421.pdf. [Date accessed: November 15, 2006].

GOLD Environment Program. 2000. Final Report. In: Outstanding Socio-Technical Innovations.

ENVISIONING A GLOBAL LEARNING NETWORK OF FLR SITES

Jennifer Conje

Summary—The concept for a global learning network of Forest Landscape Restoration (FLR) sites originated at the FLR Implementation Workshop in 2005, organized by the Global Partnership on Forest Landscape Restoration (GPFLR). The goal of this research was to draw out the elements that would lead to an effective and useful global learning network of FLR sites; and, to inform the strategy for the development of such a network. Several interviews were conducted with key individuals actively involved in FLR from international NGOs, government agencies, universities, as well as land managers at specific sites. The interview questions were aimed at drawing out people's opinions and encouraging them to think of new and innovative ways of structuring a learning network.

There was a general consensus amongst those interviewed that a global learning network of FLR sites would be useful and timely. The network would fall into the category of "Knowledge for Action," which is defined by Brown Salafsky (2004) as a group "that facilitate(s) exchange of knowledge to help practitioners do their work more effectively." Many of those interviewed felt that real life case studies and networking were the best ways to learn. Furthermore, some voiced that there was an urgent need to demonstrate and further the FLR concept. There was sensitivity that some sites were selling themselves as FLR, but in reality were not true FLR sites in the sense that the notion of planning for ecological functions at the landscape scale was not undertaken from the beginning of the process. Others expressed that though there currently was momentum and enthusiasm behind the FLR concept; the concept was short on field demonstration and rigorous testing. A network of case study sites would allow for practical demonstration, especially if there was a research component added.

Though there was enthusiasm for a learning network of sites, the respondents also felt that the usefulness of the future network was dependent on the right mix of size and composition, strong monitoring and evaluation protocols, as well as a number of other critical factors that needed to be place in order for the network to demonstrate and provide concrete evidence that FLR actually works. Based on the range of feedback given, there appeared to be two main camps of opinion regarding the selection of sites. One camp emphasized that the "effectiveness of the network is dependent on the process." Thus, before sites are selected, it is important to have a set of hypothesis to be tested across a range of landscapes. This part of the process would be intricately connected to the aims of the network, as well as its ability to implement a strong monitoring and evaluation framework. The second camp felt that it was important that the learning network not be constrained by too strict criteria on the entry of sites because it would limit the ability to learn from different kinds of sites. For example, by limiting selection to strict FLR criteria, the network may be missing out on other lessons learned from other scales of restoration. Moreover, the concept of FLR is still in development and not a purely scientific approach, thus the philosophy of the network should not be about addressing one set of problems or proving a hypothesis, but instead to take advantage of opportunities to show how to increase forest cover and improve ecosystem functions in a degraded landscape. In other words, the focus should be on learning, not formulating a stylized model for FLR. There was a caution that sometimes the scientific community gets too confined by terminology and develops criteria that at times only works in research models, as well as adds constraints that lead to missed opportunities for learning. These two differing opinions reveal that there exists constant tension between scientific credibility in the process vs. allowing the flexibility for learning not constrained by too much criteria. Both elements are important and as such, need to be balanced in the development of a network.

When asked about the optimal size of the network, the majority of people citied between 10-20 sites. There was a general sentiment that the network needed to contain enough sites in order to identify commonalities and lessons learned. Several interviewees emphasized the need for long-term commitment (at least 5 yrs) by sites to show continuity and to have long-term data to be able to ground-truth with rigor. When asked what elements characterize a good FLR learning site, the following attributes were mentioned: landscape scale, not just one catchment; decent accessibility; the ability to test alternative methods/strategies; good variety/complexity of land uses; diverse landownership and wide range of stakeholders; sound feasible business plan and stable funding base; long-term commitment; clear vision; presence of strong champion(s); institutional innovation; adaptive management undertaken at site; good documentation and monitoring; rigorous/credible way of measuring progress; and, of course, willingness to share lessons learned.

International Programs, USDA Forest Service, Washington, DC. USA;jconje@fs.fed.us

The majority of respondents felt that there needed to be strong monitoring and evaluation protocols in place in order for the learning network to be useful to participants, as well as to the further the understanding of the FLR concept. It was voiced that it is important that the network "makes sense" or it will lose credibility and leave the sites open to unfair criticism. Thus, a "common framework of communication" is the key to the network's success and each site's ability to measure conscious progress and application of FLR principles. In other words, baseline datasets were needed for comparison to derive lessons learned and to do critical analysis. In addition, it was advised that there should be a combination of questions which are relevant enough to be tested across a range of landscapes and which can be used to connect lessons learned. On the flip side of the coin, in any voluntary network, the ability to have consistent M&E across sites is dependent on the good graces of participants, especially since any reporting associated with the network (whether it be a one-page questionnaire or a more complex M&E framework) will be an extra undertaking above their normal tasks. When a land manager was asked about his/her openness about filling an additional reporting requirement for the network, he responded by saying that it's "not a big deal if you can tease out the info quickly" (thus, receptiveness was dependent on the scale of detail and data availability). It was wisely noted by one respondent that any "criteria/targets must be used to empower, not constrain or leave them open to criticism or feel overburdened to the already daunting task they have in front of them." Other feedback on the M&E of the network included the following: will only work if people are flexible and open to the notion that there exist different ways to approach FLR; important to identify attributes of success at commencement of the network; the M&E framework should contain some quantitative indicators that are relevant to policy makers; the framework should focus on at least 3 key landscape level values (Biodiversity, Livelihoods, and Forest Goods and Service); simplicity seems to be essential for adoption by members; and last, but not least, any monitoring and reporting system must enable implementation on the ground. One interviewee emphasized the importance of having the learning site members, themselves, through consensus agree upon their modes of interaction and monitoring and evaluation framework.

Aside from the obvious factor that learning sites must have enough stimulation and innovation to be worth visiting, respondents were asked about issues they wished to learn from FLR learning sites. Listed below are some of the responses:

How is the site balancing human livelihoods and biodiversity conservation?
What drove the restoration? What were the underlying causes of degradation?
What determines success and the basis for it?
How did the participants at the site develop the FLR blueprint of their landscape before commencing?
How is the Integrated Approach being implemented within the FLR context?
What is the market based mechanisms for FLR restoration?
What is the policy environment enabling FLR at a particular site?
What is the nature of the landscape mosaic and opportunities?
What are the forms and types of reforestation occurring?
What is the nature of the decision making process?

The feedback showed a definite preference for face-to-face learning, as long as the field visits were relevant enough to participants' situation at their own sites. Many preferred that network meetings be hosted at specific learning sites, mainly because it would give participants the opportunity to interact with the local communities/land managers at the site. Regional/national scale workshops were considered more valuable than international workshops. The majority felt that web based toolkits and communication (i.e. virtual discussion postings) were utilized by mainly researchers and students, but not field practitioners. In addition, it was noted that some participants in the network who are located in more remote parts may not have easy, fast, or inexpensive access to the internet. One interviewee recommended the use of CD tools in lieu of the internet. It was also emphasized that any information provided on a website should be concise and brief. In addition to the modes of learning mentioned above, some respondents felt that there was benefit in organizing sites into communities based on one or more of the following criteria: geographic basis; language; technology capability; or similar biodiversity/conservation objectives. Regular assessment of sites could be organized around disciplines or themes, possibly through some sort of peer review process to ensure well-written cross-site comparisons and synthesis at different stage of progression.

Literature Cited

Brown, M., Salafsky, N. 2004. Learning about Learning Networks. Foundations of Success, Bethesda, MD. Available online at http://www.fosonline.org/images/documents/Learning_About_Networks_7_July_04.pdf

PRODUCTIVITY AND STABILITY OF THE ALL-AGED DARK CONIFEROUS FORESTS OF THE SIKHOTE-ALIN MOUNTAINS

V.N. Dyukarev

Introduction

Studying biological productivity and stability of forest communities is an important branch of modern biology. Work in this field forms the basis of theoretical generalizations in solving complex environmental issues and related issues. It also allows for testing methods of natural management and restoration. In many countries, the problem of potential productivity of various plant communities is an object of long-term observations, especially in relation to increasing importance of evaluating carbon balance on forest sites. The all-age forests formed by *Abies nephrolepis* Maxim. and *Picea ajanensis* Fisch., s.l. are of the most environmental forming value in the Sikhote-Alin Mountain landscapes. They occupy more than 30 % of forest \ territories of the region and dominate upper mountain belts (800-1200m alt). Climate in the investigation area is typically monsoon. The summer is wet and cool; winter is comparatively snowless and cold. Total annual precipitation in the lower belt of fir forests is 700-750 mm. The upper level of the precipitation distribution is 1200-1400 mm. Average air temperature in July is approximately 15º, and in January it is -20º, -25º. Soils are brown mountain-taiga, with low and average thickness, very rocky and long-frozen.

Materials and Methods

It has been found that in the green moss – fern type of dark coniferous forest under conditions typical of the South and southern part of the Middle Sikhote-Alin Mountains, the stand development cycle lasts approximately 120 years and consists of six stages, each of them 20 years duration (Dyukarev et al. 1971, Kozin 1970, Rozenberg et al. 1971). Aboveground biomass of the functioning part of the tree layer was evaluated on sample plots characteristic of all stages of stand development. Biomass fractions were determined by model trees, chosen in accordance with diameter classes. Stems and crowns were weighed separately. Correlation of bark and wood was calculated from weighed samples of tree stems. Dry branches were weighed separately. Mass of dead sprouts on living branches was calculated by correlation between living and dead parts of model branches. Weight of needles was evaluated from model branches, chosen by pairs from the middle of every fifth part of crown length. Leaf mass was calculated by correlation of their weight and weight of sprouts. Weight samples for evaluation of humidity were chosen from all biomass fractions with at least three subsamples. Adequacy of weight for various tree parts varies between 4% and 11%.

Results and Discussion

Stability of dark coniferous forests results from cyclic recurrence of stand age development. Stability is closely connected with productivity, involving such indices as value and rate of phytomass accumulation. In the course of stand development all the indices of forest biogeocoenosis are changed. Over the period of the most pronounced edificatory role of basic forest forming species and the most constant biogeocenotic characteristics, total phytomass is highest, the rate of its accumulation decelerates, the ratio between photosynthesizing and other fractions is relatively stable, and the general structure of the system corresponds to the rational balance of productivity and stability (Rozenberg and Dyukarev 1973).

With aging and the decline of the dominant generations of the basic forest forming species, a compensating mechanism is the rapid increment of younger generations in a portion of the photosynthesizing phytomass fraction, thus providing conditions for stability of the system during this period and serving as a basis of its biological resistance in future.

High intensity of all biogeocenotic (ecosystem) processes during this period is closely connected with features of formation of primary biological productivity in boreal forests and, first of all with the characteristic formation and structure of the leaf biomass. Thus, in the most widespread green-moss and green-moss-ferny types of dark-coniferous forests, needles account for over 20 % of the total aboveground biomass of a forest stand. The absolute amount of needles increases twice and by the end of this stage reaches its maximum - more than 10 ton ha^{-1} (dry weight). The age distribution of needle biomass is especially characteristic. During the maximal efficiency of system, in the middle of a stage when the pure increment of all aboveground biomass reaches 4.5-5.0 ton ha^{-1} yr^{-1}, and the common more than 10.0 ton ha^{-1} yr^{-1}, the share of 1-, 2- and 3-year-old needles is the highest in total needle biomass making up 80-90%. The 1-year-old needles account for 36-38 % (Dyukarev 2000, 2006, Soil formation 1993).

This age distribution of foliar biomass is the reason that despite the very high density of stems in this

Institute of Biology and Soil Science, Vladivostok, Russia; email-dyukarev@ibss.dvo.ru

period of stand development of forests and the very strong phytocoenotic interaction of plants, the biomass of needles reaches higher values than in the less dense but older forest stands where the share of young needles considerably decreases, at approximate total stock of the needles. The following stage is characterized by completion in reestablishment of the edificatory role of basic forest forming species; biological stability and all the characteristics of the biogeocoenosis stabilize and the system reverts to the most balanced state and maximal efficiency. In the recovery phases these processes are complicated by a longer period of the active accumulation of phytomass and total instability of the system; however, they keep the same direction of development.

Thus the high intensity of biomass increase of dark coniferous species in the initial (post-disintegration) stages of age development of forest stands is a condition for reviving the edificatory role of forest forming trees, the biological stability of the new main generation, with a basis providing for the further preservation of stability of forest ecosystems. The common duration of the period of stabilization of forest ecosystems in many respects depends on the possible speed of accumulation of organic substances; under homogeneous climatic conditions, this is determined by habitat potential.

An indicator of ecological stability of dark coniferous forests and ecosystems is the general slowing of all biogeocenotic processes, including biomass production. The steady parity of all fractions of various biomass layers in phytocoenosis (the share of leaves of the main canopy during this period makes up 3-5 % of the common aboveground biomass of forest stands). Homogeneous parameters of canopy structure - the areas of projections of tree crowns, their volume, and filling of crowns by organic substance - are established. The cycle of main stand generation age development comes to the climax.

Such course of alternation of generations of boreal forests and formations of their primary biological productivity provides certain stability at different stages of their age development. Thus, dark coniferous forests as ecological systems are in constant mobile balance, which determines the stability of their existence and an opportunity of constant performance of protectively-ecological functions (Dyukarev and Rozenberg 2000).

The all-aged dark coniferous forests and their cyclicity age succession result from long-lasting natural development. Now it is the steadiest form of boreal forest existence in the Sikhote-Alin Mountains. In conditions following clear cuttings and after fire succession, these processes are complicated by longer periods of active accumulation of biomass and general instability of the forest ecosystems. Knowledge of the dynamics of the productivity and stability ratio is a basis for working out forestry measures for the regulation of the process of forest biogeocenosis development (Sheyngauz et al. 2004).

Literature Cited

Dyukarev, V.N. 2006. Biological productivity of forest ecosystems and biomass map of dark coniferous and mixed forests of Primorskii krai. Proceeding of International Conference on Forest Ecosystems of Northeast Asia and its Dynamics. 22-26 August 2006, Vladivostok, Dalnauka. p. 45-47.

Dyukarev, V.N., Kozin, E.K., Rozenberg, V.A. 1971. Age development and biomass of green moss – fern – Picea ajanensis forests of Sikhote-Alin. *Bioproductivity of Spruce Forests*. Tartu, p.77-82.

Kozin, E.K. 1970. Age development of dark coniferous forest with *Abies nephrolepis* and *Picea ajanensis* in South and Middle Sikhote-Alin. Candidate thesis. Vladivostok. 37 pp.

Rozenberg, V.A., Dyukarev, V.N. 1973. Productivity dynamics of certain Abies-Picea forests and prospective of its study. Fifth meeting of delegates of All-Union Botanic Society. Kiev, p. 273-274.

Rozenberg, V.A., Kozin, E.K., Dyukarev, V.N. 1971. Classification, age development and production of virgin forest with *Picea ajanensis* s. l. and *Abies nephrolepis* Maxim. in the Sikhote-Alin. Twelfth Pacific Science Congress, abstract of papers, v. l, Canberra, Australia. p. 111.

Soil formation and peculiarities of biological cycle of matters in mountain forests of South Sikhote-Alin (by the example of Verkhneussuriiski Station).1993. Khabarovsk. 270 pp.

Dyukarev V.N. Rozenberg V.A./Classification, structural organization of dark coniferous forests in the Russian Far East/ Korean pine-broad leaved forests of the Far East: Proceeding from the International Conference, Portland, Oregon, 2000. p. 78-79

Sheyngauz A. S., Dyukarev V.N. & oth. Forest Fire Management in High Biodiversity Value Forests of the Amur-Sikhote-Alin Ecoregion/ Scientific-technical Basis of the Project. Khabarovsk. Dalnauka, 2004. 124 P.

USE OF PIONEER TREE SPECIES TO RESTORE HEAVY METAL-CONTAMINATED FOREST SOIL

Sim-Hee Han[1], Du-Hyun Kim[2] and Jae-Cheon Lee[2]

Abstract—To use pioneer tree species for restoration and revegetation of forest soil contaminated by heavy metals, we investigated phytoremediation ability of six tree species, *Salix pseudo-lasiogyne, S. koreensis, Chosenia bracteosa, S. purpurea var. japonica,* and *S. hulteni*, using *Populus × tomentoglandulosa* as a control. *Salix hulteni* showed highest Cd accumulation in the leaf (140mg kg^{-1}), stem (102mg kg^{-1}) and root (656mg kg^{-1}) in comparison with other tree species, and Zn accumulation was also highest in the leaf (1337mg kg^{-1}), stem (667mg kg^{-1}) and root (1977mg kg^{-1}) when compared to other tree species. Transpiration rates of S. hulteni were 2.5 mmol H2O $m^{-2}s^{-1}$ and 1.5 mmol H_2O $m^{-2}s^{-1}$ under Cd and Zn treatment, which was higher when compared to that of other species. In addition, thiol content in the leaves of S. hulteni increased up to 69.2% and 50.6% of control under Cd and Zn treatment, respectively. In conclusion, high Cd and Zn accumulation of *S. hulteni* might be associated with the higher transpiration rate and thiol content in the leaves, and *S. hulten*i was considered as a feasible material for restoration and revegetation of abandoned mine land.

Soil pollution by heavy metals has become a critical environmental concern due to its potentially adverse ecological effects. Heavy metals occur naturally at low concentration in soils. However, they are considered soil contaminants due to their widespread occurrence, acute and chronic toxicity. Ecological restoration and mine reclamation have become important parts of the sustainable development strategy of many countries. A good vegetation cover is beneficial in the restoration of contaminated land and results in enhanced amenity values as well as prevention of surface soil erosion (Baker *et al*. 1994). Therefore, successful reclamation of mine spoils may be enhanced through revegetating with pioneer species that are tolerant to poor mine spoil conditions (Voeller et al. 1998).

Recently many researchers have tried to find suitable materials and technology for remediation of metal-contaminated soils. As a result, a number of plants that have an ability to accumulate specific heavy metals have been identified, and the biochemical mechanisms for accumulation and defense against heavy metals have been investigated (Tong et al. 2004). The potential use of trees as a suitable vegetation cover for heavy-metal-contaminated land has received increasing attention over the last 10 years. Trees have been suggested as a low-cost, sustainable and ecologically sound solution to the remediation of heavy-metal-contaminated land (Dickinson 2000). Accordingly, we investigated phytoremediation ability of six tree species to select feasible materials for restoration and revegetation of forest soil contaminated by heavy metals,

Materials and Methods

Plant Materials and Treatments—*Salix pseudo-lasiogyne* (Spl), *S. koreensis* (Sk), *Chosenia bracteosa* (Cb), *S. purpurea var. japonica* (Spj) and *S. hulten*i (Sh), and *Populus × tomentoglandulosa* (Pt) as a control were used to evaluate phytoremediation ability. Cuttings were planted in containers with vermiculite in early spring 2006. At seven weeks after planting, 15 cuttings (five replicates each for three treatments) of the same height were transplanted to individual plastic pots. Cuttings were given 200 mL of 1mM $CdSO_4$ solution and 4mM $ZnSO_4$ solution for 4 months.

Measurements and Analyses—At the end of treatment, transpiration rates were measured with a portable photosynthesis system (Li-6400, Li-COR Biosciences, Inc., Lincoln, NE, USA). Three fully expanded stem-attached leaves per plant were measured at light saturation (1200 μmol m^{-2} s^{-1}). The CO_2 concentration during measurements was maintained between 340 and 360 μmol CO_2 mol^{-1} air, leaf temperature was 24.0 ± 0.2°C and RH was 60 ± 5%. Data from two replicate measurements were averaged for each plant. Leaves of the freshly harvested plants were used for the determination of total thiol content. Fresh leaves (0.1 g) were homogenized in 1.5 mL cold buffer containing 5% (w/v) 5-sulfosalicylic acid and 6.3 mM DTPA. The homogenized samples were centrifuged (15,000xg, 10 min) and 250 μL of extract was mixed with 50 μL of Ellman's reagent (5,5'-dithiobis-2-nitrobenzoic acid) in 2.5 mL of 0.1 M sodium phosphate buffer (pH 8) containing 1 mM EDTA. Then, the mixtures

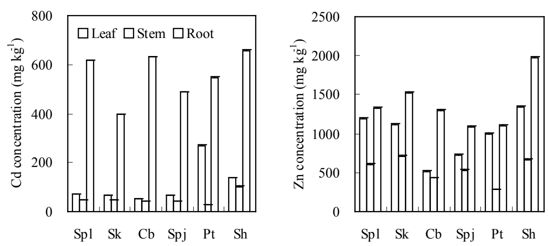


Figure 1—Average Cd and Zn concentration in leaves, stems and roots of six tree species treated with 1mM $CdSO_4$ and 4mM $ZnSO_4$ solution. Each bar represents mean ± s.d. of five replicates.

[1] Forest Seed Research Center, Korea Forest Research Institute, Chungju 380-941, Republic of Korea; email-simhec02@foa.go.kr
[2] Dept. Forest Genetic Resources, Korea Forest Research Institute, Suwon 441-350, Republic of Korea

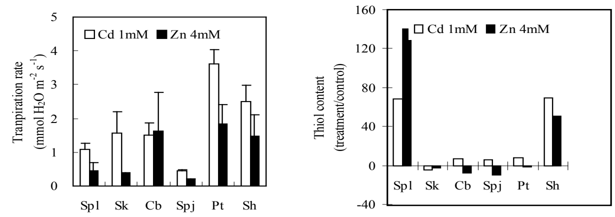


Figure 2—Transpiration rates and thiol content in the leaves of six tree species treated with 1mM $CdSO_4$ and 4mM $ZnSO_4$ solution. Each bar represents mean ± s.d. of five replicates.

were incubated at room temperature for 15 minutes. The absorption was recorded at 412 nm against a blank sample.

At harvest, leaves, stems and roots were carefully removed, and then thoroughly rinsed with distilled water twice. After oven drying the tissues at 70°C to constant weight, the dry-weight yields of leaves, stems and roots were recorded. Dried leaves, stems and roots (0.5 g each) were ground and used to determine Cd and Zn concentration. Nitric acid (70%, 15 mL) and hydrogen peroxide (30%, 5 mL) were added to 0.5 g of dried, ground plant sample in a digestion vessel. Samples were digested using the microwave digestion system, cooled after addition of distilled water, and filtered prior to analysis. Cd and Zn content in the digested tissue were measured by atomic absorption spectrophotometer (AA-6701F, Shimadzu, Tokyo, Japan).

Results and Discussion

Metal concentrations in plants vary with plant species (Alloway et al. 1990). Plant uptake of heavy metals from soil occurs either passively with the mass flow of water into the roots, or through active transport crosses the plasma membrane of root epidermal cells. Cd concentrations in plants ranged from 28 mg kg^{-1} to as high as 656 mg kg^{-1}, with the maximum being in the roots of *S. hulteni*. In addition, the roots of *S. pseudo-lasiogyne S. koreensis, C. bracteosa, S. purpurea var. japonica* and *P. × tomentoglandulosa* also contained significant amounts of Cd (397-616 mg kg^{-1}). In most plant samples, the root Cd concentrations were much greater than those of the shoot Cd contents, indicating low mobility of Cd from roots to the shoots and immobilization of heavy metals in roots. Zinc concentrations in the plants varied from 285 to 1977 mg kg^{-1}. Like Cd, the maximum value was found in the roots of *S. hulteni*. In addition to *S. pseudo-lasiogyne, S. koreensis, C. bracteosa, S. purpurea var. japonica* and *P. × tomentoglandulosa* also contained significant amounts of Zn (1079-1517 mg kg^{-1}). Meanwhile, *S. pseudo-lasiogyne, S. koreensis, P. ×tomentoglandulosa, S. hulteni* had high Zn concentrations in both the leaves (1001-1337 mg kg^{-1}) and roots (1104-1977 mg kg^{-1}). Similar to Cd, Zn concentrations were greater in the roots than the shoots.

Transpiration rates under Cd and Zn treatment showed significant differences among six tree species. Among six species, transpiration rates of *S. hulteni* were 2.5 mmol H_2O $m^{-2}s^{-1}$ and 1.5 mmol H_2O $m^{-2}s^{-1}$ under Cd and Zn treatment, respectively, which was a higher level when compared to that of other species. The transpiration of plants mainly triggers the uptake of soil water by roots. Grifferty and Barrington (2000) reported that under high transpiration condition soil solution Zn was promoted to move into roots and upward to stems and leaves of plant via transpiration stream of water. The present study shows prominent correlation between transpiration and uptake of heavy metal.

In addition, thiol contents in the leaves of six species under Cd and Zn treatment showed significant differences among six tree species. Especially, thiol content in the leaves of *S. hulteni* increased up to 69.2% and 50.6% of control under Cd and Zn treatment, respectively. Metal detoxification and tolerance of plants can be achieved by numerous mechanisms such as chelation by metal-binding compounds, metal deposition in vacuoles, and alterations of metabolites. Phytochelatines (PCs), a class of small thiol (SH)-rich peptides, comprise one of the mechanisms involved in the chelation of heavy metals. It has also been suggested that increased Cd tolerance is associated with higher concentrations of PCs and accumulation of high molecular weight PCs (Rauser 1999). In conclusion, high Cd and Zn accumulation of S. hulteni might be associated with the higher transpiration rate and thiol content in the leaves, and *S. hulteni* was considered as a feasible material for restoration and revegetation of the abandoned mine land.

Literature Cited

Alloway, B.J., Jackson, A.P., Morgan, H. 1990. The accumulation of cadmium by vegetables grown on soils contaminated from a variety of sources. *Science of the Total Environment* 91: 223-236.

Baker, A.J.M., McGrath, S.P., Sidoli, C.M.D., Reeves, R.D. 1994. The possibility of *in situ* heavy metal decontamination of polluted soils using crops of metal-accumulating plants. *Resource Conservation Recycling* 11: 41-49.

Dickinson, N.M. 2000. Strategies for sustainable woodland on contaminated soils. *Chemosphere* 41: 259-263.

Grifferty, A.. Barrington, S. 2000. Zinc uptake by young wheat plants under two transpiration regimes. *J. Environmental Quality* 29: 443-446.

Rauser, W.E. 1999. Structure and function of metal chelators produced by plants: the case for organic acids, amino acids, phytin and metallothioneins. *Cell Biochemistry Biophysics* 32: 19-48.

Tong, Y.P., Kneer, R., Zhu, Y.G. 2004. Vacuolar compartmentalization: a second-generation approach to engineering plants for phytoremediation. *Trends in Plant Science* 9: 7-9.

Voeller, P.J., Zamora, B.A., Harsh, J. 1998. Growth response of native shrubs to acid mine spoil and to proposed soil amendments. *Plant and Soil* 198: 209-217.

REMOTE ASSESSMENT OF NORILSK POLLUTION IMPACT ON SUBARCTIC LANDSCAPES

S.T. Im, V.I. Kharuk , E.V. Fedotova

Abstract—The emissions of the Norilsk mining industrial complex (69°N, 88°E) have a dramatic impact on the forest-tundra landscapes in the Siberian North. The damage is caused mainly by SO_2 (the annual output is about 2 millions tons). Satellite data (NOAA/AVVHR, Terra/MODIS, and Landsat) were analyzed for detection and classification of the damaged forested territories. Sketch maps of lichen vigor, needle sulfur content, and forest vigor were used as the reference data. Also on-ground observations of temporary and permanent test plots were included in the analysis. The satellite-derived maps of vegetation vigor and industrial dust load were generated for the landscapes within the industrial impacted and adjacent territories. The relationship between SO_2 and heavy metal, from one side, and vegetation vigor, from the other side, were obtained. Three-dimensional (3D) analysis was used to relate level of impact with landscape features (elevation, azimuth, and slope steepness). It was shown that at least three categories of vegetation vigor could be detected: heavy damage, moderate damage, slight and non-damaged territories. Forest mortality at 120 km and forest damage at distances up to 200 km from the smelters was observed. The total affected forested area was estimated as 3 millions ha. The Norilsk phenomenon is one of the greatest human-caused impacts on the northern landscape.

V. N. Sukachev Institute of Forest, Academgorodok, 660036, Russia, Krasnoyarsk; e-mail-stim@ksc.krasn.ru

VARIATION OF SUSPENDED SOLID CONCENTRATION AND EC OF STREAM WATER DURING THE STORM EVENT IN THE REGROWTH AND REHABILITATION FORESTED CATCHMENTS, SOUTH KOREA

Jaehong Jun, Kyongha Kim, Jaeyun Yoo, Hyung Tae Choi and Yongho Jeong

Abstract—This study was conducted to investigate how the qualities of stream water vary during a storm event in the regrowth and rehabilitation catchments in Yangju, Gyeonggido, from June to September 2005. The suspended solid concentration during the event increased concurrently with the stream flow. The peak of suspended solid concentration usually precedes the peak flow. A clockwise hysteresis loop for the relationship between discharge and suspended solid concentration exists for event 2. The maximum value of EC in each event showed in the early stage of rising limb. EC decreased during the rising limb, showed a minimum value at peak flow, and gradually increased to pre-event levels. The suspended solid concentration and the EC during each event were higher in the regrowth catchment than in the rehabilitation catchment. These results indicate that a forest soil disturbed during clearcutting at the regrowth catchment was still unstable.

Methods

The experimental catchments are located at Gyeonggido near the Seoul metropolitan area and have been established since erosion control work in 1974. After the erosion control work was completed, a rehabilitation forested catchment was established, which consists of a mixed forest ranging from 20 to 30 years of age. A regrowth forested catchment was identified, which consists of coppice regrowth since a clearcutting in 1996. The water sampling system was triggered when rainfall exceeded about 3 mm in 15 min and 24 samples were collected every 2-hr. A known volume of water (100 ml) was vacuum filtered through a CF/C(0.45 μm membrane) filter and residues were oven dried at 105°C for 2 hours. Suspended solids concentration for each sample was determined by weighting the individual sample. Electrical Conductivity (EC) of stream water was also measured.

Results

We sampled two storm events during the observation period. The precipitation and 10-day antecedent precipitation index of event 1 were 41.0 mm and 140.0 mm, while those of event 2 were 96.0 mm

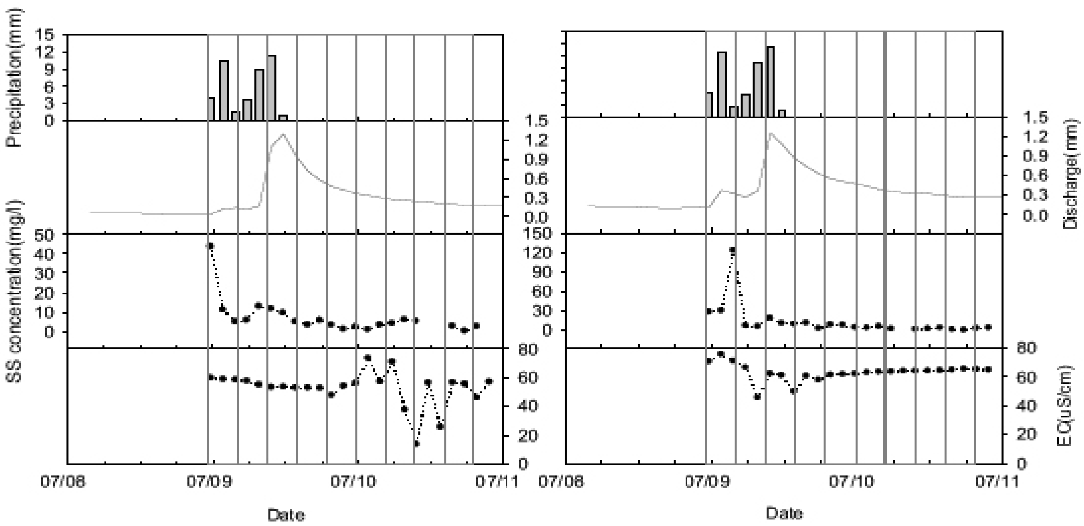


Figure 1. Observed precipitation, discharge, SS concentration and EC of event 1 in the rehabilitation(left) and regrowth(right) catchments.

Korea Forest Research Institute; Seoul, Korea; email-junejh@naver.com

and 32.5 mm. Figures 1 and 2 show the observed precipitation, discharge, suspended solids (SS) concentration, and EC in the rehabilitation and regrowth catchments during events 1 and 2.

Electronic Conductivity—In all storm events, EC of stream water showed maximum values before discharge started to increase. EC rapidly decreased during the rising limb, reaching minima at peak discharge, and then gradually returning toward pre-storm values.

Suspended Solid Concentration—Figures 3 and 4 show the relationship between discharge and SS concentration in the rehabilitation and regrowth during event 1 and 2. A clockwise hysteresis loop exists in the relationship between discharge and SS concentration. However, for event 1 in the regrowth catchment, the hysteresis trend was observed to be anticlockwise at the beginning of the event. SS concentration rose quickly and the maximum value of SS concentration of each storm emerged on the rising limb. The magnitude of the hysteresis loop is in proportion to rainfall intensity and amount. The maximum values of suspended solid concentration during each event were 2.8 to 4.3 times higher at the regrowth catchment than at the rehabilitation catchment. And the EC was also higher at the regrowth catchment than at the rehabilitation catchment. These results indicate that a forest soil disturbed during clear cutting at the regrowth catchment is still unstable.

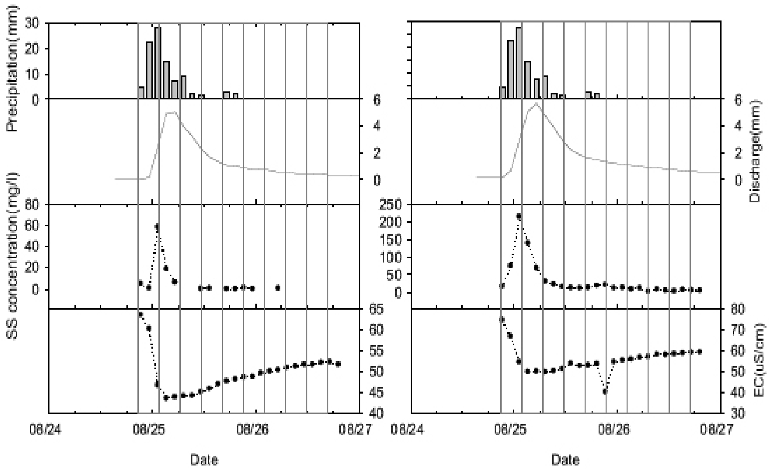


Figure 2. Observed precipitation, discharge, SS concentration and EC of event 2 in the rehabilitation(left) and regrowth(right) catchments.

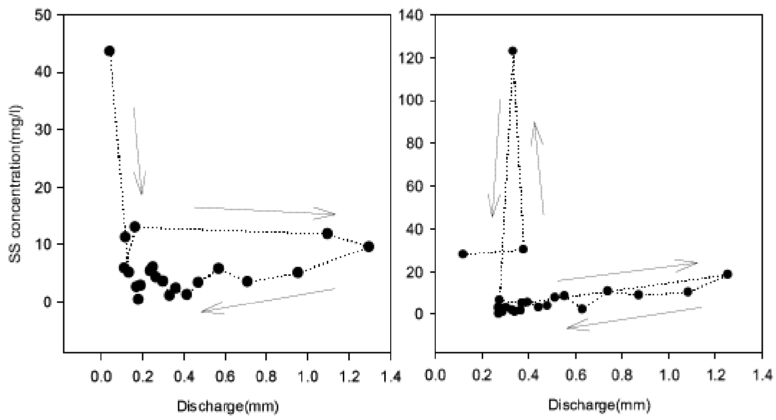


Figure 3. Relationship between discharge and SS concentration of event 1 in the rehabilitation(left) and regrowth(right) catchments.

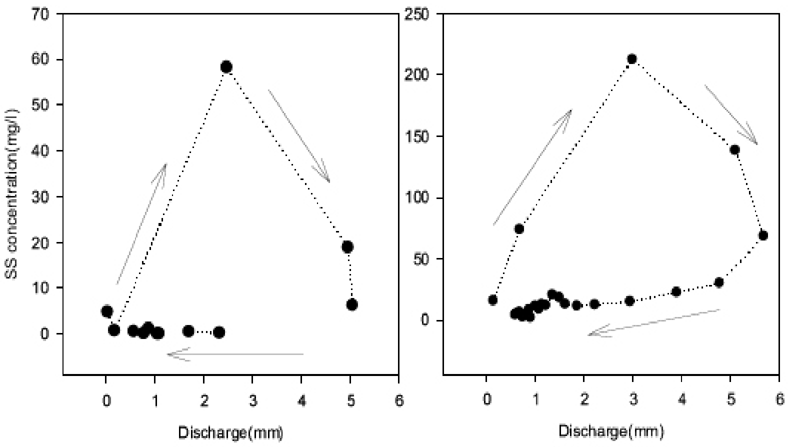


Figure 4. Relationship between discharge and SS concentration of event 1 in the rehabilitation(left) and regrowth(right) catchments.

RESTORATION OF GILAN FOREST BY USING LANDSCAPE ECOLOGY APPROACH CASE STUDY: (SHAFAROD WATERSHED)

N. Khazaei and F. Azari- Dehkordi

Abstract—The goal of restoration is to decrease human impacts on ecosystems, and let them to recover. There are several reasons that forest habitat quality is reduced, and fragmentation is one of the main concerns for forest landscapes. We consider forest restoration to restore connections between forest patches via several corridors in the landscape. The study area we considered was the Shafarod Watershed located in the Gilan Province of Iran. The watershed covers 39,800 ha; about 36,000 ha of the study area is forested and the rest is a rural area. The objective of this research was to introduce a new method for ecological restoration of forests by using ecological landscape elements. Corridors are recognized as linear elements of landscape, which can connect patches. Thus, we classify patches as natural or man-made patches. Each patch on the Shafarod landscape was classified in terms of nearness to a river or distance from a road, and natural patches. Therefore, each patch had three codes. That gave the best possibility for forest restoration using corridor patches. Then we classified stepping-stones according to their size (Patches with greater than 1 ha are suitable for stepping-stone patches). In Shafarod Watershed of the 683 patches with a total area of 36,200 ha, 56 patches with 200 ha for restoration were recognized and the total area that these patches need to create corridors for restoration is about 62 ha.

Department of Environmental Planning, University of Tehran Iran; emai-noushinkhazaei@yahoo.com

HYDROGRAPH SEPARATION USING GEOCHEMICAL TRACER BY THREE-COMPONENT MIXING MODEL FOR THE CONIFEROUS FORESTED CATCHMENT IN GWANGNEUNG GYEONGGIDO, REPUBLIC OF KOREA

Kyongha Kim, Jae-Yun Yoo, Jae-Hong Jun, Hyung Tae Choi and Yong-Ho Jeong

Abstract—This study was conducted to separate stream water by two and three components models for the coniferous forested catchment Gwangneung Gyeonggido near Seoul, Korea (N 37°45′, E 127°09′). This catchment was covered by *Pinus korainensis* and *Abies holophylla* planted at stocking rate of 3,000 trees ha^{-1} in 1976. Thinning and pruning were carried out twice, in the spring of 1996 and 2004 respectively. We monitored eight successive events during the period from June 15 to September 15, 2005. Throughfall, soil water, and groundwater were sampled by bulk sampler after each event. Stream water was sampled every 2-hr using an ISCO automatic sampler for 48 hours. The geochemical tracers among five cations were determined by the result of principal components analysis.

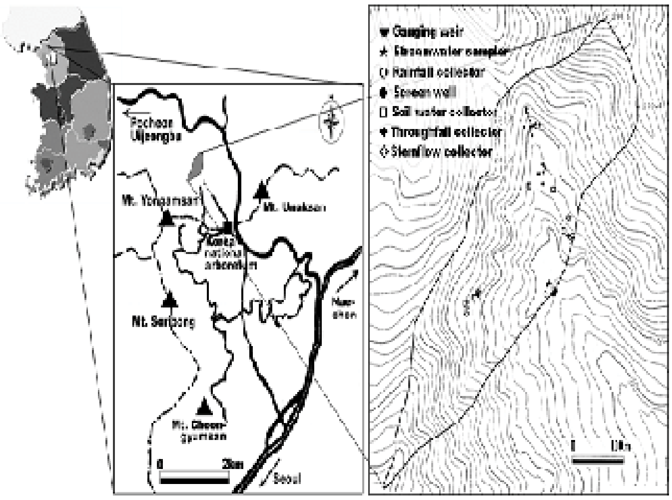


Figure 1. Location of the study catchment.

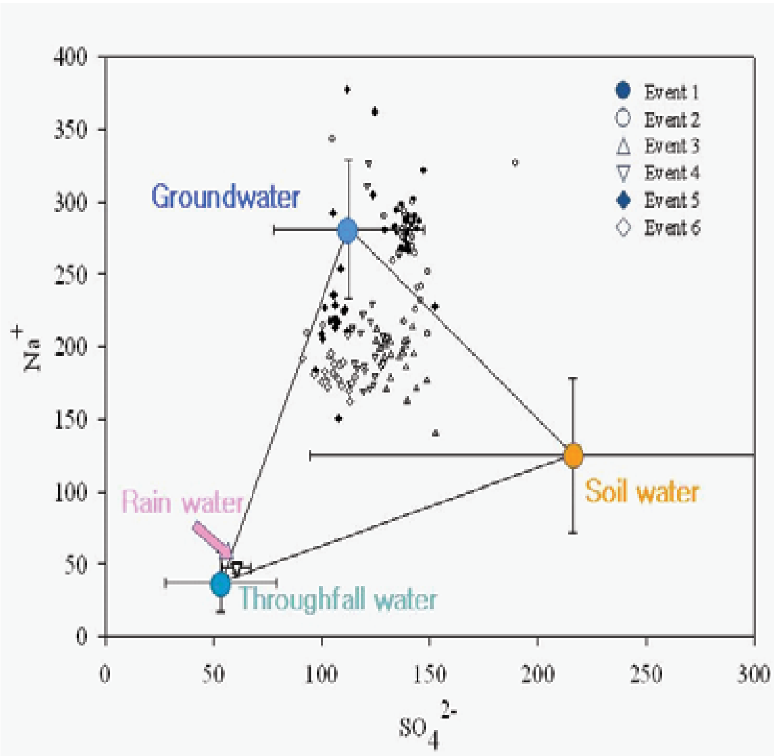


Figure 2. Concentrationsof tracers for stream flow and end member.

Figure 2 shows the concentrations of SO_4^{2-} and Na^+ for stream water and the end members during the six events. The concentrations for stream water are almost distributed within the triangle diagram of the end members including throughfall, soil water and groundwater except events 1 and 2. Sulfate (SO_4^{2-}) and sodium (Na^+) were suitable as natural tracers as shown in the figure. Average contributions of throughfall, soil water, and groundwater to producing stream flow for the six events were 17%, 25% and 58% respectively. The antecedent precipitation index (API) plays an important role in determining which end member prevails during events. There was a big difference of API between the events 2 and 3 in Table 1. We found that event 2 with lower API produced more ground water compared with the event 3, with higher API. On the other hand, throughfall in event 3 contributed much more toward than event 2. That may be caused by saturation and overland flow production in areas where soil water

Department of Forest Environment, Korea Forest Research Institute, Seoul 130-712, Korea; email-kkyha@foa.go.kr

content is near saturation. In the event 2, much rainfall that had infiltrated and was stored in soil resulted in a runoff ratio less than 10%, while event 3 showed a higher runoff ratio, 53%.

Figure 3 shows the results of hydrograph separation using a three-component mixing model for events 2 and 3. The early stages of the event 2 produced only groundwater but event 3 produced throughfall and soil water. As a result, API controls the runoff producing mechanism whether surface or subsurface flow prevails.

Components		Event 2	Event 3
Observed period		June 26~28, 2005	July 1~2, 2005
Precipitation(mm)		147.2	105.6
Maximum rainfall Intensity (mm/10min)		11.1	17.7
Antecedent Precipitation Index, API_5(mm)		0.0	161.9
Peak flow(mm/10min)		0.16	1.28
Total runoff(mm)		14.9	51.0
End member contribution (mm/%)	Throughfall	0.2/1.4	9.4/18.4
	Soil water	3.4/22.8	19.2/37.6
	Ground water	11.3/75.8	22.4/44.0

Table 1. Rainfall characteristics and end member contribution to events 2 and 3.

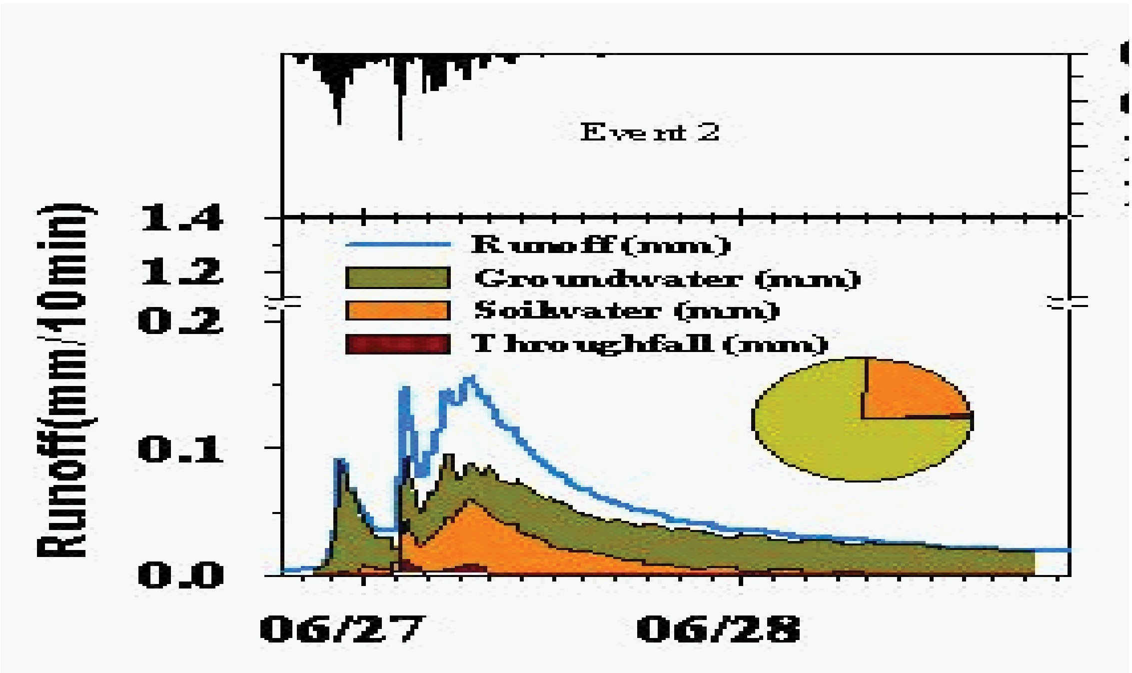


Figure 3. The results of hydrograph separation for events 2 and 3 by a three-component mixing model.

PRACTICE MODEL DEVELOPMENT CONSIDERING SCENIC CHARACTERISTICS OF URBAN FOREST BY UTILIZATION TYPE

Suk-kuwon Kim, Kwangsoo Lee, Youngsoo Kim, Sangwon Bae, Youngje Kang,
Hyeon-sup Kim, Munho Jung

Abstract—Although there are some secondary natural forests, most forests around metropolitan areas are comprised of tree species for afforestation and erosion control that were planted in the 1970s. Nowadays urban forests are broadly used as space for recreation and other uses. Because they are comprised of various types, reasonable management considering scenic characteristics is very difficult. Although new techniques are applied to urban forests to maintain scenic characteristics, it is difficult to judge the success of these new techniques. To establish good practice techniques, it is important to develop techniques consistent with ecological principles through understanding stand structure, growth state, scenic characteristics, and site types of urban forest. This study was conducted to supply basic data for urban forest management for the sustainable conservation and utilization of urban forest by analyzing tree growth, characteristics, and utilization types of artificial and natural stands. The results are as follows. Factors such as forest type, altitude, slope gradient, direction, drainage pattern, road network etc. were compiled in a database using digital topographic maps and forest type maps. Artificial stands showed rapid decline of vigor, and many gaps occurred in secondary stands. Practices to maintain soil fertility and forest stand vigor are needed.

For developing a practice model, eight stand types were categorized including scattered trees, sparse trees, stable, dense, gap occurring, proper density, and natural regeneration were classified. According to core scenic factor analysis, eight scenic types such as footpath, daily life utilization, scene, landmark, prospect, birds-eye view, background, and valley type were classified. User request types were classified as nature experience, nature study and space utilization type. The preference analysis showed that the most preferred type was natural regeneration, second was closed type, and the least preferred was the gap occurring type. For the management of urban forests, stand type, site, utilization type, space utilization, vegetation, scene and forest type should be considered.

Korea Forest Research Seoul,Korea; email-ksk5409@foa.go.kr

AN EXPERIMENTAL STUDY USING SOIL SEED BANK FOR ECOLOGICAL RESTORATION IN A CONSTRUCTED AREA

Jeung Hyun Koh[1] and Yukihiro Morimoto[2]

Abstract—The main objectives of this comparative study were 1) to compare the floristic similarity of species composition between the extant vegetation and seedlings from soil seed bank and 2) to quantify the potential contribution of soil seed bank to ecological restoration of forest in a constructed area, in which ecological impact mitigation was called for in conjunction with a power plant extension. Forest topsoil of seven plots was collected from the surface soil after measurements were taken on the ground vegetation in each plot. A greenhouse experiment was conducted and monitored to analyze the germination potential of soil seed bank. The forest topsoil was spread on plastic trays (0.7 m^2 x 7) filled with a 5-cm-layer of sterilized potting mix. Also, comparative experiments using forest topsoil and commercially obtained seeds on a cut slope were conducted to evaluate the effects of soil seed bank on revegetation including species diversity. A geo-textile method was constructed to reinforce the lower layer of slopes and revegetation methods including soil seed bank and commercial seeds were carried out on the upper layer by machinery. The total size of quadrats was 320 m^2 (20 m^2 x 16). The results of monitoring for 2-yrs in a greenhouse were as follows: 1) seedlings of soil seed bank per 4.9 m^2 were 1,269 with 36 species (1st year) and 2,615 with 25 species (2nd year). 2) 38±8% of the flora species were germinated from soil seed bank. The results of monitoring for 5-yrs on the cut slope were as follows; 1) 34 species of seedlings were present and 15 species were recorded both in the extant vegetation and the soil seed bank, floristic similarity of species composition between them was 41%, moreover, seven tree species from adjacent places were present. 2) Species richness of soil seed bank was 3.4~7.8 times more than those of commercial seeds. 3) Number of seedlings was 4.3~36.1 per 1 m^2 in soil seed bank plots. 4) Indices of biomass 5-yrs after construction in the soil seed bank were similar or superior to those of conventional methods by commercially obtained seed stocks. It can be concluded that the use of soil seed banks would be effective to promote establishment of diverse landscape and vegetation.

Figure 1. 1-yr after spreading soil seed bank in a greenhouse.

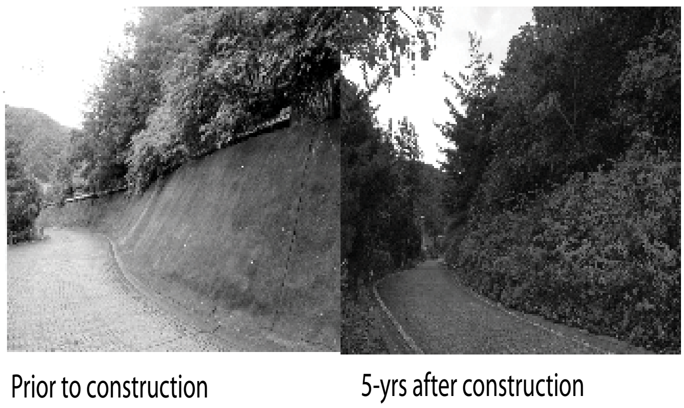


Figure 2. Change in the landscape on the cut slope.

[1] Korea Institute of Construction Technology, Goyang-Si, Gyeonggi-Do, Korea; email-koh1031@hanmail.net
[2] Kyoto University, Kyoto, Japan

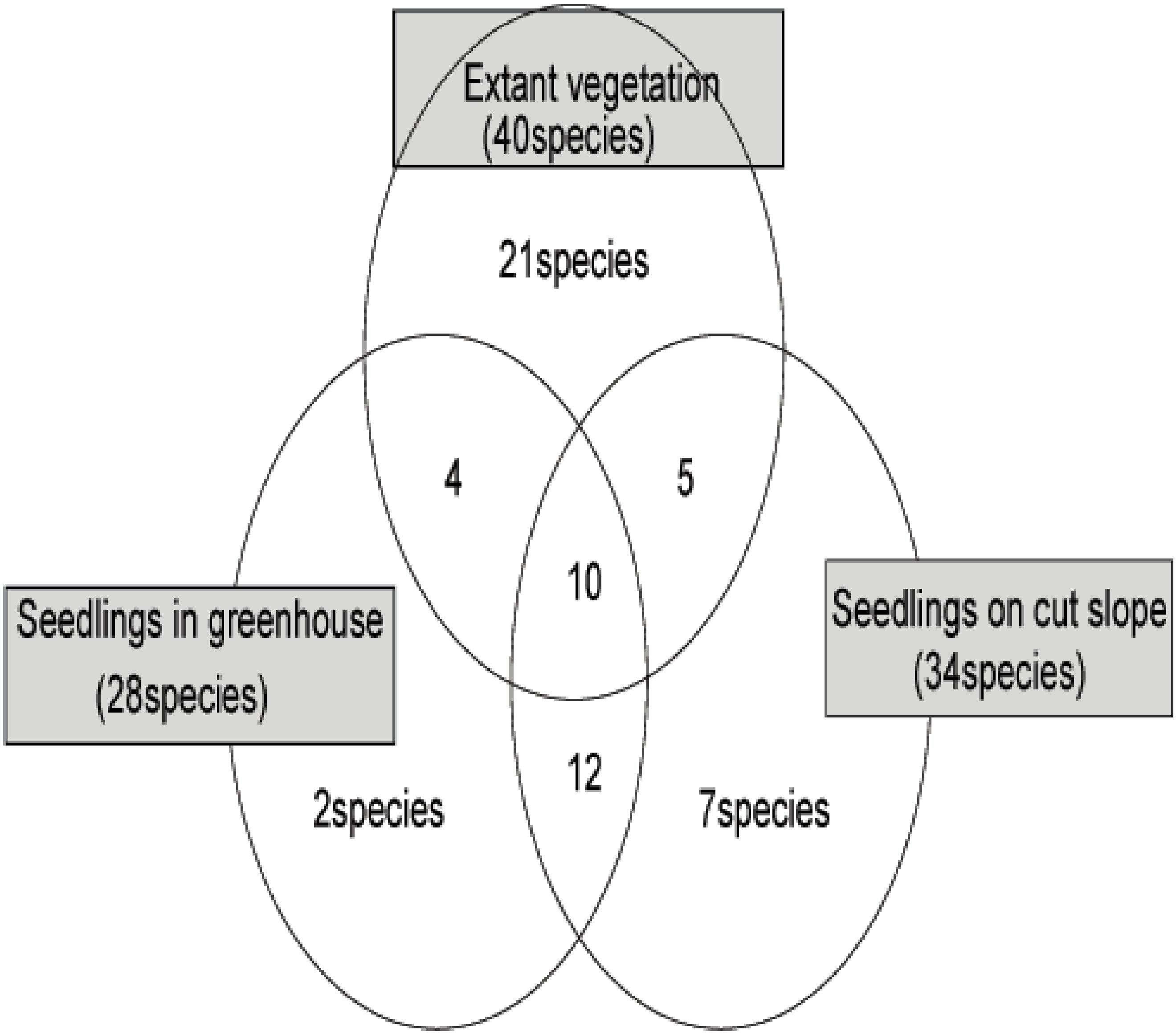


Figure 3. Correlation of species composition of vegetation and soil seed bank.

NATURE RESTORATION AREAS IN ESTONIAN FORESTS: MONITORING OF DYNAMICS

Diana Laarmann & Henn Korjus

Summary—Almost all Estonian forests have been influenced by human activities. There are too few natural forests of high quality even with the large wooded areas in Estonia. Furthermore, forests do not assure enough habitats for species depending on old-growth forests. Managed forests can grow fast for many years without expanding its natural properties. Management activities should be avoided in many cases for supporting natural development of a forest. The time period for altering a managed forest into a natural forest is rather long as the process can last for centuries. It is necessary to improve natural features and conservation value of the preserved areas to ensure preservation of forest ecosystems in long-term. Several measures can be applied at nature conservation areas for that purpose. Nature restoration aims to promote natural succession processes and improve the habitats for many species dependent on the lacking natural elements in forests.

The first specially designed nature restoration experiments were started at Karula National Park and Lahemaa National Park in 2001. The total need for nature restoration was estimated respectively at 19% and 23% from all forests of the national park. In 2003, 350 ha of forests for nature restoration at several protected areas were selected within the European Union Life-Nature project "Protection of priority forests habitat types in Estonia." All nature restoration activities have been done according to conservation plans for the protected area.

Monitoring of restoration areas is continuous long-term research that enables us to evaluate the success of restoration activities and, if necessary, to plan some additional activities needed for success. Monitoring also enables development of more advanced methods of nature restoration. The objective of nature restoration is to promote natural succession processes and increase habitat for species depending on the missing natural elements in forests. The main method for nature restoration monitoring in Estonia is forest stand monitoring by permanent sample plots (PSP) accompanied with assessment of stand nature value and species-specific special properties.

Establishment of PSP for monitoring nature restoration areas was started in the autumn of 2003. Fifty restoration areas with permanent sample plots were established (Table 1). Selected stands were man-made, middle-aged, normal or too dense, pure coniferous stands on mineral soils. 28 PSP are on areas where restoration activities have been carried out and 22 PSP are control plots on areas without restoration activities. PSP are established before restoration activity is done and are re-measured after restoration activity and then re-measured with intervals of three years (Figure 1). Gradually this interval will be lengthened up to ten years. PSP are high-accuracy large circular forest sample plots with tree position data recorded. Restoration responses will be monitored on tree, stand, and restoration area levels. Tree-level monitoring reflects the growth, death, and decomposition of the tree but also species occupying the tree on

Forest site type	All sample plots: dominant tree species		Including sample plots with restoration activities		Sample plots without restoration activities	
	Scots pine	Norway spruce	Scots pine	Norway spruce	Scots pine	Norway spruce
Rhodococcum	21	1	12	1	9	0
Myrtillus	4	8	2	4	2	4
Oxalis	0	16	0	9	0	7
Total	25	25	14	14	11	11

Table 1. Distribution of permanent sample plots by dominant tree species and forest site type.

Estonian University of Life Sciences, Tartu, Estonia; email-diana.laarman@emu.ee

different development stages. Tree-level monitoring is also important in cases where trees are treated differently within the stand and these different treatments should be observed. Stand-level monitoring enables observation of different stand components and their changes but also changes in forest stand composition and structure. Restoration-area-level enables monitoring of the change of overall naturalness of an area.

Biodiversity in a given area is usually evaluated through surveys of species richness in different taxonomic groups. Species-specific special inventories include ground vegetation monitoring, insect monitoring, lichen monitoring, and fungi monitoring. Ground vegetation is monitored on PSP by circular plots with radius 0.6 m. Normally the number of the plots is 16 per one PSP. In certain cases 1 m by 1 m rectangular sample plots are combined with the circular plots. All ground vegetation species on sample plots have been determined, but also their height, vitality, development stage, and amount are recorded. On fungi and lichen monitoring plots the observations on living and dead trees, tree roots, and sumps are added. All lichen species are determined. Insect monitoring is especially valuable and proper to evaluate changes on restoration areas because of insect species and habitat richness, fast life cycle, distribution patterns and lot of monitoring methods available. Species determinations on lichens, fungi, and insects are done in special laboratories in most cases.

The overall goal is to monitor the changes and processes in stands after restoration activity is done. It is important to distinguish between normal development in a stand and the direct influence of restoration measures. Therefore similar areas without restoration measures also should be monitored.

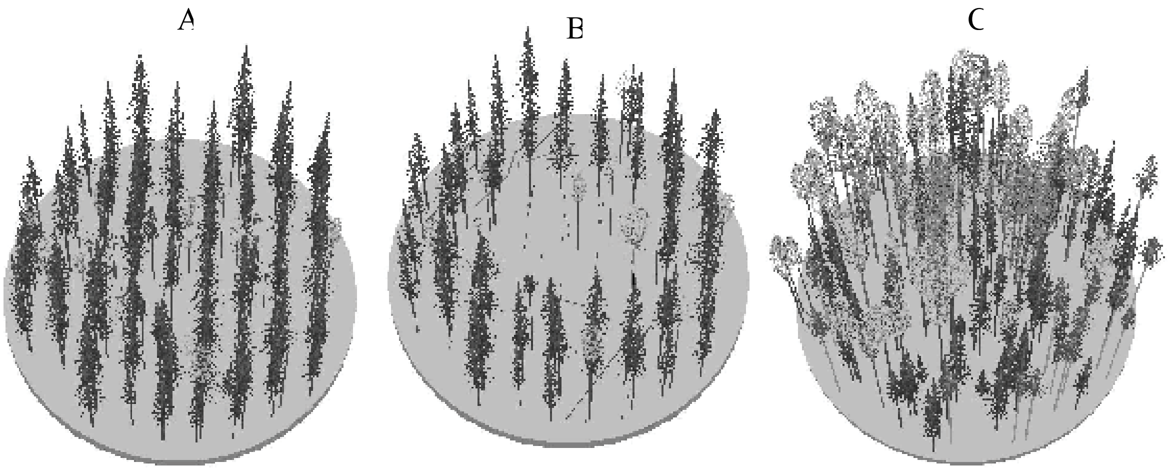


Figure 1. Sample stand (30-year-old even-age planted Norway spruce stand) suitable for restoration activity (A), same stand after restoration activity is done (B), same stand modelled after 30 years of development; target stand is uneven-age mixed forest (C).

DEVELOPMENT OF PROGRAM FOR FIELD SURVEYING ON THE DEBRIS FLOW USING BY PDA (PERSONAL DIGITAL ASSISTANT)

Changwoo Lee, Hojoong Youn, Chun-yong Lee, Yongho Jeong, Choongshik Woo

Abstract—Debris flows in forests for the last ten years resulted annually in more than 22 casualties and loss of property about 15.6 billion won in Korea. The scale and analysis of disaster characteristics should be investigated and estimated by a disaster expert. However, such an investigation and survey requires a lot of manpower and is arduous because lots of surveying equipment must be transported in rough terrain in many distributed areas. Technically it is very difficult to find precise positions in mountainous areas with only topographic maps. For enhanced precision, consistency, and efficiency of field surveying of the debris flow, a program using a PDA (Personal Digital Assistant) was developed. The PDA was fitted with a GPS (Global Positioning System) receiver and included the files of digital topography, geology, forest type, and forest sites map of a target area in the field. Using this program, position and various other information was easily able for the target area from a digital map. This allowed us to obtain the needed data without much surveying equipment.

Method

This program consists of a PDA-PC synchronization module, data management module based on desktop GIS, and field sheet module on the PDA based on a mobile GIS. The development and operational environment of the program is shown in Figure 1.

Results and Discussion

Field Sheet Module on PDA Based on Mobile GIS—This module is used to find surveying information such as collection of objective information related to geography and site environment. It uses the PDA with a GPS and memory card that have a digital map. Therefore, the information on location and digital properties of the target area are recorded automatically on the PDA (Figure 2). The surveying sheets consist of five sheets that include a general outline (rainfall, damage status etc.), torrent status (slope, length etc.), collapsed area (width, depth etc.) and sediment area (accumulation, area etc).

Data Management Module Based on Desktop GIS—This module is used to manage and search a data base, which is created through field investigation. Data is sent to an Excel file automatically and can be effectively arranged and analyzed (Figure 3).

PDA-PC Synchronization Module—This module converts field data on the PDA into a desktop PC format for further use (Figure 4.). This program would be helpful to increase accuracy through digital mapping of investigated sites, to implement management of field sheets, to reduce the differences among investigators' skill when acquiring complicated geographic information in difficult mountainous areas.

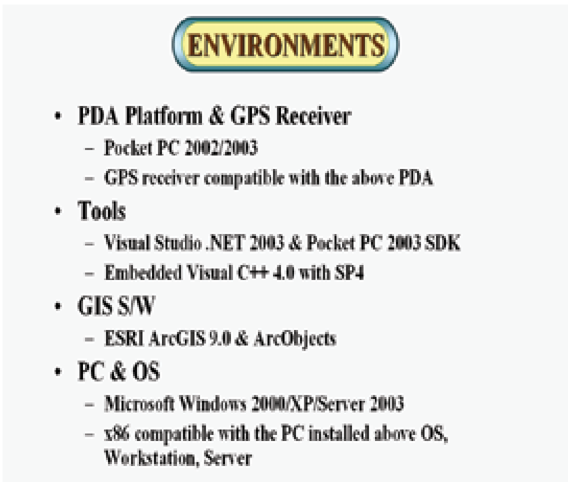


Figure 1. Development environments on Program

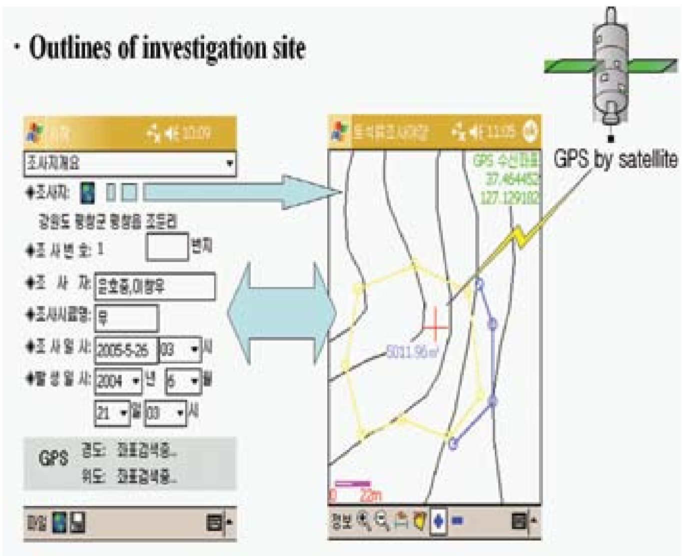


Figure 2. Field sheet on PDA

Korea Foret Research Institute, Seni, Korea; email-leecw@foa.go.kr

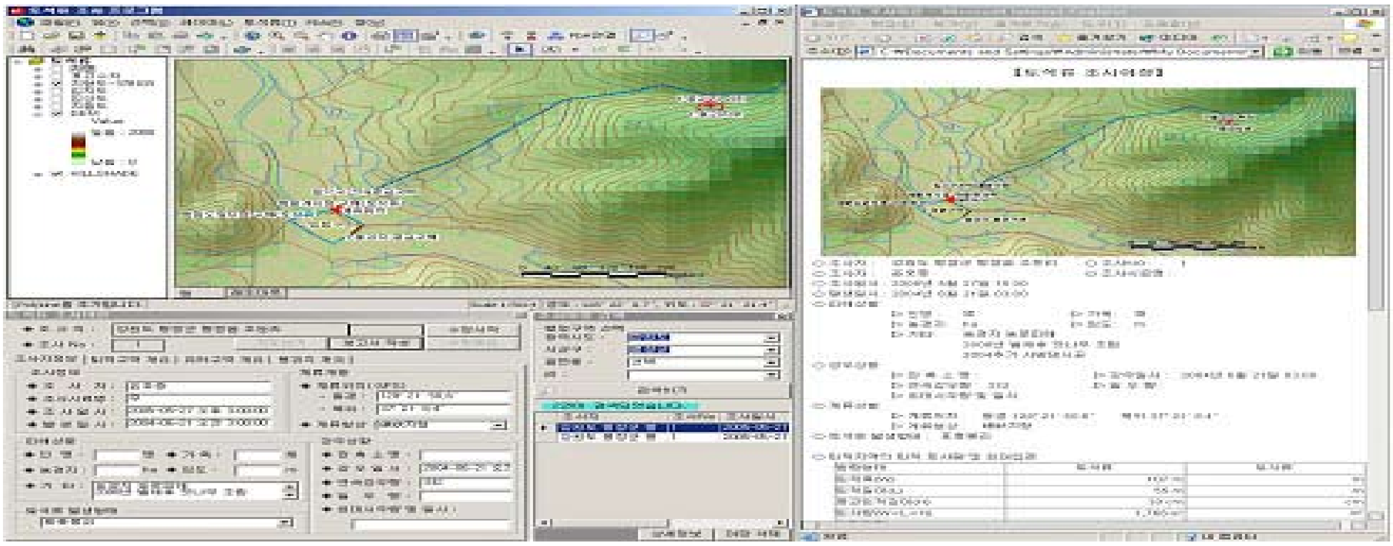


Figure 3. Data management on desktop PC

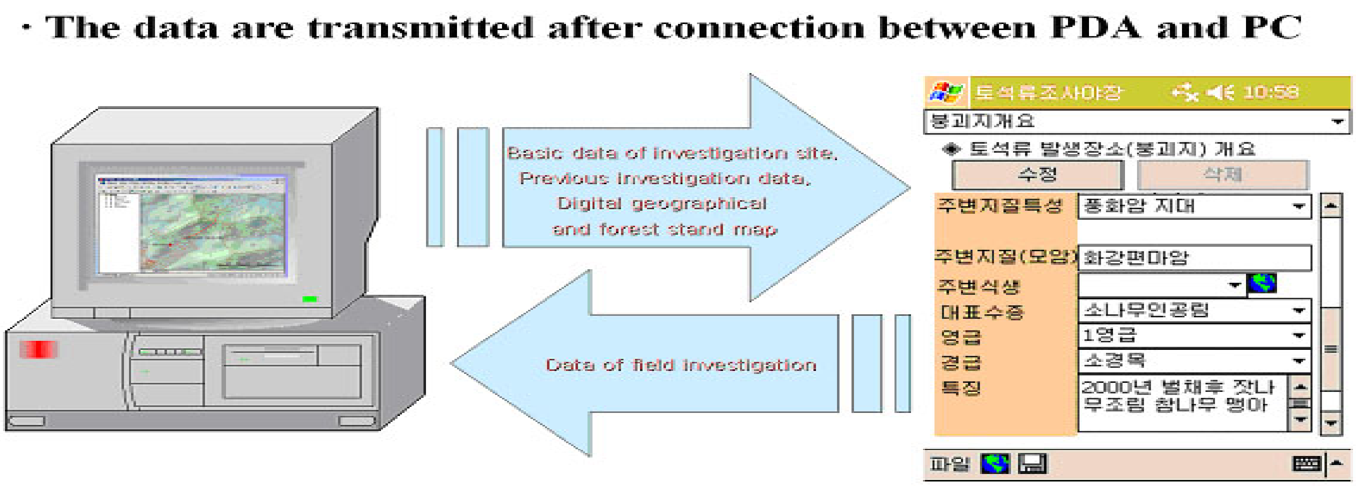


Figure 4. PDA-PC synchronization

EFFECTS OF AIR POLLUTION AND ACID DEPOSITION ON THREE *PINUS DENSIFLORA* FORESTS IN SOUTH KOREA

Choong Hwa Lee, Seung-Woo Lee, Eun-Young Kim and Yong-Ho Jeong

Abstract—Although a large area of forest damage due to acid deposition has not yet been found in South Korea, nevertheless some local declines frequently have been reported, especially for *Pinus densiflora* (Japanese red pine), the most common coniferous tree. In the present study, we evaluated the effects of acid deposition on forests. The results of monitoring ambient SO_2, acid load, soil pH, and tree decline from 1988 to 2001 in urban, industrial, and mountainous areas along a gradient of atmospheric pollution are reported. During the study period, annual mean SO_2 concentrations in the urban area averaged 13 ppb with a maximum of 31 ppb in 1989; industrial and mountainous areas averaged 14 ppb and 6 ppb, respectively. Annual mean acid loads were 0.09 and 0.11 kmol H^+ ha^{-1} in urban and industrial areas, significantly higher than the 0.03 kmol H^+ ha^{-1} in the mountainous area. The surface soil of the red pine forest in urban and industrial areas was acidified (pH 4.1-4.3), whereas in the mountainous area the pH was higher (5.4). On the other hand, based on defoliation and discoloration measured in 1996 and 2001, degree of decline in the pine trees in the two polluted areas was higher than in the mountainous area. The data indicate that the combined effects of high air pollution and acid deposition-induced soil acidification (possibly Ca deficit and Al toxicity) could adversely influence Japanese red pine.

Korea Forest Research Institute, 207 Cheongyangni-2 dong, Dongdaemun-gu, Seoul, 130-712, Korea Email: hwa21@foa.go.kr

FORMULATING A LANDSCAPE PREFERENCE MODEL USING A MIXED CONDITIONAL LOGIT MODEL: THE CASE OF VISITORS TO THE CAIRNGORMS NATIONAL PARK IN SCOTLAND

Dukjae Lee[1], C. Paul Mitchell[2], Kenneth J. Thomson[2]

Abstract—In order to verify the effect of landscape itself as well as visual elements on landscape preferences, conditional logit models for choice-based landscape preference were formulated for visitors to National Parks in Scotland. To measure landscape preferences, a photo-questionnaire composed of paired photographs of the Cairngorms National Park in Scotland and the Jirisan National Park in Korea was distributed to sets of visitors to the Cairngorms National Park at major viewing points. It was concluded that the effect of Cairngorms landscape itself was more important than that of the Jirisan landscape from a different culture in determining the landscape preferences of the Cairngorms visitors, although visual elements played a considerable role. This implies that landscape restoration should be prudently processed because physical change of typical landscapes into more preferred forms does not always provide a higher degree of landscape preference.

The restoration of landscape has become an important theme in recent scientific and policy work (Haines-Young and others 2006, Tong and others 2006, Gobster 2001), and an important aspect is the arrangement of visual elements from the aesthetic point of view. Visual elements are the most important factors which contribute to the landscape, and they determine landscape preferences as an individual element or as a whole, constituting landscape itself. To formulate a predictive model for landscape preferences, a psychophysical approach in which visual elements of landscapes determine landscape preferences has been widely used (Shafer and others 1969, Daniel and Schroeder 1979). For landscape preference, however, individual perception has been mainly evaluated by ranking elements in order of importance (Arriaza and others 2004, Tips and Savasdisara 1986), or by rating them on a scale indicating strength of preference (Hammitt and others 1994). However, a full model of choice helps to conceptualise the issues related to preference judgement. Choice in the form of alternatives is inherent in the expression of preference (Hogarth 1980). The principal purpose of this study was to examine the effect of landscape itself in a choice-based landscape preference model based on the psychophysical approach in the case of visitors to the Cairngorms National Park in Scotland, and to suggest implications for landscape restoration.

Conditional Logit Model (Clm)

A common type of statistical model for discrete choice situations is the logit model. In this model, the predicted probability of observing outcome m given xi is expressed as follows (Long 1997):

$$P(y_i = m \mid x_i) = \frac{\exp(x_{im}\,\beta)}{\sum_{j=1}^{J} \exp(x_j\,\beta)}$$

where
i : observation number
m : mth choices
J : number of parameters
x: attributes of the choice alternatives.
$P(y_i = m \mid x_i)$: probability of observing outcome m given xi

The conditional logit expression may be extended to include the characteristics of the individual along with choice characteristics through incorporating individual covariates called alternative specific constants (ASCs). The ASCs are the location parameters of the random utility component and are not associated with any one attribute, so that they capture the effect of omitted variables (Louviere and others 2000). In the case of choosing one of three categories, the combined form of two linear logit models that use the 3rd category as a baseline is specifically represented as follows:

$$\log\left[\frac{P(y_i = m \mid x_i)}{P(y_i = 3 \mid x_i)}\right] = \beta_{0m} + \sum_{j=1}^{J} \beta_j (x_{mij} - x_{3j})$$

In this study, two conditional logit models (CLMs), respectively with and without the ASCs, were formulated for landscape preference. Based on the examination of the independence from irrelevant alternatives (IIA) property and on the estimated McFadden's ρ2, conclusions were drawn as to which was more appropriate, and a better-fitted model was subsequently suggested.

Survey Method and Data Collection

The Cairngorms National Park of Scotland and the Jirisan National Park of Korea were selected as typical natural landscapes for each cultural group (Lee 2006). The Cairngorms National Park, located in the central Highlands of Scotland (latitude 57° N. and longitude 3°40' W. approximately), is a new

[1] Korea Forest Research Institute, Seoul, South Korea; email-foeco@naver.com
[2] School of Geosciences, University of Aberdeen, Aberdeen, U.K.

(and the second) National Park in Scotland. The most impressive topography of the Cairngorms is characterised by the extensive summit plateaux at about 1,000m, with accompanying rock-cliffs and ex-glacial features of lochs (lakes) and glens (valleys). The Jirisan National Park, located in the southern central part of Korea (latitude 35° N. and longitude 127°34′ E.), was established as the first National Park in 1967. The physical features of the area are distinctive with a rolling plain, hills and mountains culminating in the highest peak of Cheonwangbong (1,915m) in the eastern part of the mountain. Using a digital camera, landscape photographs were taken through the main footpath of each National Park (i.e. the Lairig Ghru in the Cairngorms, 43km; Nogodan-Cheonwangbong in Jirisan, 25.5km). Nine selected photographs showing the typical natural landscape of each Park were arranged in pairs using the method of Ross (1974). In addition, final questionnaires composed of pairs of landscape photographs were randomly distributed to visitors to the Lochnagar visitor centre of Cairngorms National Park (Table 1).

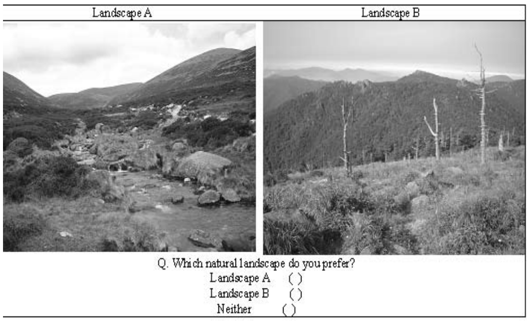


Table 1--Illustration of questionnaire

In order to generate variables of visual landscape elements for determining landscape preference, digital image processing was used with photographs of each National Park. A photographic image was segregated into the different regions in which landscape features were represented by different textures, e.g. vegetation, water, and sky (e.g. Shafer and others 1969). Each segregated region was then quantitatively evaluated by both scalar measurement (e.g. area and perimeter) and RGB colour, using ERDAS 8.3 IMAGINE software. The data produced were subsequently reduced to orthogonal principal components. The calculated factor scores were used as explanatory variables in formulating the logit model, whose response variable was a choice of preferred landscape between alternatives. Analyses of the data for logit models were conducted by using the R version 2.01.

Results and Discussion

Principal component analysis (PCA) was undertaken to select a subset of variables which represented the underlying patterns of relationship between visual landscape elements and thus the important characteristics of landscape. Five common factors explained 88.75% of the total visual elements of landscapes and sufficiently represented the characteristics of the photographs that composed the visual landscape elements. The first factor (F1) was summarised as near-distance-related landscape component; the second (F2) as middle-distance-related, the third (F3) as water-related, the fourth (F4) as far-distance-related, and the fifth (F5) as sky-colour-related. After the calculation, the factor scores of the visual landscape elements were subsequently used as the independent variables in the logit analysis of landscape preference.

The logit model for visitors to the Cairngorms National Park was estimated from 88 participants visiting the Lochnagar visitor centre. More than half of the respondents were over 40-years-old. The mean age was 43.0 years, and the range was 9 to 75 years. The gender proportions were similar between males (51.2%) and females (48.8%). In terms of occupation, students accounted for a significant proportion, about a fifth of the respondents (18.6%). Many of the older respondents revealed their occupation as retired (17.4%). Almost half of the respondents had visited the Cairngorms National Park more than 10 times.

Two landscape preference models were formulated using CLM for the choice of landscape alternatives (Table 2). Model CNP1 was a CLM with three choices excluding the ASC. Only photo-characteristic variables were assumed to be a predictor for landscape choice. All attributes except F4 were found to be significant predictors of Cairngorms NP visitors' choice of landscape photograph, as evidenced by p-values < 0.05. In order to test the IIA assumption, the restricted model was estimated as follows:

$$\log\left(\frac{P_{CNP}}{P_{JNP}}\right) = -0.355(F1)^{(**)} + 0.250(F2)^{(**)} - 0.258(F3)^{(**)} - 0.188(F4)^{(**)} - 0.092(F5)^{(**)}$$

The restricted model suggested that the IIA property might be violated, because the sign of F4 in the restricted model was opposite to that in the unrestricted model. In addition, the overall fit of the model measured by McFadden's ρ2 was 0.19, which was slightly below the range of good fit suggested by Louviere and others (2000). Tests of the choice data indicated that CLMs without the ASC (i.e. Model CNP1) did not show a good fit. Under these conditions, the parameter estimates of model CNP1 were therefore likely to be biased. Model CNP2 was the mixed CLM with three choices including the ASC. The results from the conditional

Model		CNP1 – simple CLM			CNP2 – mixed CLM		
Type	Name	Coef.	Exp(coef.)	S.E.	Coef.	Exp(coef.)	S.E.
Constants	Cairngorms	n/a	n/a	n/a	3.121(**)	22.678	0.223
(ASC)	Jirisan	n/a	n/a	n/a	2.041(**)	7.701	0.206
PV	F1 (Near)	-0.302(**)	0.739	0.058	-0.678(**)	0.508	0.076
	F2 (Middle)	0.384(**)	1.467	0.053	0.043	1.044	0.060
	F3 (Water)	-0.756(**)	0.469	0.059	-0.118	0.888	0.067
	F4 (Far)	0.043	1.044	0.077	-0.665(**)	0.514	0.108
	F5 (Sky)	-0.186(**)	0.831	0.039	-0.155(**)	0.856	0.043
N		2376			2376		
DF		5			7		
LR		514			848		
Wald		451			491		
R-square		0.194			0.300		

Table 2--Conditional logit model (CLM)

logit analysis are shown in Table 2. The restricted model suggested that the IIA property was not considerably problematic for the unrestricted model. The overall fit of the model as measured by McFadden's ρ2 was 0.30, representing a very good fit:

$$\log\left(\frac{P_{CNP}}{P_{JNP}}\right) = -1.079^{(**)} - 0.680(F1)^{(**)} + 0.045(F2) - 0.096(F3) - 0.683(F4)^{(**)} - 0.149(F5)^{(**)}$$

In short, the ASC modelled CNP2 was more appropriate, suggesting that the landscape preference model should incorporate an effect of landscape itself due to omitted photo-characteristic variables (PV) on landscape choice. Landscape preferences of Cairngorms NP visitors were determined by the latent effect of landscape itself, beyond visual characteristics. If all characteristics of two photographs, one of the Cairngorms and one of the Jirisan, were the same, then Cairngorms respondents would have had a tendency to select the Cairngorms NP photograph (ASC=3.12) rather than the Jirisan NP photograph (ASC=2.04).

In order to formulate landscape preference model of visitors to the Cairngorms National Park in Scotland, the principal purpose of this study was to suggest a CLM that examines the effect of landscape itself along with visible landscape elements as a factor determining landscape preference in the choice between the Jirisan landscape of Korea and the Cairngorms landscape of Scotland. It was revealed that the mixed CLM was more appropriate for simulating landscape preference than the simple CLM that excludes the effect of landscape itself. The landscape preference model including the effect of landscape itself satisfied the IIA assumption and showed high goodness of fit. In other words, the effect of the Cairngorms landscape itself was more important than that of the Jirisan landscape from a different culture in determining the landscape preferences of Cairngorms visitors, although visual elements also played a considerable role. This implies that landscape restoration should be prudently processed because physical change of typical landscapes into more preferred forms does not always provide a higher degree of landscape preference, and because it takes a long time until modified landscapes incorporate social and cultural meanings.

Literature cited

Arriaza, M.; Canas-Ortega, J.F.; Canas-Madueno, J.A.; Ruiz-Aviles, P. 2004. Assessing the visual quality of rural landscapes. *Landscape and Urban Planning* 69(1): 115-125.

Daniel, T.C.; Schroeder, H.W. 1979. Scenic beauty estimation model: predicting perceived beauty of forest landscapes. In: Our National Landscape. USDA Forest Service General Technical Report PSW-35. Berkeley, Calif.: Pacific Southwest Forest and Range Experiment Station. 514-523 p.

Gobster, P.H. 2001. Visions of nature: conflict and compatibility in urban park restoration. *Landscape and Urban Planning* 56(1-2): 35-51.

Haines-Young, R.; Watkins, C.; Wale, C.; Murdock, A. 2006. Modelling natural capital: The case of landscape restoration on the South Downs, England. *Landscape and Urban Planning* 75: 244-264.

Hammitt, E.W.; Patterson, E.M.; Noe, P.F. 1994. Identifying and predicting visual preference of southern Appalachian forest recreation vistas. *Landscape and Urban Planning* 29(2): 171-183.

Hogarth, M.R. 1980. Judgement and Choice: *The Psychology of Decision*. New York: John Wiley. 250 p.

Lee, D. 2006. Cross-cultural comparison of landscape preference for the National Park: An approach from a typicality of landscape. *Korean J. of Environment and Ecology* 20(4): 482-492.

Long, J.S. 1997. *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks: SAGE. 328p.

Louviere, J.J.; Hensher, A.D.; Swait, D.J. 2000. *Stated Choice Methods*. New York: Cambridge University Press. 402p.

Ross R.T. 1974. Optimal orders in the method of paired comparisons. In: Maranell, G.M., ed. *Scaling: a Sourcebook for Behavioral Scientists*. Chicago: Aldine. 436 p.

Shafer, L.E.; Hamilton, E.J.; Schmidt, A.E. 1969. Natural landscape preferences: A predictive model. *Journal of Leisure Research* 1(1): 1-19.

Tips, E.J.W.; Savasdisara, T. 1986. The influence of the socio-economic background of subjects on their landscape preference evaluation. *Landscape and Urban Planning* 13: 225-230.

Tong, C.; LeDuc, M.G.; Ghorbani, J.; Marrs, R.H. 2006. Linking restoration to the wider landscape: A study of a bracken control experiment within an upland moorland landscape mosaic in the Peak District, UK. *Landscape and Urban Planning* 78(1-2): 115-134.

SMALL RODENTS AND POST-FIRE SILVICULTURAL MANAGEMENT IN SOUTH KOREAN PINE FORESTS

Eun Jae Lee[1], Woo-Shin Lee[1], Shin-Jae Rhim[2], Sung Jin Park[1] and Ju Young Lee[2]

Summary—We examined changes in habitat and densities of three small rodent species, Korean field mice (*Apodemus peninsulae*), Korean large-toothed red-backed voles (*Eothenomys regulus*), and black-striped field mice (*A. agrarius*), in unburned forest, and in forest burned 4 years earlier with damaged trees removed and with pine (*Pinus densiflora*) left unharvested.

This study was located in the pine forest area (37° 13′ N, 128° 18′ E) of Samchuck, Gangwon Province, Korea. The experimental design was a randomized-block design with replicate blocks of unburned plot and two different post-fire management practice stands at each of three locations (blocks) at the study area. These nine plots were selected on the basis of operational scale, proximity, and reasonable grouping into respective blocks based on location and elevation (Sullivan et al. 2000). Each 90 x 90 m study plot was divided into a grid pattern, consisting of a 10 x 10 m array, for trapping and surveying habitat. Forest-floor small rodent populations were sampled on 10 occasions for one night at 1-week intervals from July to September 2004. Trapping grids (90 x 90 m) had 100 (10 x 10 array) trap stations at 10 m intervals with a Sherman live trap at each station (Rhim and Lee 2001, Lee 2005). Characteristics of each stand were measured at each trapping station within 5-m diameter circles. For each tree and snag within a circle we recorded species and diameter at breast height (DBH). The number, length and diameter of downed tree and coarse woody debris (CWD) also were recorded. The understory coverage was classified into the following four categories, based on the percentage of cover, following Rhim and Lee (1999); 0 (coverage percentage = 0 %), 1 (1-33 %), 2 (34-66 %) and 3 (67-100 %). The number of woody seedling was also counted in each circle. The survey was done in July-August, 2004.

Forest structure was dramatically changed by post-fire silvicultural practices. Coverage of vertical layers, number of stand trees, volume of downed coarse woody debris, and number of downed trees were significantly different among study areas. In the unburned stand, the coverage of over- and mid-story vegetation was more developed than in the other stands. The coverage of understory vegetation was higher in the burned stand than in the unburned stand. Over- and mid-story coverage was removed by the forest fire, and understory vegetation had significantly developed in both burned stands by the time of our study. The burned stand with damaged trees remaining had a greater volume of downed CWD ($F_{2,4} = 8.57$, $P = 0.05$) and number of downed tree ($F_{2,4} = 7.62$, $P = 0.05$) than did in the other stands. Due to the post-fire management practices, volume and number of pieces of downed tree and number of woody seedlings were significantly decreased in burned stands with damaged trees removed than in stands where they were left.

We captured 302 individual small rodents (Korean field mice, *Apodemus peninsulae*; Korean large-toothed red-backed voles, *Eothenomys regulus*; and black-striped field mice, *A. agrarius*) on 584 occasions during 90 trap-nights in 2004. Korean field mice represented 65.2% of the total small mammals captured, followed by Korean large-toothed red-backed voles (27.2%) and black-striped field mice (7.6%). There were more captured small rodents in unburned stands (139 individuals) than in burned stand with damaged trees left (106 individuals) and damaged trees removed (57 individuals). Also, there were more small rodents in burned stands with damaged trees left than in removed stands. However, the density of black-striped field mice

[1] Department of Forest Sciences, Seoul National University, Seoul 151-921, Korea, e-mail: 2lejae@naver.com,
[2] Department of Animal Science and Technology, Chung-Ang University, Ansung 456-756, Korea

was greater in both types of burned stand than in unburned stands, because they prefer open forest conditions (Yoon 1994). Both types of burned stands evidently provided open habitat for black-striped field mice. Management and habitat influence densities of small rodent populations, and the habitat variables considered can be manipulated by forest managers through applications of post-fire management practices. We found that understory cover and woody debris were the habitat components most strongly related to small rodent densities. Post-fire silvicultural practices affect stand structure and forest-floor small rodents that should be considered when evaluating post-fire management in burned stands. Natural restoration may be better for small rodents than post-fire practices in forest fire areas. It would be prudent to investigate the response of other wildlife communities, e.g., birds, amphibians, large mammals, to post-fire silvicultural practices, because other species may have quite different responses to these particular forest conditions. There is a need to carefully assess ecological effects of post-fire practices over longer-time periods. Studying populations over longer-time periods will reduce the impact of high temporal variation on the estimation of treatment effects, and will give a better sense of the long-term impacts of management. Longer-term experiments are needed to elucidate effects of potential pine forest management strategies on forest fire.

Literature Cited

Lee, E. J. 2005. The impacts of coarse woody debris on rodents after forest fire. MSc dissertation, Department of Forest Resources, Seoul National University. Seoul, Korea.

Rhim, S. J. and Lee, W. S. 1999. Differences in small mammal populations due to different habitat structure in natural deciduous forest. *Journal of Korean Forestry Society* 88: 179-184.

Rhim, S. J. and Lee, W. S. 2001. Habitat preferences of small rodents in deciduous forests of north-eastern South Korea. *Mammal Study* 26: 1-8.

Sullivan, T. P., Sullivan, D. S. and Lindgren, P. M. F. 2000. Small mammals and stand structure in young pine, seed-tree, and old-growth forest, Southwest Canada. *Ecological Applications* 10: 1367-1383.

DISTRIBUTION AND LAND USE OF TRADITIONAL BUDDHIST TEMPLES AND ADJACENT AREAS IN SOUTH KOREA

Hyunjung Lee and Dowon Lee

Abstract—The total land area owned by 863 temples in South Korea covered 928 km^2, which was equal to 0.93% of the national land area dominated by forests (88.3%). More than 80% of the temples in number were nested in forested and agricultural landscapes. Many temples were located near watershed divides in the map of intermediate-scale watersheds, and most of the temples possessing large land areas are located near large watershed divides. Over 70% of the temples lie in areas higher than 100 m of relative elevation and the 41 temples that owned the larger land areas were all situated at higher elevations, indicating that large temples are predominantly distributed in mountainous regions. Large temples are conservative due probably to less human access, and enhance spatial heterogeneity in the forest matrix with their gardens and structures.

Buddhist temples are unique elements in many Korean landscapes, as they are remarkably conservative and distributed all over the country. Korean Buddhist temples may be characterized in the context of a watershed as their locations were based on Feng-shui principles, which are concerned with a concept of watershed (Choi 2000, Lee 2003). Hence, spatial characteristics of temples were related to different scales of watersheds at the national level of South Korea. However, data regarding spatial distribution and pattern of temples are not easy to acquire.

Materials and Method

We characterized the locations and land use of the remaining traditional Buddhist temples and adjacent areas in South Korea, based on representative temples, data for which we acquired. Then, we proposed an index of relative elevation, defined as the difference in the elevation at a temple location and at the mouth of watershed for identifying the mountainous area we intended to extract. The index is useful in showing relative locations of temples within watersheds.

Results and Discussion

The total land area owned by 863 temples covers 928 km^2, which equals 0.93% of the land area of South Korea. The total land area of temples is comprised of forests (88.3%), with cropland (7.6%), building areas (0.6%), and other uses (3.55%). Regardless of land ownership, more than 80% of the temples were nested in forested and agricultural landscapes. Many temples were located near watershed divides in the map of intermediate-scale watersheds, and most of temples possessing large land areas were located near large watershed divides. Over 70% of the temples lay in areas higher than 100 m of relative elevation and the 41 temples that owned larger land areas than the mean value were situated at regions higher than 100 m of relative elevation. This indicated that large temples are predominantly distributed in mountainous regions. While temples of large land areas are within forested ecosystems, usually near the divides of large watersheds, temples with small land areas are concentrated in developed districts, in particular, in or near Seoul.

Conclusions

The total land area owned by Buddhist temples was overwhelmingly dominated by forests, and regardless of land ownership most temples were nested in forested and agricultural landscapes. Many temples were located near divides in the map of intermediate-scale watersheds. Most temples possessing large land areas were located near large watershed divides. Most temples lay in areas higher than 100 m of relative elevation. Large temples especially are predominantly distributed in mountainous regions. Large temples are conservative due probably to less human access, and they enhance the spatial heterogeneity in the forest matrix with their gardens and structures.

Acknowledgements

We thank the Dongkuk University for conferring an opportunity for us to open the subject by joining 100th Anniversary International Conference "Ecology and Buddhism in the Knowledge-based Society (Seoul, Korea, May 25-26, 2006)". We are indebted to the Jogye Order Foundation and the Ministry of Culture and Tourism for providing relevant data. Special thanks go to Eunsook Kim who input a lot of data into an Excel file.

Literature Cited

Lee, D. 2003. *Ecological Knowledge Embedded in Traditional Korean Landscapes*. Seoul National University Press, Seoul, Korea (in Korean with English abstract).

Choi, W. S. 2000. *Excursions to Buddhist Priest Dosun's Auspicious Sites.* Shigongsa, Seoul (in Korean).

Graduate School of Environmental Studies, Seoul National University, Seoul, South Korea; email-lun980@snu.ac.kr

SOIL BIOGEOCHEMICAL RECOVERY AFTER APPLYING DOLOMITE AT A RESTORED *MACHILUS THUNBERGII* STAND, SOUTHERN KOREA

Seung Woo Lee, Choong Hwa Lee, and Yoon Young Lee

Abstract—Nutritional imbalance in forest ecosystems with very acidic soils is a problem, as soil acidification and nutrient deficiency are supposed to be disturbance factors lowering site productivity and forest health, particularly in forests receiving high loads by acid deposition from industrial areas. Liming is a recovery method for soils deteriorated by soil acidification. A *Machilus thunbergii* secondary stand at Mt. Youngchui in southern Korea was limed in 2000 with dolomite in doses of 0, 2.0, 2.5, 3.0, 3.5, and 4.0 ton ha^{-1}. Soil chemical properties, respiration of surface rooting zone, and tree growth were examined after four years. A substantial increase of pH, N, P and base nutrients (Ca^{2+} and Mg^{2+}) in the surface soil was attributed to liming, whereas exchangeable Al^{3+} was decreased with increasing amounts of lime. As estimated from a linear regression between the changed soil pH and liming amount, the lime requirement for target soil acidity (pH 5.5) was almost twice as much by Arrhenius simple method. This means that field factors should be used for reasonable estimation of lime requirement. Although C/N ratio in the soils did not change noticeably, liming increased the content of organic carbon and total nitrogen, soil respiration (CO_2 g m^{-2} hr^{-1}), and *Machilus thunbergii* growth. The positive relation of the changes in soil pH, nutrients, and tree growth indicates that liming in acidified forest ecosystems may ameliorate soil degradation and improve nutrition and microbial activity as well as tree growth, and be effective in maintaining the health of the restored forest.

Department of Forest Environment, Korea Forest Research Institute, 207 Cheongnyangni 2dong, Dongdaemun gu, Seoul, Korea, 132-701, Email: soilloverlee@foa.go.kr

RESTORATION OF OAK FORESTS: THE RELATIVE IMPORTANCE OF FACILITATION AND COMPETITION FROM SHRUB VEGETATION DURING ESTABLISHMENT OF YOUNG SEEDLINGS

Anna Monrad Jensen

Abstract—The natural temperate broadleaved forests of Southern Scandinavia and Sweden have almost completely been transformed by humans into monocultural conifer forests and farmlands, leading to loss of some important woodland key habitats and biodiversity. Reintroducing temperate broadleaved species, especially oaks (*Quercus robur* and *Quercus petraea*), is important in order to restore and strengthen such forest types. A successful establishment of young oak seedlings is therefore critical. Interspecific competition from natural vegetation is considered to be an important element during structural changes in plant communities, and may therefore be a major factor during the establishment of young oak seedlings. Competition from herbaceous vegetation has been observed to reduce the establishment success of young oaks, whereas interference from shrub vegetation does not have to be negative for the oak seedling. The project aims to assess the relative importance of facilitation and competition from shrub vegetation, during the establishment period in young oak seedlings in temperate oak dominated forest in Southern Sweden. We hypothesize that: 1) The fitness of oak seedlings grown in natural shrub vegetation may either decrease as a result of direct competition, or increase due to a facilitation effect caused by the shrub vegetation; 2) If the shrub vegetation increases the survival of oak seedlings, such an effect is due to a reduced browsing from mammalian herbivores and indirectly to a reduced below ground competition caused by herbaceous vegetation; 3) If direct competition occurs between the oak seedlings and the shrub vegetation, it is mainly for light. Practical experience and understanding of the interspecific competition and facilitation situation for oak seedlings grown in shrubs may be important when developing nature-based and cost-efficient regeneration methods, to ensure a successful conservation and restoration of Southern Sweden's broadleaved woodlands.

Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, Alnarp, Sweden; email-Anna.Jensen@ess.slu.se

FOREST FRAGMENTATION AT THE LANDSCAPE LEVEL AND METAPOPULATION DYNAMICS: EFFECTS ON REPRODUCTIVE TRAITS, GENETIC DIVERSITY, AND GENE FLOW IN CONIFERS

Alex Mosseler[1], Lisa M. O'Connell[2] and Om P. Rajora[2]

Abstract—Research on the impact of forest fragmentation on the reproductive fitness of wind-pollinated, temperate-zone tree species has been neglected compared to animal-pollinated, tropical species.The reproductive fitness and mating system of white spruce (*Picea glauca* (Moench) Voss) was assessed in a landscape highly fragmented by agriculture in central Canada. We sampled 104 trees from 23 stands that ranged in size from 1 to >500 trees. Stands were isolated by 250-3000 m from the nearest neighboring stand. Overall, estimates of outcrossing were high (t_m = 94% and mean t_s = 91%). We found low but significant bi-parental inbreeding (t_m - t_s = 3.2%). Allozyme-based outcrossing estimates did not differ significantly among three stand-size classes: small (<10 trees), medium (10-100 trees) and large (≥100 trees). The actual inbreeding rate, estimated from combined empty seed and allozyme data, was significantly higher in medium-size stands than in large-size stands. We found no differences in genetic diversity of the filial (seed) population among small, medium, and large stands. Reproductive success, measured by the number of filled seeds per cone, increased with stand size. A reduction in the total number of seeds per cone, a measure that includes both filled and empty seeds, suggested that trees from smaller stands can be pollen limited. The proportion of empty seeds (post-zygotic abortions) was the highest in smaller stands, suggesting that inbreeding levels were also highest in these stands. However, the proportion of empty seeds was the lowest among single, isolated trees, suggesting that increased wind movement around these single trees reduces selfing and consequently post-zygotic abortion. The number of filled seeds per cone in stands with <100 trees was also negatively correlated with the distance to the closest white spruce stand, with a sudden drop in the number of filled seeds per cone at distances of over 400 m between stands. We found that isolation and fragmentation negatively impact reproductive success in P. glauca through pollen limitation and increased inbreeding. However, germination success and seedling growth were not adversely affected, suggesting that inbred individuals may be largely eliminated during the seed development stage. Our results indicated that stands with several hundred individuals should be maintained to minimize the impact of forest fragmentation on population viability in white spruce and other conifers with a similar mating system. Overall, these results indicate that white spruce stands in this fragmented habitat are resistant to genetic diversity losses, primarily through high pollen-mediated gene-flow and early selection against inbred embryos.

[1] Natural Resources Canada, Canadian Forest Service-Atlantic Forestry Centre, P.O. Box 4000, Fredericton, NB, E3B 5P7, Canada, Email - amossele@nrcan.gc.ca; [2] Faculty of Forestry and Environmental Management, P.O. Box 44555, 28 Dineen Drive, University of New Brunswick, Fredericton, NB, E3B 6C2, Canada

LANDSCAPE CHARACTER AND CLASSIFICATION IN KOREA BASED ON WATERSHED USING GIS AND MULTIVARIATE STATISTICS, FOR THE NAKDONG RIVER BASIN

Jeong-Hak Oh, Jino Kwon, Jun-Hwan Shin, Young-Kul Kim, and Myoung-Sub Choi

Abstract—The goal of this research was to evaluate and analyze the landscape-ecological characteristics of the Nakdong River Basin, Korea based on watersheds by using Geographic Information System (GIS) for integration of spatial-temporal information and multivariate statistical techniques to evaluate interrelationships among selected factors for ecological environmental assessment of each watershed. According to the analysis, the Nakdong River Basin is categorized into five groups. Sub-categories can have six groups, based on horizontal characteristics with respect to land use. Regions were classified into forest, agricultural, and urban regions. Based on vertical characteristics with respect to topography, regions were classified into mountainous, mountains-and-fields, and field regions.

Recently, regions are often subdivided into a variety of spatial sub-regions for hierarchical understanding of ecosystems and systematic management of the environment (Omernik 1995, Jenerette et al. 2002). Generally speaking, environment is considered to be physical and biotic elements that constitute our surroundings (Kwon 2002). For these, it is necessary to clearly understand ecosystems and from a broad landscape-ecological perspective that combines all natural resources and to closely examine structures and functions of all environmental factors (Rapport et al. 1998, Oh 2005). In this sense, to understand and grasp landscape ecological character in Korea, 48 ecological factors were selected and analyzed based on ecological land estimation, watershed-based environment information, natural environmental factors (temperature, rainfall, warm index, cold index, moisture index, solar radiation, elevation, slope, etc.), forest structure (spatial structures and functions of forest patches by landscape indices), and land use patterns (temporal landcover changes by change matrix, urban (%), agriculture (%), forest (%), soil loss estimation by RUSLE model, etc.).

Results and Discussion

According to cluster analysis in the ArcGIS 8.3 program, the Nakdong River Basin is categorized into five groups with 6 sub-groups to evaluate interrelationships among selected factors for ecological environmental assessment of each watershed.

Based upon land use patterns, most of the regions were covered with forest. For those forested regions that had the least potential of ecological disturbance by humans, a new forest management technique should be developed to sustain the ecological and environmental function of forests and to reduce the impacts of environmental change on forests from the outside.

For the agricultural regions that were mostly located near upper- and mid- mainstream of the Nakdong River, environmental-friendly agricultural techniques should be used via improvement of cultivation processes and buffer strip afforestation to prevent direct inflow of soils, fertilizers, and other chemicals into the stream network.

Urban regions were largely distributed along the lower-mainstream of the Nakdong River. Impervious pavement had a significant impact on water-quality and the hydro-ecosystem. Therefore, an environmentally-friendly land use plan should be developed that may increase the ratio of pervious surface and add a significant amount of green space by planting on rooftops and slopes.

Literature Cited

Jenerette, G.D., Lee, J., Waller, D.W., Carlson, R.E. 2002. Multivariate analysis of the ecoregion delineation for aquatic systems. *Environmental Management* 29(1): 67-75.

Kwon, J. 2002. Sense of place – A concept of Korean prototype landscape with reference to a new policy of urban fringe forest. England. Sheffield: Sheffield University. pp174-186. Ph.D. Thesis.

Oh, J.H. 2005. An approach in landscape ecology for natural resource management. Korea. Daegu: Kyungpook National University. pp.202-237. Ph.D. Thesis.

Omernik, J.M. 1995. Ecoregions: A Framework for Managing Ecosystems. *George Wright Society Forum* 12(1):35-50.

Rapport, D., Costanza, R., Epstein, P.R., Gaudet, C., Levis R. 1998. *Ecosystem Health*. Springer-Verlag. New York.

Division of Forest Ecology, Korea Forest Research Institute, 207, Cheongyangni-2 dong, dongdaemun-gu, Seoul, 130-712 Korea; email-jehoh@foa.go.kr

STUDY OF TREE SEED DISSEMINATION IN DARK NEEDLE FIR-KOREAN PINE-BROADLEAVED FOREST IN USSURYISKY RESERVE, SOUTH PRIMORYE, RUSSIA

T. P. Orekhova[1], Yu. I. Man'ko[1], A. I. Kudinov[1], G. A. Gladkova[1], G. N. Butovets[1], E. V. Zhabyko[1], A. N. Yakovleva[1], Kang Ho Sang[2], Koo Lee Don[3]

Abstract—Unique dark needle fir - Korean pine - broadleaved forests, including the valuable medicinal plant *Panax ginseng*, are specific for the Ussuryisky Reserve. A permanent study plot was established for complex investigations that included stand dynamics, seed productivity, and seed dissemination. Stand density was 608 trees ha^{-1} and comprised 18 species. Dominant canopy tree species were *Abies holophylla, Pinus koraiensis,* and *Tilia amurensis*. The stock volume was about 662 m^3 ha^{-1} and mainly consisted of coniferous trees, although coniferous trees are absent in the middle and shrub layers. The flowering and fruiting of trees in this study plot was not regular during the period of investigation (2004-2006). A high level of seed productivity was registered only in 2004. By the analysis of seed productivity of coniferous trees and the number of seedlings and young trees, it is supposed that the number of conifer trees will decrease while broadleaved trees will gradually cover the canopy layer.

Materials and Methods

The study plot 15-2004 (Spl.15) with an area of 1 ha was marked out on a southwest slope of Ussuryisky Reserve located at 43°39' N and 132°23' E. The position of trees and crowns were mapped and the floor vegetation was described by forestry and geobotanical methods (Sukashev and Zonn 1961, Rabotnov 1983). The number of naturally regenerated seedlings and seed-fall was studied in 25 subplots (2 m^2) and 36 seed traps (0.5 m^2) from May to November, respectively. The viability of seeds was determined by X-ray method (Simak 1970, Smirnova 1978) and tetrazolium (TTC) test (International rules 1984).

Results and Discussion

Stand density was 608 trees ha^{-1} and comprised of 18 species. Dominant canopy tree species were *Abies holophylla, Pinus koraiensis* and *Tilia amurensis*. The age of the trees was about 300-350 years. The third layer, where the main amount of trees (66%) is concentrated, was dominated by *Carpinus cordata, Acer mono*, and *A. pseudosiboldianum.* The stock volume was about 662 m^3 ha^{-1} and mainly consisted of coniferous trees, although coniferous trees are absent in the middle and shrub layers. The shrub layer is a mosaic, homogeneous, projective covering about 30-50% dominated by *Eleutherococcus senticosus, Philadelphus tenuifolius* and lianas. The herb layer had a projective covering of about 80% and consisted of forbs and large herbs. The soil on Spl.-15 is a Mountain-forest Brown Soil, with well-differentiated humic horizon, loamy, stony. Drainage is satisfactory. Chemical and physical soil properties are favorable for trees growth.

The number of naturally regenerated seedlings on the study plot was about 1.4 thousand seedlings ha^{-1} and consisted of mainly *Pinus koraiensis* (32%) and *Quercus mongolica* (41%). A high level of seed productivity was registered in 2004. The collected seeds referred to 12 species in the number of 12,800 thousand seeds ha^{-1}. The yield consisted of seeds of *Betula costata* (39.4%) and nuts of *Tilia amurensis* (37.4%), and one half of seeds were undeveloped. The viability of seeds of other species was better, such as *Pinus koraiensis* (86.6%), *Carpinus cordata* (59.4), and *Tilia taquetii* (65%). In 2005 the yield of seeds was considerably less. In the first part of summer, trees suffered from the lack of humidity and unripe seeds of *Acer mono*, *Carpinus cordata* and *Quercus mongolicae* fell down. We suppose that this is a protective reaction of the trees to drought. The productivity in 2005 was 2,579 thousand seeds ha^{-1} of 13 species. However, the vitality of the seeds was low. Half of the yield consisted of undeveloped nuts of *Carpinus cordata* (46.4 %). A cold and long spring in 2006 and summer drought caused a fall of a significant amount of *Tilia taquetii* seeds. Total seed-fall was 2,041 thousand seeds ha^{-1}, belonging to 14 species but consisted mainly of undeveloped seeds of *Betula costata* and *Tilia taquetii.*

Conclusions

The amount and quality of tree seeds on this study plot changed during the period of investigation and depended on weather conditions (air humidity and temperature, precipitation). By the analysis of seed productivity of coniferous trees and number of seedlings and young trees, it is probable that

[1] Pr. Stoletiya Vladivostoka 159, Institute of Biology & Soil Science FEB RAS, Vladivostok, Russia, 690022, t_orekhova@yahoo.com
[2] NICEM, Seoul National University, Seoul, 151-921, Republic of Korea,
[3] Department of Forest Sciences, Seoul National University, Seoul, 151-921, Republic of Korea

the number of conifer trees will decrease while broadleaved trees gradually will cover the canopy layer.

Acknowledgments

This research was supported by a grant from the Korean Science and Engineering Foundation (KOSEF) "Ccooperative research for development of useful natural resources and restoration of degraded ecosystems in Northeast Asian regions" and the overseas laboratory program of the Korea Research Foundation (KRF-2005-212-F00002)

HOW DO BIRDS UTILIZE PATCHES IN THE RURAL LANDSCAPE IN SONGMAL-RI, ICHEON, GYONGGIDO, KOREA?

Chan-Ryul Park, Myoung-Sub Choi,
Young Kul

Abstract—This study was conducted to address how bird diversity is maintained in rural landscapes composed of paddy fields, bibosoop, forests and villages. We surveyed the patch use of birds in breeding (May) and non-breeding seasons (October) in 2005 and 2006, and we focused on patch movement of cavity nesters. Birds were identified using binoculars (8 x 30), songs and calls, and the number of individuals was counted and recorded. We selected eight points and recorded the movements of observed birds the starting and arriving patches as follows: bibosoops (Bibo), Jacheongryong (Ja), Wubaekho (Wu), paddy fields (Pad), *Pinus koraiensis* forests (Pkf), backyard forests (Baf), villages (Vil), and outside the landscapes (Out). When we observed group movement or continuous movement, we regarded it as one sample because of the aggregation behavior and group formation of birds. Birds frequently visit the village and backyard forests during non-breeding periods, but they visit the bibosoop, paddy field and village during breeding periods. Cavity nesters seldom visit the patches during non-breeding periods, but they frequently visit the bibosoop and village. Our results suggest that bird diversity could be related with the village and indirectly connected with the conservation efforts of bibosoops by villagers.

Division of Forest Ecology, Korea Forest Research Institute, Seoul, Korea; email-chandrap@chol.com

PRELIMINARY SURVEY OF WILDLIFE AND BIOTOPE IN KOREAN TEMPLE LANDSCAPE

Chan Ryul Park[1] and Dowon Lee[2]

Abstract—Wildlife and habitats were surveyed in ten temple landscapes from June to October, 2005 to examine how temple landscapes enhanced biodiversity. Twenty-five species of birds, three species of mammals, and one species of reptiles and amphibians were recorded. Among the birds, great tit (*Parus major*) and daurian redstarts (*Phoenicurus auroreus*) were observed in all the temples. Great tits are abundant species in the forest areas, but daurian redstarts are not so common (at least in the areas we visited, but not in ordinary forests). The three species of mammals were chipmunk (*Tamias sibiricus sibiricus*), squirrels (*Sciurus vulgalis vulgalis*), and Korean weasels (*Mustela sibirica coreana*). Six significant biotope components were recognized and recorded in the temples: 1) a wooden building, 2) small ponds, 3) bare grounds and lawn, 4) rooftop of Buddhist sanctum, 5) space under the eaves of tile-roofed house, and 6) dead trees. As the attitude of monks can attract the wildlife and other organisms in the boundary of temple landscape, the interaction of temple and nature may contribute to forming eco-friendly ecosystems.

[1] Division of Forest Ecology, Korea Forest Research Institute , Seoul, Korea; email: chandrap@chol.com
[2] Graduate School of Environmental Sciences, Seoul National University

DEVELOPMENT OF C&I FOR ECOLOGICAL RESTORATION OF DEGRADED FOREST ECOSYSTEM

Yeong Dae Park [1], John A. Stanturf [1] and Don Koo Lee [2]

Introduction

Restoration of degraded forests is one of the main global environmental challenges. Ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). The conceptual idea for restoration, returning an ecosystem to its historic trajectory and recovering its former biotic composition, looks like a hope for saving the world and it has captured serious attention not only of researchers, experts, and managers but also of the informed public as Non-Governmental Organizations (NGOs). The concept of criteria and indicators (C&I) has been mainly used in the field of sustainable forest management (SFM) since the Rio Earth Summit in 1992 but the development of C&I for application to ecological restoration is needed for deciding which restoration treatments to apply and for monitoring and evaluating their subsequent success. This paper aims to review what kinds of ecological attributes have been used for forest restoration in the recent scientific literature and to discuss how to efficiently develop C&I for ecological restoration.

Materials and Methods

We searched and collected all published articles using the search engine of the ISI Web of Knowledge, using the keywords 'forest' and 'restoration' from 1997 to 2006. We reviewed all articles and categorized them by publication year, keyword, site-scale, restoration techniques, ecological attributes used as indicators for evaluation, and statistical approaches.

Results and Discussion

A total of 479 articles were published from 1997 to 2006 (Figure 1). Ecological restoration is one of the fastest growing fields of forest science but recently the concept for 'ecological restoration' has been moving to 'forest landscape restoration,' which is a kind of integrating term for achieving ecological integrity and enhancement of human wellbeing. The majority of the studies for ecological restoration were carried out in North America and the most frequently used technique for restoration was planting seedlings with native species. The numerous indices for identification of vegetation structure and diversity such as plant cover, density, biomass, and various diversity indices were used for an indicator to measure restoration. All these indices were attributes of forest structure. However, soil properties and nutrient pool were mostly used to represent the aspect of restoration of forest function. Among the attributes, soil organic matter, organic carbon, and litter dynamics were mostly used as indicators for restoration research. Restoration achievement was commonly evaluated by using a group comparisons such as ANOVA and t-test to compare the variables from reference sites directly, and multivariate analysis such as DCA (detrended correspondence analysis) were used to intensively identify the changes in plant and environmental factors.

Acknowledgement

This work (KRF-2006-214-F00009) was supported by the Korea Research Foundation Grant funded by the Korean Government (MOEHRD).

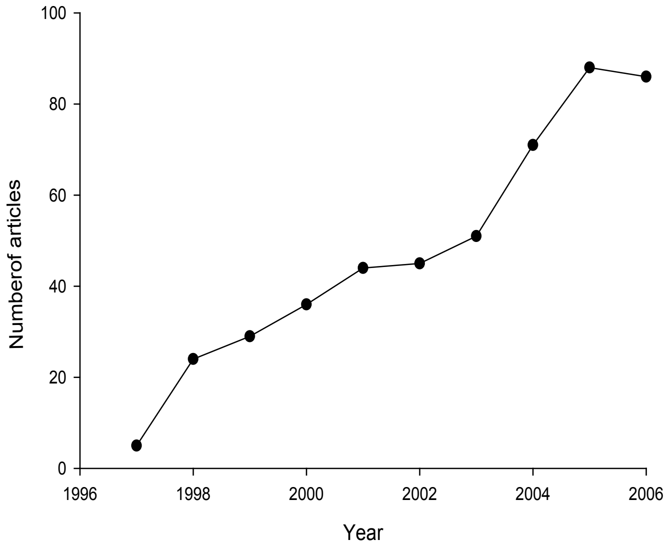


Figure 1. Number of articles in the ISI web of knowledge 'forest' and 'restoration'

Literature Cited

Society for Ecological Restoration International Science & Policy Working Group. 2004. The SER International Primer on Ecological Restoration. www.ser.org & Tucson: Society for Ecological Restoration International.

[1]Center for Forest Disturbance Science, USDA Forest Service, 320 Green Street, Athens, GA 30602, U.S.A. [2] Dept. of Forest Sciences, Seoul National University, Seoul 151-921, Republic of Korea; E-mail: parkyd70@gmail.com

REGULATION OF GROWTH AND DEVELOPMENT OF SECONDARY STANDS WITH KOREAN PINE BY DIFFERENT CUTTINGS IN THE SOUTH SIKHOTE-ALIN MOUNTAINS, RUSSIAN FAR EAST

L. A. Sibirina[1], T. A. Komarova[1], D. K. Lee[2], H. S. Kang[3]

Abstract—Some information is presented on the condition of the Korean pine-broadleaved forest of the South Sikhote-Alin Mountains, which reflects the restoration process in these forests. Experimental thinning in the secondary associations was conducted for 30-yrs. Restoration of Korean pine position as the main forest- forming species can be 40-yrs accelerated by thinning.

The Korean pine-broadleaved forest stands are the most valuable formation of the Far East forests. Korean pine is the main component of these forests and a major source of timber for long-term commercial harvesting. Long-term unrestricted forest use along with wildfires have resulted in the depletion of the resource potential and contributed to the degradation of one of the most valuable forest formations in our country. The area of Korean pine stands decreased by half (Neshataev 1987, Koryakin and Romanova 2000). The problem of restoration and sustainable management of Korean pine-broadleaved mixed forests is an important objective for foresters in the Southeastern regions of the Russian Far East. The aim of our work is to understand the regeneration of Korean pine forests by using thinning systems in the young secondary-mixed stands containing Korean pine.

Methods

In 1977, we began an experiment to determine the influence of intermediate felling on the growth of Korean pine and spruce in young secondary-mixed stands containing Korean pine in the territory of the Verkhneussuriyskiy Forest Station IBS DVO RAS (area is 4500 ha). The Station is located in the northern part of South Sikhote-Alin Mountain system in the Primorsky Krai (44º 01′ N 134º 10′ E). We traced the dynamics of the growth rate of a young generation of the main coniferous species – Korean pine (*Pinus koraiensis*) and spruce (*Picea jezoensis*) on the two permanent plots (p.p.) for 20-yrs after cutting in the deciduous broadleaved-dark coniferous-Korean pine forest (Table 1).

We made intermediate cuttings (clear, partial, and selective cutting) for Korean pine and spruce in 1977 and 1987. We used our scheme for selecting trees. Intermediate cutting of Korean pine and spruce was conducted as follows: all thin trees of category S-3 (diameter up to 16-cm) were cut down, and those of diameter class of 20-cm were dried at roots. Sound trees of category S-1, which slowed development of Korean pine, were cut less often. Intensity of intermediate cutting depended on quantity of Korean pine and other valuable species.

Results and Discussion

Mixed-shrub Korean pine forest with yellow birch is the most widespread type of Korean pine–broadleaved formation. They usually occupy steep and very steep slopes, and less often are found on gentle slopes. Aspect is mainly northern, western and eastern, up to an elevation of 600-700 m a.s.l. The usual accompanying species in this type

Characteristics of the research areas

#-year; number of sections; plot size (ha); year of major cutting	Location; exposure; elevation; soil	Forest community; forest association to the major cutting (index of types of forest on Yefimov, 1955)	Underbrush and lianas: distribution; density; predominant species	Grass layer: development; distribution; a covering; predominant species
22-1977; 4; 0.7; 1965	44°01′54,01″N 134° 11′33,80″E; NW′5-10° 620-630 m; brown forest	Dense coniferous-broadleaved young stands with old trees; K-IV	Well developed, multi-species, irregular; 0.3-0.6; *Acer barbinerve, Corylus mandshurica, Eleutherococcus senticosus, Lonicera maximoviczii, Padus asiatica, Philadelphus tenuifolius, Sorbaria sorbifolia, Spiraea ussuriensis, Actinidia kolomikta, Schisandra chinensis*	Well developmed, mosaic, irregular about 40%, *Athyrium sinense, Pseudocystopteris spinulosa, Carex campylorhina, C. xiphium, Leptorumohra amurensis*
47-1986; 3; 0.7; 1965	44°01′15,79″N 134° 09′07,51″E; NW′10-15° 500-510 m; brown forest	Dense of coniferous-broadleaved young stands with old trees; K-IV	Well developed, multi-species, irregular; 0.1-0.5; *Acer barbinerve, Corylus mandshurica, Eleutherococcus senticosus, Euonymus pauciflora, Philadelphus tenuifolius, Actinidia kolomikta, Schisandra chinensis*	On swath the development is weak, mosaic, from 3% to 50%. On logway Well developed, about 40%. *Carex campylorhina, C. reventa, C. xiphium, C. ussuriensis, Lycopodium annotinum, L. juniperoideum, Maianthemum bifolium, Phegopteris connectilis*

[1] Institute of Biology and Soil Science, Russian Academy of Sciences, Russian Federation, Vladivostok, Russia; email-sibirina@ibss.dvo.ru
[2] Department of Forest Science, Seoul National University, Republic of Korea
[3] NICEM, Seoul National University, Republic of Korea

are yellow birch, linden, fir, and spruce; less often elm, ash, oak, maple, aspen are included. The impurity of co-dominant species can reach more than 50% on a growing stock basis (Quality class forest stands - IV-III).

Secondary stands after harvesting were formed of coniferous and deciduous species. All of the coniferous part of the new forest stand was formed from residual undersized, large, partially average-sized undergrowth, preserved after the main cutting.

Under the influence of thinning it was possible to generate the mixed forest stands with participation of Korean pine on both sites. The best results were evidenced on section #3 (p.p. 22-1977 and p.p. 47-1986) where the share of Korean pine reached 20-30%. The best results of experimental thinning were obtained at cutting of large undergrowth and undersized trees. The Korean pine, which underwent thinning, has overtaken spruce and fir of similar age in height and diameter. Its stock has increased twice on the average, in comparison with the control section where natural regeneration of wood community after clear cutting was observed. Intensive thinning (up to 70%) accelerates the introduction of Korean pine trees into the reproductive phase; formation of macro– and microstrobiles was recorded on section # 3 (p.p. 47-1986) 12-yrs after the firth thinning. The number of cones on a branch was 1-3.

Thinning in regenerative process after clear cutting provides for restoration of climax forest type. In fact, even if a fourth of the total average-size undergrowth of Korean pine and half of the large undergrowth will be part of the forest stand, it will be enough for restoration of Korean pine domination. The primary objects of thinning should be natural forest stands, where the share of Korean pine in the secondary stand is not less than 5-10%.

In secondary stands, which regenerated after the main cuttings in Korean pine forests, the share of Korean pine can be close to minimal, and main forest forming trees are fir and spruce (p.p. 47-1986, section #2), spruce and birches (p.p. 22-1977, section #1 and #2), Korean poplar (p.p. 22-1977, section #4), and other combinations of tree species. In such cases it is necessary to conduct thinning of Korean pine in combination with partial planting of Korean pine for acceleration of reforestation succession.

Acknowlegments
This research was supported by a grant from the Korean Science and Engineering Foundation (KOSEF) "Cooperative research for development of useful natural resources and restoration of degraded ecosystems in Northeast Asian regions" and "Overseas laboratory program" Korea Research Foundation (KRF-2005-212-F00002).

PARTICIPATORY LAND USE PLANNING APPROACH IN FIJI ADDRESSING FLR ELEMENTS

Markus Streil[1] and Eliki Senivasa[2]

Abstract—Forests are an important socio-economic resource on the Fijian Islands covering 45% of the landmass and providing essential environmental services. Only 16% of land is classified as arable land and more than 80% is customary-owned land not saleable. Two government-initiated forestry companies are leasing customary-owned land and restoring degraded grassland on the drier leeward sides of the islands and enriching logged-over, degraded native rain forests in wetter zones respectively. Native forests have a high rate of endemism (up to 65%) but commonly rated low value without existing valuation of its goods and services. More than 85% of land is customary owned belonging to indigenous clans that can only be leased by others that can hamper integrated planning and development on landscape level. Forest loss and degradation continue with unsustainable shifting cultivation on steep land and excessive forest harvesting. The Forest Landscape Restoration (FLR) elements need to be examined to see how far it is or can be incorporated into the existing participatory land use planning approach. Semi-structured interviews and the SWOT method was used to initially analyse FLR principles along the Tikina (district)-based land use planning approach. Research results indicate that the FLR concept is practical in the Fijian context and can demonstrate strengths in regards to restoring environmental benefits and services, reducing vulnerability of forest biodiversity and services (soil protection) and empowering local communities. The Fijian-community-based land use planning covers most FLR principles and shows only some shortcomings within restoration of forest biodiversity and habitats, connecting forest fragments across landscapes, addressing conflicting land use interest, and proper valuation of goods and services. These FLR elements can be adapted based on practical experience and should be incorporated in the existing land use approach to achieve sustainable land and forest management in Fiji.

[1] SPC/gtz Pacifc-German Regional Forestry Project (PO Box 14041 Suva, Fiji Islands); email: markuss@spc.int[2] Fiji Forestry Department Silviculture Research Division

INTERCROPPING OF PAPER MULBERRY FOR SUSTAINABLE LAND USE IN THAILAND

Maliwan Tanasombat[1], Bunvong Thaiutsa[1], Katsutoshi Sakurai[2], Ladawan Puangchit[1], Montathip Sommechai[1], Phadungsak Suekeaw[3]

Abstract—Paper mulberry is a drought-resistant and shade intolerant non-timber-forest crop, and is an opportunistic crop that can be used to counter the ecological risks of monoculture and the increasing degradation of land. Paper mulberry is used as raw material for special and high quality paper in Thailand. Teak, eucalyptus and banana were intercropped with paper mulberry, with consideration to the crops effect on soil and environmental quality. Paper mulberry and teak, eucalyptus or bananas were planted at a spacing of 4 by 6 m in a Latin Square design. Paper mulberry combined with eucalyptus or teak had better growth and development than with banana. Natural regeneration of paper mulberry in terms of the number of sprouts originating from root suckers showed a progressive development. With regard to the biomass of paper mulberry, the highest amount of inner bark and total biomass was recorded when combined with teak (112.0 g stump^{-1} and 1,697.4 g stump^{-1}) followed by the combination with eucalyptus (85.0 g stump^{-1} and 1,640.0 g stump^{-1}), and banana (58.0 g stump^{-1} and 1,070.4 g stump^{-1}).

Paper mulberry is a drought-resistant and shade intolerant non-timber-forest crop that grows well on well-drained and fertile soil derived from limestone (Udomchoke et al. 2001). There are two main species, *Broussonetia papyrifera* and *B. kazinoki*; both are mainly used in hand papermaking. Thammincha (2001) reported that 68% of inner bark consumed in Thailand is locally produced; the rest is imported from Laos and Myanmar. Half of the local production is harvested from natural stands that are normally found in reserved areas. Consequently, some conflicts occur between villagers and foresters about paper mulberry harvesting. An agroforestry system was recommended by using paper mulberry as an intercrop due to the conflicts and its high demand (68,000 Mg yr^{-1}) in paper manufacturing (Supapornhemin et al. 1999). In China, paper mulberry was determined to be suitably grown with many crops such as prosomillet, soybean, sesame and melon, and in addition tea, which must be sown under mulberry or bamboo (You 1991). In this study, *B. kazinoki* was selected to be investigated because it is well known for high quality fiber (Kobayashi 2001) and its shrubby form with several stems (Tajima et al. 2001), which can be a good combination with forest crops. Teak (*Tectona grandis*), eucalyptus (*Eucalyptus camaldulensis*) and banana (*Musa paradisiaca*) were grown as intercrops due to ecological and local requirements. The aim of this study was to determine the optimum combination between agricultural crops and forest crops with *B. kazinoki* that can provide efficient income for the farmers.

Results and Discussion

Study site—The study site was established at Thong Pha Phum Forest Industrial Organization (FIO) plantation, Thong Pha Phum district, Kanchanaburi province, western Thailand. The elevation of the study site is 170 m a.s.l. with moderate annual precipitation (1,765 mm). The average temperature in 2000 was 26.5 °C with an average relative humidity of 83%.

Soil properties—Soil parent material is residuum and soil type was classified as Inceptisols. The morphological characteristics, physical, and chemical properties of soil in the study site indicated the high potential for tree-crop cultivation. Although the high clay content in this soil can affect soil morphological characteristics and physical properties such as soil structure, consistency, bulk density and in particular, hydraulic conductivity (by interaction between soil solution and the solid matrix (Klute and Dirksen 1987), there were no obvious negative effect for plants in this intercropping system. On the other hand, soil structure with medium granular, friable consistence and high percentage of soil porosity in surface and subsurface soil can be suitable for plant growth. In addition, pH (H_2O) in this layer was 5.8, an effective level for plants to take up nutrients with low risk from aluminum toxicity (Young 1997). Chemical properties in surface soils may be used as an indicator for nutrient availability to plants because most roots are concentrated in the A horizon. Comparing the optimum concentration of essential elements for plants (Soil Science Department 2001), the concentration of total carbon (T-C),

[1] Kasetsart Agriculture and Agro-Industrial Product Improvement Institute, Forestry,Kasetsart University, 50 Phaholyothin, Jatujak, Bangkok, 10900 Thailand; email-tanasombat@hotmail.com
[2] Faculty of Agriculture, Kochi University, B200, Nankoku, Kochi 783-8502 Japan
[3] National Park, Wildlife and Plant Conservation Department, Jatujak, Bangkok 10900 Thailand

Table 1--Soil physical properties at the study site in Thong Pha Phum

Depth (cm)	Air phase (%)	Liquid phase (%)	Solid phase (%)	Bulk density (g cm^{-3})	Hydraulic conductivity (cm sec^{-1})	Porosity (%)	Sand (%)	Silt (%)	Clay (%)	Soil texture
00-05	23.5	41.5	35.1	0.919	0.0 x 10-2	64.9	9.43	68.69	21.88	SiCL
20-40	21.7	40.2	38.2	1.026	0.0 x 10-3	61.8	7.76	8.97	83.27	HC
40-60	30.4	36.8	32.8	0.913	0.0 x 10-3	67.2	3.85	4.33	91.83	HC

SiCL=Silty Clay Loam; HC= Heavy Clay

Table 2--Soil chemical properties at the study site in Thong Pha Phum

Depth	$pH(H_2O)$	pH(KCl)	EC	T-C	T-N	C/N ratio	CEC	Exchangeable cations						BS	Av. P
								Na	K	Ca	Mg	Al	H		(P_2O_5)
cm			mS m^{-1}	g kg^{-1}	g kg^{-1}		cmol(+) kg^{-1}							%	mg kg^{-1}
00-20	5.8	4.5	12.5	49.8	3.5	14.2	24.51	0.06	1.49	3.93	4.83	0.06	0.30	42.1	27.7
20-40	5.1	4.0	7.5	28.1	2.5	11.4	19.86	0.03	0.18	0.41	0.60	2.14	0.31	6.2	6.9
40-60	4.7	4.1	11.8	17.3	1.5	11.6	18.37	0.05	0.09	0.22	0.32	1.71	0.17	3.8	6.8

EC = electric conductivity; T-C and T-N = total carbon and nitrogen;
CEC = cation exchange capacity; BS = percentage of base saturation;
Av. P = available phosphorus

total nitrogen (T-N) and average phosphorous (Av. P) was higher. Base saturation (BS) was also high in the surface layer due to high amount of exchangeable bases. For this reason, soil in this study site can be considered as fertile soil.

Growth, yield and natural regeneration of *B. kazinoki*—The survival rate for *B. kazinoki* after planting was not significantly different among treatments as shown in Table 3. Stem diameter at 10 cm above ground in the teak plot was significantly higher than those in the eucalyptus and banana plots having 2.07, 1.90 and 1.71 cm, respectively. Pearson's correlation analysis (p=0.01) showed that diameter at 10 cm above-ground was significantly correlated to the number of coppices $stump^{-1}$ after harvest. Among treatments, total height and number of coppices $stump^{-1}$ after harvest showed insignificant differences. On the other hand, natural regeneration in terms of number of sprouts ha^{-1} was significantly different within three agroforestry systems which were recorded to have 40,131, 21,200 and 19,700 sprouts ha^{-1} for eucalyptus, teak and banana plots, respectively. The difference between total biomass of B. kazinoki in the three plots was not significant. Contrary to the total biomass, *B. kazinoki* intercropped with teak showed significantly higher inner bark biomass than those in the eucalyptus plot and in the banana plot (Table 3).

Table 3--Survival rate, growth, natural regeneration and biomass of *B. kazinoki* planted in agroforestry systems

Parameters	*B. kazinoki* + Eucalyptus	*B. kazinoki* + Teak	*B. kazinoki* + Banana
Survival rate, %	88.2	89.6	85.5
Stem diameter, cm (at 10 cm above ground)*	1.90b	2.07c	1.71a
Total height, m	1.98	2.04	1.71
Natural regeneration, sprouts ha^{-1}*	40,131c	21,200 b	19,700 a
No. of coppices $stump^{-1}$	4.4	5.1	4.7
Total biomass, g $stump^{-1}$	1,640.0	1,697.4	1,070.4
Inner bark biomass, g $stump^{-1}$*	85.0 b	112.0 c	58.0 a

* = differences in the mean are significant at the 0.05 level, values within rows followed by the different superscript are significantly different using Duncan's test

In relation to growth and yield of intercropping plants, annual diameter increment at breast height (DBH) for teak and eucalyptus including the number of pseudostems $clump^{-1}$ and yield of banana were recorded (Table 4). The annual DBH increment of eucalyptus was 4.55 cm at three-years-old, which was high when compared

Table 4--Growth and yield of two-year-old intercropped plants (eucalyptus, teak and banana)

Parameters	Eucalyptus[1/]	Teak	Banana
Annual DBH increment, cm yr^{-1}	4.55	2.50	-
Number of psuedostems $clump^{-1}$	-	-	7.4
Yield, kg ha^{-1} yr^{-1}	-	-	33,056

[1/] =eucalyptus was 3-years-old

to eucalyptus in combination with other crops in Mexico (Foroughbakhch et al. 2001). For two-year-old teak, annual DBH increment was 2.50 cm, which was greater than those of teak and Leucaena intercropping in central Kerala, India (Kumar et al. 1998). The average number of pseudostems $clump^{-1}$ of banana was 7.4 pseudostems $clump^{-1}$ with 33,056 kg ha^{-1} yr^{-1} for banana fruit yield which can provide a steady income of 4,132 US$ ha^{-1} yr^{-1} for farmers. The high potential of banana has been shown to improve the farmer's income substantially when intercropped with para rubber in Sri Lanka (Rodrigo, 2001).

B. kazinoki with eucalyptus and teak combinations showed better growth and development than with the banana combination, especially for stem diameter. Natural regeneration represented by the number of sprouts originating from root suckers showed significantly effective development for *B. kazinoki* in combination with eucalyptus even though both species are fast growing that can powerfully compete for nutrients, moisture, and light. Eucalyptus showed negative effects in many studies when it was intercropped with other plants (Narain et al. 1997, Souto 2001, Molinero and Pozo 2004). However, it provided better growth opportunities for *B. kazinoki* when compared to teak and banana in this study. *B. kazinoki* intercropped with teak and banana had a small number of sprouts that may be caused by the deciduous characteristic of teak and evergreen-clump-form characteristic of banana. This phenomenon showed that the deciduous/ evergreen characteristics of the intercrops may have led *B. kazinoki* to emphasize light demand. In combination with *Andropogon gayanus*, the eucalyptus plot had a high herbaceous biomass because it gives little shade and the lowest fine root mass in the top of *A. gayanus* (Harmand et al. 2003). Growth and yield of other pioneer species in the Moraceae family were also related to light intensity (Veneklass et al. 2002, Gagnon et al. 2004).

Conclusion

In combination with *B. kazinoki*, eucalyptus and teak showed an adequate growth increment as well as yield of banana that provided a satisfactory income for the farmers. Considering the benefits from the inner bark of *B. kazinoki*, the combination of *B. kazinoki* and eucalyptus is an appropriate combination that provides optimum growth and yield for both crops. Moreover, an effective natural regeneration of *B. kazinoki* in this combination would increase the yield of *B. kazinoki* in the following harvests. Besides annual yields from *B. kazinoki*, a short rotation of eucalyptus (5 yrs) could have been an incentive for farmers to adopt this agroforestry system. There is a perception among rural communities that tree planting is too lengthy a venture, but for foresters, eight to ten years is considered to be a short-rotation period for tree crops. Normally, when the farmers venture into any activity, they expect to see financial returns within three years (Lee 2004). Therefore, *B. kazinoki* can be intercropped in eucalyptus plantations to increase diversity for ecological benefits, and to provide an annual income for the farmers as well. In teak plantations, *B. kazinoki* is recommended between rows of teak, and the combination of teak and *B. kazinoki* should be introduced into the buffer zones that are located between reserved areas and community areas. In combination with banana, although *B. kazinoki* provided lower growth and yield, it may be preferred by farmers who want high annual income. Based on these results, *B. kazinoki* can grow as an alternative crop in agroforestry systems. However, it must be kept in mind that this species is light-demanding. It would provide a good yield when its intercrops are managed as an understory. On the other hand, if *B. kazinok*i is managed as an understory, the overstory intercrops should be a thin-canopy species.

Acknowledgements
This study was supported by The Higher Utilization of Forestry and Agriculture Plant Materials in Thailand Project in cooperation with JICA (The Japan International Cooperation Agency) and Kasetsart University, Bangkok Thailand. Moreover, this project received funds from Kasetsart University Research and Development Institute (KURDI).

Literature cited

Foroughbakhch, R., Hauad, L.A., Cespedes, A.E. [and others]. 2001. Evaluation of 15 indigenous and introduced species for reforestation and agroforestry in northeastern Mexico. *Agroforestry System* 51: 213-221.

Gagnon, L.J., Jokela, E.J., Moser, W.K. [and others]. 2004. Characteristics of gaps and natural regeneration in mature longleaf pine flatwoods ecosystems. *Forest Ecology and Management* 187: 373-380.

Harmand, M.J., Donfack, P., Njiti, C.F. 2003. Tree-root systems and herbaceous species-characteristics under tree species introduced into grazing lands in subhumid Cameroon. *Agroforestry Systems* 59: 131-140.

Klute, A., Dirksen, C. 1986. Hydraulic conductivity and diffusivity: Laboratory method. In A. Klute (ed.). 1986. *Methods of soil analysis part I-Physical and mineralogical methods* (2nd ed.): 687-732.

Kobayashi, Y. 2001. The spreading of hand papermaking and paper mulberry in Asia. *In*: Proc. The International Symposium on Paper Mulberry and Hand-Made Papers for Rural Development. Bangkok, Thailand: 14-26.

Kumar, B.M., Kumar, S.S., Fisher, R.F. 1998. Intercropping teak with Leucaena increase tree growth and modifies soil characteristics. *Agroforestry Systems* 42: 81-89.

Lee, H. S. 2004. Introducing the cultivation of medicinal plants and wild fruits in Sarawak. *Southeast Asian Studies* 42(1): 60-73

Rodrigo, V.H.L., Stirling, C.M., Naranpanawa, R.M.A.K.B. [and others]. 2001. Intercropping of immature rubber in Sri Lanka: present status and financial analysis of intercrops planted at three densities of banana. *Agroforestry Systems* 51: 35-48.

Soil Science Department. 2001. *Introduction to Soil Science.* Kasetsart Univ., Bangkok, Thailand. 261 pp. (in Thai)

Supapornhemin, P., Seradee, I., Khammuang, P. [and others]. 1999. New directions of paper mulberry development. In: Proc. Production and Utilization of Paper Mulberry (KAPI and JICA ed.). Kasetsart Univ., Bangkok: 1-2.

Tajima, M., Thaiutsa, B., Puangchit, L. [and others]. 2001. Growth and allometry of Thai paper mulberry (*Broussonetia papyrifera*) and Japanses Kozo (*B. kazinoki*) grown in Thailand. In: Proc. The International Symposium on Paper Mulberry and Hand-Made Papers for Rural Development. Bangkok, Thailand: 99-117.

Thammincha, S. 2001. Role of Saa fiber to rural development. In: Proc. The International Symposium on Paper Mulberry and Hand-Made Papers for Rural Development. Bangkok, Thailand: 1-2.

Udomchoke, V., Mongkolsook, Y., Anapanurak, W. [and others]. 2001. The environmental conditions on natural distribution of paper mulberry in Thailand. In: Proc. The International Symposium on Paper Mulberry and Hand-Made Papers for Rural Development. Bangkok, Thailand: 79-90.

Veneklaas, E.J., Santos Silva, M.P.R.M., Ouden, F.D. 2002. Determinants of growth rate in Ficus benjamina L. compared to related faster-growing woody and herbaceous species. *Scientia Horticulture* 93: 75-84.

You, X. 1991. Mixed cropping with trees in ancient China. In Zhu, Z., Cai, M., Warg, S. and Jiang, Y. (eds). *Agroforestry System in China.* The Chinese Academy of Forestry People's Republic of China and International Development Research Center, Canada: 1-3.

Young, A. 1997. *Agroforestry for Soil Management*. ICRAFT, Nairobi, Kenya. 320 p.

RESEARCH ON THE EFFECTS OF FOREST SHELTERBELTS ON AGRICULTURAL CROPS

Maria Magdalena Vasilescu, Cristian Teresneu, Bogdan Candrea

Abstract—In the south of Romania many forest shelterbelts were established before 1960 to protect agricultural crops, roads, or railways. Unfortunately almost all shelterbelts were cut down in 1961-1962. Today many efforts are made for the establishment of a network of national shelterbelts. From this point of view this paper emphasizes the positive effects of shelterbelts on agricultural crops based on measurements carried out in 2005 in Teleorman County (south of Romania). Different agricultural crops such as wheat, maize and sunflower were analyzed in areas protected and non-protected by forest shelterbelts.

In the forest steppe and plain regions of Romania the proportion of land covered by forests varies between 4% and 8%. The most important reason for this low level is past deforestation and drought years. Especially in the south of Romania, forest shelterbelts to protect agricultural crops, roads, or railways were established before 1960. For political reasons almost all protection plantations were cut down in 1961-1962. From this point of view our paper outlines the benefits of agricultural crops protected by shelterbelts based on measurements carried out in 2005 in two plains in Teleorman County. Different agricultural crops such as wheat, maize and sunflower were analyzed in both protected and non-protected areas.

The effects of shelterbelts on wheat crops were analyzed in nine plots located within five shelterbelts. Within these plots a different number of sub-plots of 1 m^2 each were established at different distances away from shelterbelts to calculate the mean length of ear, mean height of corn field, mean number of grains per ear, and mean weight of grain for two wheat varieties *(Dropia and Flamura* '85). The maize crops were examined in two forest shelterbelts including two plots. The parameters studied in 4.9 m^2-size sub-plots were the mean length and diameter of corn cobs as well as the mean height of maize crop. The sunflower crops were analyzed in two forest shelterbelts including five plots. In sub-plots of 4.9 m^2-size, the mean diameter of capitulum and the mean height of sunflower crops were computed.

Results and Discussion

Even though 2005 was a wet year the results are relevant, showing a positive and significant influence of forest shelterbelts up to 20-25 H distance (H = mean height of shelterbelt). The most relevant conclusions of the study are as follows:

- in 22 out of 30 cases for *Flamura*'85, the mean length of ears from the protected field was higher than in the non-protected field
- in 24 out of 30 cases the mean height of the protected crop was higher than in the non-protected one
- in 29 out of 30 cases the mean number of grains per ear in the protected crop was higher than in the non-protected one;
- in 13 out of 30 situations the mean weight per grain from the protected field was higher than in the non-protected field.

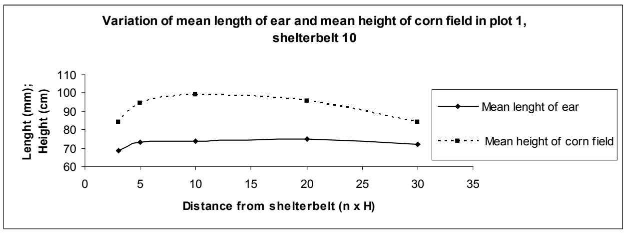


Figure 1--Influence of shelterbelt 10 (plot 1) on the wheat crop

The correlation coefficient showed positive and significant correlations between the mean length of the ear and mean height of corn field, the mean length of the ear and mean number of grains per ear. The values of the same coefficient show significantly negative correlations in 3 out of 6 cases for the mean number of grains per ear and mean weight per grain.

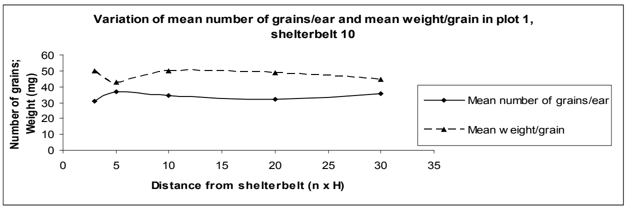


Figure 2--Influence of shelterbelt 10 (plot 1) on characteristics of ears

All statistical populations were homogenous. The coefficients of variation are less than 30% for each 1 m^2 sub-plot resulting uniformity in the characteristics of ears from the protected fields as compared with the non-protected area. This analysis outlines the direction of change that

Table 1--Mean values of wheat parameters in non-protected areas

Mean length of ear (cm)	Mean height of corn field (cm)	Mean number of grains per ear	Mean weight per grain (mg)
6.71	82	28.22	47.36

University "Transilvania" of Brasov, Brasov, Romania; email-vasilescum2001@yahoo.com

shelterbelts induced on wheat crops at different distances away from shelterbelt.

Using two parameters (mean number of grains per ear and mean weight per grain), the surplus of yield was estimated for *Flamura*'85 in different plots from protected areas. The results indicate at least 6% of additional yield, even in a wet year like 2005. This surplus can be 9,000 kg in a 50 ha area with shelterbelts in case of a medium yield (3,000 kg ha^{-1}).

Table 2--Surplus of yield for *Flamura'85* in the protected areas

Shelterbelt/Plot	Surplus of yield in the protected area (percent)	
	Without road area	Without road area and shelterbelt
Shelterbelt 8, Plot 3	12.77	5.91
Shelterbelt 9, Plot 2	19.82	12.73
Shelterbelt 10, Plot 1	19.35	12.27
Shelterbelt 10, Plot 2	12.86	5.99
Shelterbelt 10, Plot 3	12.82	5.96

The measurements (2005) on maize crops showed that in most situations the surplus of yield in the protected field was caused by the second cob/ one corn plant. The analyzed populations were homogenous and in the case of height of maize crop the variation coefficients were lower than 5% in each 4.9 m^2- sub-plot.

The results of the sunflower crop emphasize the fact that near to shelterbelts, the break of plants caused by the excess water was almost nil. This process was very active away from shelterbelts. The most relevant influence of shelterbelts on sunflower crops are up to 10 H from the protective culture. The analysis of variation indicates homogenous populations also in each 4.9 m^2-sub-plot.

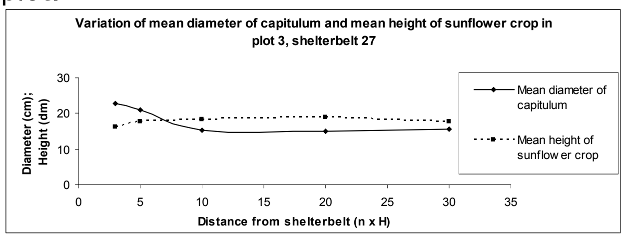


Figure 3--Influence of shelterbelt 27 (plot 3) on the sunflower crop

The values of the correlation coefficient showed a positive and significant correlation between the distance from shelterbelts and mean height of sunflower crops. The values of the same coefficient showed a significant negative correlation in 4 out of 5 situations for mean diameter of capitulum and mean height of sunflower crops. The same correlation was found in 3 out of 5 cases for the distance from shelterbelts and mean diameter of capitulum.

EFFECTS OF SOD CULTURE ON SOIL EROSION, SOIL PROPERTIES, AND NUT YIELD AND QUALITY IN THE AGED CHESTNUT ORCHARD

Hyung-kyu Won, Yoon-Young Lee, Seung-Woo Lee, Choong-Hwa Lee, Yong-Ho Jeong

Abstract—Chestnut trees are economically the most important nut tree species cultivated in rural and mountainous area of Korea. In recent years, most of the aged chestnut orchards showed low nut productivity because of soil devastated by abuse from chemical fertilizer and herbicide. Therefore, this study has investigated the effect of the sod culture to recover devastated soil. We selected the potent herbs such as *Lolium multifloraum, Festuca arundinacea, Secale cereale, Artemisia iwayomogi* and *Pteridium aquilinum* var. *latiusculum* in cultivation experiments. In a field lysimeter experiment, soil erosion in the herbicide treatment plot was three times higher than in the sod culture plot. After four years of sod culture, soil bulk density decreased significantly, while there was a tendency to increase in the herbicide treatment plot. Soil organic matter, total nitrogen, available phosphate and exchangeable cation concentration increased significantly in the sod culture plot. Available phosphate concentration within soil in the sod culture plot was forty-times higher than that in herbicide treatment plot. Also, nut production and the proportion of large-sized nuts in the sod culture plot was 8~30% and 6~24% higher than those in herbicide treatment plot, respectively. These results suggest that sod culture could have mulching effects on soil and promote an increase in nut productivity in aged chestnut orchard.

Department of Forest environment, Korea Forest Research Institute, 207 Cheongnyangni 2dong, Dongdaemun gu, Seoul, Korea, 132-701 Email: won2125@foa.go.kr

ROLE OF MICROENVIRONMENT FOR RESTORATION ON FOUR TROPICAL SPECIES IN THE LA MESA WATERSHED, PHILIPPINES

S.Y. Woo[1], D.K. Lee[2], Y.K. Lee[2] and W. M. Carandang[3]

Abstract—Seedlings of four tree species (*Bischofia javanica, Dracontomelon dao, Erythrina orientalis,* and *Pterocarpus indicus*) were planted in flat and sloping grassland in plantation sites established in May 2002 in the La Mesa watershed, Philippines. Tree growth and net photosynthetic rate (PN) were monitored. The height, diameter at the root collar, and PN of the four species grown in the sloping grass site were larger than those of seedlings grown in the flat grass site. In addition, soil moisture contents in the sloping grass site were higher than those of the flat grass site. Growth of the four species was probably strongly associated with microenvironments (e.g. air temperature) in both tested sites.

[1] Department of Environmental Horticulture, University of Seoul, Seoul 130-743, Republic of Korea; email-wsy@uos.ac.kr
[2] Department of Forest Sciences, College of Agriculture and Life Sciences, Seoul National University, Seoul, 151-921, Republic of Korea
[3] Institute of Agroforestry, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines.

LAND COVER CLASSIFICATION AND FOREST AREA CHANGE DETECTION OF DMZ IN KOREA

Hee Moon Yang, Jung Hwa Chun, Jong Hwan Lim, Joon Hwan Shin

Abstract—This study was carried out to characterize the present land cover for the Demilitarized Zone (DMZ) and its surrounding area, the Civilian Control Zone (CCZ) in Korea, and to detect change over time using remotely sensed images. Land cover changes in the DMZ and CCZ were mapped by comparing past and present Landsat TM 5 and 7 satellite images. Land cover maps showing seven categories of present land cover and change were developed using supervised classification techniques including calculation of NDVI and GIS overlay between 1987-1989 and 2001. The main category of quite large change is 'Forest 1 class' of which stem density and viability are relatively high. The area of change was larger in North Korea than in South Korea due to the conversion of forests into cropland and barren land for food production and supply of fuel wood. Forests inside the DMZ showed better connectivity than the surrounding area.

The Demilitarized Zone (DMZ) is 4 km wide and 248 km long, and lies across the middle part of Korea along the Military Demarcation Line since 1953. Another 10-20 km was added to the width as the Civilian Control Zone (CCZ) that allowed only the military access in the southern part of the DMZ. While preventing public access keeps some area from human disturbances, other areas have been disturbed frequently for military purposes such as sight clearing. These frequent disturbances have created forests more open than the landscape might naturally have, resulting in more diverse landscape mosaic with various habitats from open areas to closed canopy structures (Shin et al. 2002, John et al. 2003). The ecosystem of the DMZ may change into another direction in case of Korean unification because the disturbances by the army operations would no longer exist while disturbances by humans may increase because public access is available. Therefore, we should keep trying to understand and monitor the DMZ ecosystem and apply the experience for better conservation and/or management of the ecosystem.

Materials and Methods

To detect forest cover change over time more accurately, LANDSAT Thematic Mapper(TM) 5 and 7 satellite images of 1987-1989 and 2001 taken at the same phenological period were used because phenological differences between two images may cause misclassification of pixels. Because of the complexity of the data and the lack of ability to predict the ideal combination of images for clustering, iso-data cluster images first were produced by unsupervised classification. NDVI (Normalized Difference Vegetation Index) was also calculated as a tool to evaluate forest condition and its viability related to the disturbance regimes in the DMZ. Supervised classification was then executed based on the iso-data cluster images, NDVI images, and ground truth data obtained by field survey. Post-Classification Comparison involves the classification of each of the images independently, followed by a comparison of the corresponding thematic labels to identify areas where change has occurred. The comparison of separately classified images was carried out visually, or quantitatively to detect such changes as forest to non-forest cropland or non-urban to urban conversion.

Results and Discussion

Classification results were developed into maps showing seven categories of land cover in 1987-1989 and 2001. Due to the difficulty of separating closely allied categories, such as grasses and bushes, from one another in a single satellite image, it was decided to simplify the classification classes. Thus, grassland was included in relatively young forest stand with low stem density (Forest 2 Class). As a matter of fact, it is not easy to find grassland without any shrub species and woody species in Korea except for artificial pasture land. The main category of large change was 'Forest 1 class' of which the stem density and viability are relatively high. The area of 'Forest 1 Class' decreased from about 640,716 ha to 526,970 ha. The doubling of the 'Forest 2 Class' was presumed to be the increased regeneration of young trees followed by disturbances such as fire, insects, and cutting. The area of change was estimated to be larger in North Korea than in South Korea mainly due to the conversion of forests into dry fields and barren land for food production and supply of fuel wood. The forests inside the DMZ showed better connectivity than the surrounding area in some of the southern parts. Forest deterioration was more severe in western low land than in eastern mountainous area.

Division of Forest Ecology, Korea Forest Research Institute, 207, Cheongyangni-2 dong dongdaemun-gu, Seoul, 130-712 Korea; email-ycology@foa.go.kr

Conclusions

The DMZ and CCZ were unique ecosystems maintained by the combination of military operations and prevention of public access, which did not include human being but mainly controlled by human being, resulting in high biodiversity in particular areas along with low biodiversity areas, rather than a well preserved ecosystem. The area surrounding the DMZ, however, has been under the pressure for urbanization and the expansion of dry field and barren land according to the results of this study. Building and maintaining a network to connect these high biodiversity areas and ecological corridors should come with forest restoration to conserve the surrounding areas in order to make the forest ecosystem in the entire DMZ fully functioning. A master plan for the rational conservation and management of the DMZ and surrounding areas should be prepared to suggest overall plan to conserve and manage the DMZ and surrounding areas in a nature-friendly manner, which is a uniquely maintained ecosystem that soon may be gone if Korea is unified.

Literature Cited

John, J.H., Youn, Y.C., Shin, J.H. 2003. Resolving conflicting ecological and economic interests in the Korean DMZ: a valuation based approach. *Ecological Economics* 46: 173-179.

Shin, J.H., Lim, J.H., Park, P.S., Oh, J.S. 2002. Ecological characteristics and conservation strategies for the demilitarized zone and civilian control zone of Korea. Proceedings of XI International Symposium on BIO-REFOR, pp. 235-239.

GOVERNMENT POLICY OF THE FOREST LANDSCAPES PLANNING AND MANAGEMENT IN KOREA

Rheehwa Yoo[1], Dukjae Lee[1], Siyeon Ha[1], Jaejun Kim[1], Yeonyong Yoon[1],
Sangseop Lim[2], Sinhyeong Kang[2]

Abstract—It has recently been a trend in South Korea that the landscape value of forests as an amenity resource is understood to improve the quality of life. As a matter of fact, forest landscapes have been managed for a long time through the concept of "Landscape Security Forest (LSF)," an institutional device of using landscapes for public security. According to the Article 43 of Afforestation and Forest Management Law, LSF is defined as 1) a forest that is necessary for landscape conservation around cultural heritages, recreation sites, natural parks, theme parks, etc., and 2) a forest that is necessary for landscape conservation around motorways, main roads, rail lines and suburban areas. Article 20 states that LSF is one of the urban forests that have to be used for afforestation and forest management. The area of LSF takes 27,833 ha, which is approximately 8.2% of total 341,415 ha of Security Forests. In addition, a guideline for sustainable forest management classifies forests in six functional categories in which "Living Environment Conservation Forest" is recognized as a landscape forest offering scenic satisfaction and psychological comfort to the public. Through a series of guidelines and laws, the landscape value of forests has been regarded as an important element for forest management, and likely this will increase greatly. For the purpose of landscape management nationwide and for creating amenity, the Ministry of Construction and Transportation is trying to establish a "Landscape Law" that is now pending in the National Assembly of Korea. This development is important, because the legal system is emphasising landscape value related to planning and management of forest landscape nationwide. With the Ministry, the Korea Forest Services should systematically promote a legal and institutional basis for creation and management of forest landscape resources, for example by establishing a basic scheme for landscape forest, conserving outstanding landscape resources, etc. Nevertheless, there are some obstacles to promoting a policy for forest landscapes in Korea. Firstly, there is little concern about forest landscapes. Although landscape is generally recognised as an important factor, forest landscapes are still underestimated in terms of the pattern of core landscape components. Secondly, institutional supports are insufficient for conservation and improvement of forest landscapes. Preliminary criteria for deforestation are not well stated, which leads to excessive impacts on forest landscapes due to construction of new roads, outdoor training facilities, and so on. Thirdly, technological advances in afforestation and reforestation to improve forest landscapes are needed. The method of disseminating newly developed skills also has to be considered. In conclusion, a reform measure is urgently needed in order to promote effective policy for forest landscapes for the future.

[1] Korea Forest Research Institute, Seoul, South Korea; email-cham0505@foa.go.kr
[2] Urban Forest Team, Korea Forest Service, Daejeon, South Korea.

SELECTING THE TREE SPECIES AND ESTABLISHING THE PASTURE TO COMBAT DESERTIFICATION

Ho-joong Youn, Chun-yong Lee, Changwoo Lee

Abstract—Strong winds including Asian dust coming from deserts of China and Mongolia in spring adversely affect people and forests, both environmentally and financially. Asian dust is monitored and effective control measures are devised through international joint projects. A joint research project on combating desertification has been conducted since 1996 between the Chinese Academy of Forestry and the Korea Forest Research Institute. In this research project, we have focused on improving soil and nutrients and selecting proper trees and grasses to control desertification. To combat desertification, soil improvement experiments were carried out to create suitable environments in the nursery and a windbreak in Inner Mongolia Autonomous Region, China. This study was conducted to select *Populus* clones that have cold- and salt-tolerant characteristics and drought resistant grass species for pastures.

Summary

Improvement of soil and nutrients—Tree height and breast height diameter (DBH), biomass and nitrogen (N), phosphorus (P), calcium (Ca), potassium (K), magnesium (Mg) and sodium (Na) concentrations of Xinjiang poplar (*Populus alba* var. *pyramidalis*) seedlings treated with fertilizers and soil amendments were examined in the nursery and a windbreak at Dengkou in Inner Mongolia, China. Height and DBH growth of Xinjiang poplar seedlings were higher at N and N+P fertilizer treatments than other treatments in the nursery and windbreak. Biomass of Xingjiang poplar seedlings increased after N and N+P fertilizer treatments whereas biomass decreased after P fertilizer treatment in the nursery in 2003. Total biomass was highest in the N+P fertilizer treatment, yielding 14.90g in the nursery in 2004. Foliar N concentration was higher in the N and N+P fertilizer treatments than other treatments in the nursery after one year (2003). Foliar N and P concentrations showed no differences among fertilization treatments in the nursery after two years (2003). However, N concentration in foliage was higher than in shoots and roots. Foliage N and P concentrations were highest in the N fertilizer and K-SAM (soil amendments) treatments in the windbreak after two years (2003), respectively 2.18% and 0.15%. Calcium, K and Mg concentrations in foliage, shoots, and roots were highest in the P fertilizer treatment, and P fertilization increased Ca, K and Mg concentrations in the nursery after two years (2003). Foliar Na concentration was highest in the K-SAM treatment in the windbreak in 2004, 0.03%. Native plant Yuho and K-SAM treatments increased height and DBH growth in the windbreak. Nitrogen appeared an influencing factor for early growth of Xinjiang poplar, and phosphorus had a minor affect on growth. Long-term studies are needed to fully elucidate the effects of fertilizers and soil amendments on growth and nutrients of Xinjiang poplar.

Selecting Trees Via Biotechnology—The objective of this part of the study was to select poplar clones that have cold-and salt-tolerant characteristics. We investigated net growth of the plants in terms of height and DBH of hybrid poplars in Korea and Inner Mongolia. Fifteen poplar clones were introduced into Korea from the USA and China and planted in Korea and Inner Mongolia.

Clones were measured for height, DBH, and tolerance to cold. Among these clones, clone DN-34 was selected the most desirable clone. Therefore, hybrid poplars with parentage of *Populus deltoides* and *Populus nigra* were the most recommended species for arid conditions. Among nine domestic poplar clones planted in China, BH clone had the best growth quality with 4 m of height growth and cold hardiness characteristics. Survival rate of this clone was about 90%. In conclusion, this study suggested that BH and DN-34 clones were suitable poplar species to combat desertification in dryland and clone 110 was also good candidate clone.

Selecting Glasses For Pasture Establishment—A drought resistance experiment was conducted with 56 species of cool season grasses. *Festuca arundinacea* and *Lolium perene* were selected as the most drought resistant species for pasture performance in the desertification area of China. Seed germination experiments were performed with five warm season grasses and eight legume species. Among these 13 species, five legumes (*Medicago sativa, Lotus corniculatus, Trifolium pratense, Indigofera pseudo-tinctoria, Lespedeza cuneata*) and three warm season grasses (*Cynodon dactylon, Eragrostis curvula, Arundinella hirta*) were selected as salt resistant species. Finally five

Korea Forest Research Institute, Seoul, Republic of Korea; email-kingccagag@hanmail.net

warm or cool season grasses and five legumes were found to be usable plants in the desertification area of China through special investigations in the laboratory. Two grass species (*E. curvula* and *F. arundinacea*) and three legumes (*M. sativa, T. pratense and L. corniculatus*) in Jungeerqi were estimated to live in the desertification region with high temperatures and dry conditions in the summer and low temperature in winter. These plants could be used for proper pasture performance in the desertification area. In Dengkou, *F. arundinacea* was a superior grass and two legumes (*M. sativa and L. corniculatus*) were excellent. Mixed seeding is a better revegetation method than seeding a single grass species. We recommend that seeding with a mixture of legumes and grasses is more effective for establishing pasture in the desertification area in China.

Literature Cited

Barney, C.W. 1976. *Forest Tree Planting In Arid Zones*. Academic Press.

Rita, M. 2000. Right Tree-Right Place. White Pine and Salt Tolerance. Forestry and Natural Resources, Purdue University.

Wang, R. Z. 2001. Photosynthesis, transpiration and water use efficiency of vegetative and reproductive shoots of grassland species from north-eastern China. *Photosynthetica* 39(4): 569-573.

INDEX