International Union of Forest Research Organizations
Union Internationale des Instituts de Recherches Forestières
Internationaler Verband Forstlicher Forschungsanstalten
Unión Internacional de Organizaciones de Investigación Forestal

IUFRO World Series Vol. 15

Meeting the Challenge: Silvicultural Research in a Changing World

Extended abstracts
From the conference held in Montpellier, France,
From 14 to 18 June 2004

Jointly organized by
IUFRO – Division 1 (Silviculture)
USDA Forest Service
CIRAD-Forêt
Institut National de la Recherche Agronomique (INRA)

Editors
John A. Parrotta, Henri-Félix Maître,
Daniel Auclair, Marie-Hélène Lafond

ISBN 3-901347-51-8
ISSN 1016-3263

IUFRO Headquarters
Vienna, 2005

Recommended catalogue entry:
Meeting the Challenge: Silvicultural Research in a Changing World. Extended abstracts from the conference in Montpellier, France, June 14-18, 2004, jointly organized by the International Union of Forest Research Organizations (IUFRO) - Divison 1 (Silviculture), USDA Forest Service, CIRAD-Forêt, and the Institut National de la Recherche Agronomique (INRA). John A. Parrotta, Henri-Félix Maître, Daniel Auclair, Marie-Hélène Lafond (editors). Vienna, IUFRO, 2005. - 185 p. - (IUFRO World Series Vol. 15)

ISBN 3-901347-51-8
ISSN 1016-3263

Published by:
IUFRO Headquarters, Vienna, Austria, 2005

Available from:
IUFRO Headquarters
Secretariat
c/o BFW Mariabrunn
Hauptstrasse 7
1140 Vienna
Austria

Tel.: +43-1-8770151-0
Fax: +43-1-8770151-50

E-mail: office@iufro.org
Web site: www.iufro.org

Price:
EUR 20.-
plus mailing costs

Printed by:
Austrian Federal Office and Research Centre for Forests, Vienna, Austria

CONTENTS

Page

Extended Abstracts of accepted papers not presented at conference

IUFRO Division 1 Conference

Meeting the challenge: Silvicultural Research in a Changing World

Hotel Mercure, La Grande Motte, Montpellier, France
June 14-18, 2004

PROGRAM

Monday, 14 June

9:00-10:30 **Opening session**
- Jacques Valeix (Director, Département Forêts, Cirad)
- Eric Teissier du Cros (IUFRO Vice-President, Science)
- John Parrotta (Coordinator, IUFRO Division 1)

10:30-11:00 Coffee break

11:00-12:30 **Opening session** (***continued***)
- Alain Franc (France – Coordinator, IUFRO Division 8): "Heterogeneous stands – Between silviculture and ecology, between empirical and scientific knowledge" [coauthored with Robert Jandl and Sophie Zechmeister (Austria)]
- Mark Hunt (Australia) – Special presentation on IUFRO World Congress 2005, Brisbane, Australia.

12:30-14:00 Lunch

14:00-16:00 **Technical Session 1.** ***Landscape-level management***
Moderator: Björn Hånell (Sweden)

- "Close-to-nature silviculture: an example from Italy's eastern Alps." G. Grassi, G. Minotta, R. Giannini & U. Bagnaresi (*Lead Paper*)
- "Landscape based forest management - a real world case". Martin Mendoza, Juan José Fajardo & Jesús Zepeta
- "Water management in "La Antigua" (Veracruz): a multiproduct model approach in Mexican Forestry." Ana-Rita Román-Jiménez; Martín Mendoza; Mario Martínez; Alejandro Velázquez; Juan-Manuel Torres; & Hugo Ramírez.

16:00-16:30 Coffee break

16:30-18:30 **Technical Session 2.** ***Management for non-timber values and forest health***
Moderator: Paul Vantomme (FAO/Rome)

- "Managing forests for non-wood forest products: opportunities and constraints" Paul Vantomme (*Lead Paper*)
- "Should planting of broad-leaved species be encouraged at the expense of spruce? An economic approach to a current southern Swedish forestry issue." Per Holgén & Göran Bostedt

- “Silvicultural strategies in forest ecosystems affected by exotic pests.” Kristen M. Waring and Kevin L. O’Hara

- “Gestion des produits forestiers non-ligneux par les populations en Afrique centrale : réalités et perspectives. ” Mathurin Tchatat & Ousseynou Ndoye
- “Silvicultural lessons about stand dynamics and forest health from a study of oak decline in southern Missouri.” W. Keith Moser, Kathy Kromroy, Mark Hansen, Chris Woodall, Linda Haugen & Manfred Mielke

Tuesday 15 June

08:30-10:30 Technical Session 3. *Tropical forest management*
Moderator: Henri-Felix Maître (France)

- “Research, community forests, and CITES favor sustainable silviculture of mahogany (*Swietenia macrophylla* King) in natural tropical forests”. Laura K. Snook (*Lead Paper*)
- “A new approach to silvicultural research in the Brazilian Amazon – Dendrogene.” Romy B. Sato, Ian S. Thompson, Jorge A. G. Yared, José do C. A. Lopes, Márcia Maués, Regina C.V.M Silva, Denis R. do Valle, Bernd Degen, Milton Kanashiro
- “Using models for predicting recovery and assess tree species vulnerability in logged tropical forests.” Sylvie Gourlet-Fleury, Guillaume Cornu, Sébastien Jésel, Hélène Dessard, Jean-Gaël Jourget, Lilian Blanc, Nicolas Picard
- “Connaître le tempérament des espèces pour prévoir l'évolution de la composition des forêts exploitées.” Eric Forni
- “Phytosociologie appliquée à l’aménagement des forêts : cas de la forêt de Toffo au sud-Bénin.” Jean Cossi Ganglo

10:30-11:00 Coffee break

11:00-12:30 Technical Session 4. *Social forestry and traditional management*
Moderator: Laura Snook (CIFOR/Indonesia)

- “Constraints and opportunities for better silviculture practice in tropical forestry: an interdisciplinary approach”. Bradley B. Walters, Cesar Sabogal, Laura K. Snook & Everaldo de Almeida (*Lead Paper*)
- “Community-Based Forest Management in Northern Thailand.” Minna Hares
- “Traditional natural resource management in the Tanimbar (South East Moluccas).” Yves Laumonier, Yohanes Purwanto, Bayuni Shantiko & Yan Persulessy
- “Sustainable development of forest resources in Sri Lanka: a village-based approach” Mangala de Zoysa

12:30-14:00 Lunch

14:00-16:00 Technical Session 5. *Uneven-aged management for multiple uses.*
Moderator: Kevin O’Hara (USA)

- “A new silviculture: loosening the grip”. K. J. Puettmann, K. D. Coates & C. Messier (*Lead Paper*)
- “Application of free selection in mixed forests of the inland northwestern United States.” Russell T. Graham & T.B. Jain

- "Effects of strip cutting and single-tree selection cutting on birds and their habitat in a SW Quebec extensive northern hardwood forest" Frédérik Doyon, Daniel Gagnon & Jean-François Giroux
- "Ecological and economic reasons for retaining white birch in interior spruce plantations." Chris Hawkins & Thomas W Steele
- "Uneven aged management experimentation in eastern Canadian boreal forest." Hervé Bescond, Yves Bergeron, J. Morasse & K. Harper
- "30-year response of white pine to release after partial harvesting in pine mixedwoods" Darwin Burgess, Craig Robinson & Suzanne Wetzel

16:00-16:30 Coffee break

16:30-18:30 **Technical Session 6.** ***Forest structure and biodiversity***
Moderator: John Stanturf (USA)

- "Effects of forest management on biodiversity of ground vegetation in Canadian and European conifer forests." Andreas Schmiedinger, Jürgen Kreyling, S. Ellen Macdonald & Carl Beierkuhnlein (*Lead Paper*)
- "Silviculture of beech – present and future challenges?" Palle Madsen, Khosro Sagheb Talebi, Kazuhiko Terazawa, Robert Rogers & Katrine Hahn
- "Effects of topography on regeneration pattern of sub-alpine forests in Western Sichuan of China." Shirong Liu, Yuandong Zhang, Changming Zhao, Zuomin Shi and Xingliang Liu
- "Characterisation of forest structure of Scots pine stands across a 120-year rotation." Fernando Montes & Isabel Cañellas

Wednesday 16 June: Field excursion

Thursday 17 June

8:30-10:30 **Technical Session 7.** ***Quantifying silviculture***
Moderator: Daniel Auclair (France)

- "Modelling as a forest management decision tool in response to climate change: regional impacts of climate change on wood production and carbon storage in temperate forests." Denis Loustau et al. (*Lead Paper*)
- "Assessing effects of forest management on selected public forest goods and services: a case study." Daniel Köchli & Peter Brang
- "Quantifier les objectifs de la silvaculture à l'aide du concept de peuplement cible". Philippe Nolet, Frédérik Doyon & Éric Forget
- "Silvicultural systems for non-traditional and multiple objectives: exploring alternatives." James N. Long & Scott D. Roberts
- "A light-capture based stand dynamics model for forecasting response to silvicultural practices." Arthur Groot & Jean-Pierre Saucier

10:30-11:00 Coffee break

11:00-12:30 **Technical Session 7 (continued).** ***Quantifying silviculture***
Moderator: Daniel Auclair (France)

- ”Productivity relationships in managed forest stands.” Kevin L. O’Hara (*Lead Paper*)
- “Modelling response to midrotation thinning and fertilization in loblolly pine plantations.” Ralph L. Amateis
- “Wood production, litter fall and humus accumulation in thinning experiment in Norway Spruce CZ 13 – Vitkov.” Marian Slodicak & Jiri Novak
- “Investigating scale-dependent stand heterogeneity with structure-area-curves”. Eric Zenner

12:30-14:00 Lunch

14:00-16:00 **Technical Session 8:** ***Forest restoration and conservation.***
Moderator: Palle Madsen (Denmark)

- “Silviculture for restoration of degraded temperate and boreal forests”. John A Stanturf, Palle Madsen, & Emile S. Gardiner (*Lead Paper*)
- “Restoring bottomland hardwood forests: a comparison of four techniques” John A Stanturf, Emile S. Gardiner, James P. Shepard, Callie J. Schweitzer, C. Jeffrey Portwood, & Lamar Dorris
- “The theoretical basis of mining-quaries land recultivation in taiga zone in Russian north-west”. Evgeniy V. Abakumov, Olga V. Lisitsina, & Elvira I. Gagarina
- “Silvicultural measures for conservation of dune landscapes in Russia.” Anton V. Doroshin & Anatoliy V. Zhigunov
- “Les unites pilotes d’amenagement, de reboisement et d’agroforesterie : nouvelle approche de gestion durable des forets Congolaises“ Antoine Mountanda, Pierre Taty & Jean Albert Placide Kaya

16:00-16:30: Coffee Break

16:30-18:00: **IUFRO Division 1 Business Session**

<u>Friday 18 June</u>

08:30-10:30 **Technical Session 9:** ***Plantation management***
Moderator: Chris Hawkins (Canada)

- “Implications of legal and policy regulations on rural development: the challenge of agroforestry”. Christian Dupraz et al. (*Lead Paper*)
- “Growth and species interactions in a mixed plantations of *Eucalyptus globulus* and *Acacia mearnsii.*” David Forrester, Jürgen Bauhus & Annette Cowie
- “The potential of using wood ash and peat ash as forest fertilizer on peat soils in Sweden” Björn Hånell
- “Potential for legume introduction in short rotation plantation forests as a means to increase productivity and maintain site fertility? – the need for coordinated research” Jean-Pierre Bouillet, Jose Leonardo M. Gonçalves, Jacques Ranger, Antoine Galiana, Jean de Dieu Nzila, Philippe Deleporte & Jean-Paul Laclau
- “Rationale for developing teak clonal plantations”. O. Monteuuis, D.K.S. Goh & H.F. Maître

- “Taxon-specific responses of subtropical *Pinus* to site preparation technique on very wet sites in the southeast Queensland coastal lowlands.” Mark A. Hunt, David O. Osborne, Ken Bubb & Marks R. Nester
- “Industrial coniferous plantations in Russia.” Igor V. Shutov & Anatoliy V. Zhigunov

10:30-11:00 Coffee Break

11:00-12:30 **Technical Session 10. *Silviculture and biodiversity conservation.***
Moderator: Sylvie Gourlet-Fleury (France)

- “Impact of selective logging on mating system and gene flow of a tropical rain forest species.” Mathieu Lourmas & Marie-Hélène Chevallier (*Lead Paper*)
- “On the genetic diversity of nursery stock as influenced by culling practices: the case of *Pinus cembra* L.” Raphael Th. Klumpp
- “Studies on the endangered pondberry (*Lindera melissifolia* [Walt] Blume).” Margaret Devall, Nathan Schiff, Tracy Hawkins, Kristina Connor, Craig Echt, Emile Gardiner, Paul Hamel, Ted Leininger & Dan Wilson.
- “Plantation technology and field performance of selected tree species of multiple end uses indigenous to Indian Peninsula”. KKN Nair, C Mohanan & George Mathew

12:30-14:00 Lunch

14:00-15:30 **Closing Session:** Summing up and discussion of future directions.
Moderators: John Parrotta & Henri-Felix Maître

Introduction and Meeting Report

The present volume of the IUFRO World Series contains extended abstracts of the nearly 60 papers presented during the technical sessions of the IUFRO All-Division 1 (Silviculture) Conference held at the Hotel Mercure-La Grande Motte, in Montpellier, France from June 14th-18th June 2004. This conference, entitled “Meeting the Challenge: Silvicultural Research in a Changing World”, was convened to explore the changing role and expectations of silviculture to meet new challenges and societal needs around the world. Through their presentations of current research and subsequent discussions, conference participants considered how silvicultural research findings and new research initiatives can be best applied to solve emerging forest management issues.

The event was jointly sponsored by our hosts in Montpellier, CIRAD-Forêt and the Institut National de la Recherche Agronomique (INRA), and the USDA Forest Service. Conference participants included over 70 forest scientists from 23 countries in the Americas, Europe, Africa, Asia and Australia, representing a significant proportion of Division 1’s Research Groups and Working Parties. A superb in-conference field trip, organized by our hosts in Montpellier, introduced participants to the rich history, culture, cuisine, and natural beauty of the Camargue region.

The conference was opened by Jacques Valeix (Director, CIRAD-Forêt) who welcomed participant on behalf of the local organizers and hosts, and IUFRO Vice-President (Science) Eric Teissier du Cros, who provided an overview of IUFRO, its activities and programs. In his opening talk Division 8 coordinator Alain Franc challenged participants to develop more effective theoretical and practical models to link silvicultural and ecological research as an approach to multidisciplinary issues related to biodiversity conservation, multifunctional forestry and sustainable forest management. Mark Hunt, on behalf of the 2005 IUFRO Congress Organizing Committee, followed with a special presentation on the IUFRO World Congress to be held in Brsibane, Australia.

Technical sessions included presentations and discussion of papers on a broad range of topics related to landscape-level forest management, tropical forest management, management for non-timber values and forest health, social forestry and traditional forest management, uneven-aged management for multiple uses, quantifying and modeling the effects of silvicultural treatments, plantation management, forest restoration, and silvicultural approaches to biodiversity conservation.

Technical Session 1 - “Landscape-level management” - was moderated by Björn Hånell (Sweden/SLU) and included three papers.

Grassi et al. examined the use of a traditional selection cutting system to achieve “close-to-nature”, uneven-aged coniferous stands in Italy’s eastern Alps, reporting that the ”Cadarino” system tested resulted in desired irregular structures even at small scales, though at the cost of frequent, moderate cuttings. **Mendoza et al.** discussed the use of a landscape ecology approach to development of policies and silvicultural management practices for a mixed pine forest in western Mexico, where local residents and landholders support continued timber harvesting yet see a need for the modification of the current evenaged management system designed solely for timber production to a more refined set of practices designed to transform future forest structure and composition to a more natural state with a greater diversity of stand structures and lower degree of fragmentation while continuing to be managed for timber production. Finally, **Roman-Jiménez et al.** presented a multiproduct model approach to forest watershed management in Veracruz, Mexico; this case study highlighted the importance of public recognition of the non-timber products and environmental and social services provided by forests in the region, with particular attention to water quality.

Technical Session 2 - "Management for non-timber values and forest health", moderated by Paul Vantomme (Belgium/FAO), included 5 presentations.

Vantomme's opening paper discussed the large and globally increasing opportunities and societal demands for managing forests for non-timber values and for improving overall forest ecosystem health. He argued that despite the growing public recognition of the importance of non-timber forest values, forest management, legislation, and particularly silviculture continue to focus mainly on timber production. The paper by **Holgén & Bostedt** discussed issues related to valuation of forest recreation and biodiversity conservation in southern Sweden, where timber profitability of oak and beech are much lower then for spruce. They argued that methodologies to assess monetary values of the non-timber products and benefits of (mixed) broadleaved forests (assuming they have a higher biodiversity and landscape recreational value then pure spruce stands) need much to be improved, and that reliable measures of the Willingness to Pay (WTP) by the society needs further, more extensive, testing, and the need for research to evaluate the extent to which recreation forests can or should be managed for timber production, if at all, and on the associated silvicultural methods and systems are most cost-efficient for the society. **Waring & O'Hara** discussed the evolution of silvicultural strategies in forest ecosystems affected by exotic pests in the USA, from a primarily genetics focus towards a broader scope of understanding of both host and pest ecology within an integrated pest management approach.Research on Oak decline in Southern Missouri (USA), discussed by **Moser et al.**, shows that species mix and density influence forest mortality and growth rates. The authors pointed out that over-mature (mixed broadleaved) stands may have high biodiversity and recreational value, but are also prune to higher forest health problems. A paper by **Podshivaev** (not presented) discussed research related to the situation in the Leningrad region of Russia where decreasing mature coniferous (mainly spruce) stands and increasing areas of fresh clearcuts, burns and as well as young, mature and overmature deciduous (aspen) stands have resulted in higher biodiversity levels, including higher mammalian herbivore populations (mainly elk, beaver) but which are also having serious negative impacts on these forests.

Discussions during this session highlighted the fact that natural forests provide a large number of NTFPs and which are important to sustain the livelihoods of forest dependent people, such as for example demonstrated for the Central African region (**Tchatat & Ndoye**). However, despite their (local) importance and high frequency of NTFP species in the forest, these species are not covered by forest management plans and forest products legislation, which still focus mainly on the timber component. Opportunities for managing forests for non-timber products and services are manifold and already endorsed by many (inter-)national Conventions and related SFM initiatives. In addition, among the public at large, but particularly within environmental and donor agencies, there are high expectations for the possibility that the commercial use of NTFPs and forest services can contribute both to forest biodiversity conservation and income generation. However there is still a serious lack of reliable quantitative information, assessment methodologies and technical knowledge to manage forests for these resources. Key research challenges for silviculturalists raised during this session included: how to integrate non-timber products and values (higher biodiversity and recreational demands) into current timber stand management in ways that is technically feasible and economically cost-effective; development of reliable methodologies to assess the non-timber monetary values and society's willingness to pay for these or to forsake (part of) the timber revenue; and the impact of (changing) species composition of the stand on forest health, wildlife stocking and strategies for integrated pest management.

Technical Session 3 - "Tropical forest management", moderated by Henri-Felix Maître (France/CIRAD-Forêt), included 5 presentations highlighting a number of trends and challenges in tropical silviculture.

Selective logging is not able to create openings in the canopy wide enough to assure the regeneration of many major commercial species, as discussed by **Snook** for mahogany in Quintana Roo (Mexico), and by **Forni** for light-demanding species in Cameroon. Without the help of an intensive silviculture that creates large forest gaps, these species seem to be fated to a progressive decline. An alternative solution involving establishment of artificial plantings of indigenous species at sufficient densities in open forest areas (**Nair** – Session 10) is not always possible and may be questionable from the point of view of biodiversity conservation. Predictive models or these extremely complex ecosystems often show a long-term decline in important commercial species in selectively logged forests, where their long-term survival depends on the presence of large reproductive individuals and on the recruitment rate of young trees (**Gourlet-Fleury et al.**). However, **Lourmas & Chevallier** reported (in Session 10) that selective logging has a low impact in the genetic diversity of sapelli (*Entandrophragma cylindricum*: Meliaceae). It is therefore very difficult to make general predictions on logging impacts, and therefore research on a case-by-case basis is needed, optimally involving multidisciplinary teams and programmes. An innovative research approach is suggested and offered in Brazilian Amazon to overcome this kind of challenge (**Sato et al**.). To improve tropical silviculture and natural forest management, foresters and researchers must consider both the relationship of these practices to local traditional management (as discussed by **Hares**, **de Zoysa** , and **Laumonier *et al***. in Session 4) and the landscape management considerations (**Mendoza et al**. – session 1), which may include phytosociological studies (**Ganglo**).

There has been a renewed interest in the role of forest plantations and their significant impacts on the environment, social life, productivity, industry and the economy. The emerging trend in plantation forestry is towards short-term optimisation of returns on investment made on fewer and smaller areas of land. More intensive cultural and management practices include agroforestry systems consisting of trees in combination with other crops that generate earlier cash flow are progressively supplanting traditional extensively managed long rotation plantation systems (**Mountanda et al.** – Session 8). Such intensification requires superior quality planting stock and adapted silviculture methods. Depending on the species, special attention must therefore be given to proper provenance, progeny or clone selection in order to reach the highest yield and quality in the shortest time frame (**Monteuuis et al.** – Session 9).

Technical Session 4 - "Social forestry and traditional management", moderated by Laura Snook (Indonesia/CIFOR), included 4 presentations highlighting several issues.

In tropical countries from Indonesia and Thailand to Mexico, governments have become progressively more aware of the importance of integrating traditional villagers into decision making and management of local forests, to meet their own and the nations' needs for timber and nontimber products and conserve forest environmental services while reducing the potential for conflict between villagers and government forest management agencies. In some areas, international donors, NGO's and scholars have played an important role in this process, by introducing participatory research processes to help local communities articulate their needs, and interact more effectively with local governments. While respect for the importance and value of traditional systems of management is increasing, it is also clear that these systems need to be complemented by technical knowledge and support from government agencies and researchers so that local villagers and local forests can better meet the pressures of increasing demands and threats from inside and outside the system. However, translating technical knowledge of silvicultural management practices to sustain or enhance productivity into implementation of practices by forest managers, from traditional villagers to commercial timber producers, is a challenge. Discussions highlighted the enormous disparity in the level of silvicultural practice, and the opportunities to apply silviculture, between tropical and temperate settings. All the studies in this session were carried out in tropical settings where institutional issues, governance, and differences in availability of and approaches to knowledge create a framework within which the application of silviculture can be much more complicated than the technical aspects.

Walters et al. discussed factors favoring or impeding adoption of silvicultural practice by users in the Philippines, Amazonia, and Mexico. These include (a) learning by observation and imitation of motivated and successful individuals, and the importance of incentives including protection, tenure and government programs; (b) constraints related to obtaining good planting material, lack of knowledge of management, poor technical support and lack of financial resources for both commercial logging firms and small scale farmers; and (c) support of dedicated foresters, secure tenure and interest in long term, government regulations/guidelines, external research support, in relation to silvicultural practices to regenerate mahogany in community forests Quintana Roo.

Hares utilized surveys in villages of several ethnic groups in a study of the impacts of the logging ban in northern Thailand and support to community-based forest management. Three categories of land use were identified: conservation forest (no logging, sometimes NTFP gathering), community forest (source of products), and agricultural areas; combination areas in this region are gazetted and defined by community. While villagers feel forest conservation is important to their livelihoods, national park gazetting was perceived by villagers as threat to livelihoods. Under village-based rules, permissions to cut trees based on need, and hunting now widely banned; reforestation and fire management are controlled from outside the villages. Government extension agents have taught villagers how to more effectively manage fires and provide seedlings for reforestation. It is likely that management will require mixture of traditional and introduced systems to meet needs of population.

Laumonier et al. discussed the strong traditional management systems in the isolated islands of Tanimbar in Indonesia, and the history of local resistance to exploitation of natural resources by outsiders. Current projects work with the new local government and population to develop land use plans based on participatory research, capacity building, and transparency. Traditional resource management systems (i.e., for shifting agriculture and copra, NTFP's, timber harvesting and sale, marine fishing) limit exploitation, but their effectiveness it not known, nor are they adapting to new challenges like fishing by outsiders. Additional research, including further silvicultural research, to support greater capacity to adapt, and to integrate traditional systems with official resource use system are needed.

Traditional village forests in Sri Lanka, discussed by **de Zoysa**, are disappearing due to elimination of common property rights. Demand for forest products exceed productive capacity of forest resources, benefits not equitably distributed. Multiple products are obtained through complex patterns of access and use. Villagers seldom integrated into government forest planning. The paper highlights the need to develop processes for decisionmaking and equitable allocation as well as stimulating tree planting to meet needs

Technical Session 5 - "Uneven-aged management for multiple uses", moderated by Kevin O'Hara (USA/UC-Berkeley), featured a series of closely related presentations on uneven-aged silviculture. These presentations display the ongoing evolution in uneven-aged silviculture from rigid systems to flexible systems that attempt to emulate natural disturbance regimes. These new systems are assumed to more closely represent natural structures and to enhance diversity and stand resistance to disturbance.

Püttmann presented a rationale for a new, more flexible approach to silvicultural management that recognizes the changing societal demands for forest goods and services and the better utilizes insights from modern ecological research regarding complexity, heterogeneity and stochasticity of forest ecosystems. In the interior northwest of North America, **Graham & Jain** described a "free-selection" system that maintains flexibility to favor healthy, fire resistant trees. **Burgess et al.** showed how basal area influences development of understory eastern white pine in Canada. Also in eastern Canada, **Bescond et al.** showed how partial cutting can be used to favor irregular stand structures and **Doyon et al.** examined the effects of partial cutting on bird species. Finally, in an even-aged application in western Canada, **Hawkins & Steele** showed how spruce-birch mixtures were more productive and healthier than pure spruce stands.

Technical Session 6 - “Forest structure and biodiversity”, moderated by John Stanturf (USA/Forest Service), included 4 presentations that focused on forest management and its effects on biodiversity at the stand level.

Schmiedinger et al. reported on studies investigating the long-term effects of forest management practices on understory vegetation biodiversity in Canadian and European conifer forests and the development of standardized survey and analysis methods to detect areas with high biodiversity. **Madsen et al.** presented a broad, global, overview of challenges for silvicultural research on beech, highlighting the benefits of close collaboration between researchers, managers, and scientists in other disciplines in identifying and carrying our priority research. The presentation by **Liu et al.** reported results of an analysis of topographic influences on the distribution of old-growth, naturally regenerated and planted forests in the sub-alpine forest zone of Western Sichuan in China. Their analyses were useful for determining the potential and limitations of natural regeneration of these forests, and the most appropriate altitudinal ranges and aspects for artificial regeneration as a complementary measure where natural regeneration is inadequate. **Montes and Cañellas** presented a study of structural changes in managed even-aged Scots pine stands in the Central mountain range of Spain through an analysis of a chronosquence of stands up to 120 years of age. Their results indicates that while natural regeneration and stand structure exhibits great variability between stands of similar ages, the development of these stand leads to a normalization of stand structure at landscape level.

Technical Session 7 - “Quantifying silviculture”, moderated by Daniel Auclair (France/INRA), included 9 presentations.

The paper by **Loustau et al.** utilized a modeling approach to examine the regional impacts of climate change on wood production and carbon storage in northern northern broadleaved forests (*Fagus* and *Quercus*) and atlantic southern pine forest (*Pinus pinaster* Ait.) in France, and discussed the potential of forest management to adapt forests to climate scenarios. **O’Hara**, in his review of the state-or-knowledge on productivity relationships in managed forest stands, reexamined several classical relationships in silviculture, in particular concepts related to the efficiency of converting growing space to stem volume increment of trees and stands, the temporal dynamics of tree and stand respiration, and the relative productivity of forest stands with different structures. His analysis focused on the influence of variables that affect the amount and distribution of volume or biomass during stand development, specifically initial density and fertilization as well as subsequent control of density, species composition, stand structure, and age structure. **Long and Roberts** discussed a number of examples from the southeastern and western United States to illustrate how systematic development and careful evaluation of silvicultural alternatives can be an effective way to identify potentially conflicting goals and objectives, and to ultimately refine and refocus management objectives. The paper by

Köchli and Brang reported their use of a forest growth simulator and a GIS to assess the effects of three management strategies on selected goods and services in a peri-urban catchment in Switzerland over a 50-year period. **Zenner** examined the question of spatial scale in assessing structural complexity in old-growth forest stands, which concluded that understanding structural pathways and determining characteristic patterns of old-growth structure in natural stands are prerequisites for maintaining biological diversity, sustaining forest productivity, and enhancing and restoring old-growth ecosystems within managed ecosystems. The presentation by **Groot and Saucier** discussed progress in their on-going development of a stand dynamics model based on light capture by individuals trees as a means to provide robust, long-term forecasts of stand development in response to a wide variety of silvicultural treatments, as well as to natural disturbances. **Amateis** presented a summary of recent research in the southeastern United States aimed at development of response models appropriate for multiple treatments of thinning and fertilization of loblolly pine plantations applied at any point during a stand rotation.

Nolet et al. discussed their research in Quebec on the definition of quantifiable forest stand structural targets (and options), based on the social, economic, and ecological objectives of forest management, and their utility for development of forest management plans and specific silvicultural treatments. **Slodiak and Novak** reported the results of long-term research conducted in the Czech Republic (part of IUFRO's international European Norway spruce thinning experiment), focusing on the effect of thinning treatments on wood production, wood quality, and the influence of these plantations on soil structural development.

Technical Session 8 - "Forest restoration and conservation", moderated by Palle Madsen (Denmark/KVL), included 5 presentations focusing on key issues and innovative silvicultural practices for forest restoration in boreal, temperate and tropical regions.

Stanturf et al. set the tone of the session a synthesis paper on silvicultural approaches for restoration of degraded temperate and boreal forests, pointing out that all forestlands have been altered or influenced by human activity and that the "natural state" (i.e. without human influence) is non-existent and impossible to restore. Forest restoration includes replacing other land uses with forest (e.g. through reconstruction, reclamation, replacement, afforestation) or rehabilitation of existing forests (e.g. through monoculture plantations) towards a more natural state with a desired species composition, stand structure and natural functions. The scientific challenge involves continued improvement and interpretation of the scattered knowledge of forest stand and ecosystem functions from a dynamic perspective – and to spread this paradigm not only among research colleagues but also among land managers and the general public. Case studies presented during the session illustrated and discussed very different aspects of forest restoration, such as afforestation with bottomland hardwoods on farmland in the lower Mississippi alluvial valley in the USA (**Stanturf et al**.), reclamation in mining quarries in the taiga zone of Russia's northwest region (**Abakumov et al**.), application of silvicultural practices for conservation of dune landscapes in Russia (**Doroshin & Zhigunov**), and new approaches to improve sustainability in forest management, with particular reference to reforestation and agroforestry development in Congo-Brazzaville (**Mountanda et al**.).

Technical Session 9 - "Plantation management", moderated by Chris Hawkins (Canada/UNBC), included discussion of 6 papers demonstrating that 'complex' systems have the potential to be more productive than simple systems. Overall the papers in this session highlighted the need for continued research and the importance of getting research incorporated into policy.

The session opened with an excellent overview and specific examples of agroforestry in Europe (**Dupraz et al.**), highlighting the role of current policies and laws in hindering adoption of agroforestry systems there. The authors pointed out that while grant or subsidy schemes exist for agriculture and forestry, they are lacking for agroforestry, and in some jurisdictions, agroforestry is illegal due to tax legislation. Agroforestry systems can exceed the productivity of agriculture or forest systems alone by 30 percent. Therefore there is a need to get the politicians to create laws that promote its practice. The paper by **Forester et al.** demonstrated that mixed plantations of *Eucalyptus globulus* and *Acacia mearnsii* in Australia produced more biomass than plantations of *E. globulus* or *A. mearnsii* growing alone. A paper by **Bouillet et al.**, presented by L. St. Andre, described a protocol for mixed species plantation experiments. They provided many cautions for doing research on complex stands. Often the results of mixed species' studies are better on poor sites, particularly when one of the species is a nitrogen fixer. The authors stress that soil properties must be monitored to understand the observed species' productivities.

The remaining papers looked at issues of plantation establishment and productivity in boreal, sub-tropical and tropical regions of the world. **Hånell** presented a convincing argument that productivity could be significantly increased on about 190,000 ha of peat soils in Swedish forests if they were fertilized with wood ash and pet ash at a rate of about 5 t per ha. This level of fertilization would require about 3 to 4 years of bio-ash production. The paper by **Monteuuis et al.** presented a case for establishing clonal teak plantations given the increased demand on natural teak resources, the *in situ* preservation of existing plantations for biodiversity, limitations of seed derived planting stock, and pressure to intensify teak productivity. Clonal cultures have demonstrated good growth in plantations at 10 years (28 to 30 m and 40 cm in diameter). These plantations can be managed as monocultures or in an agroforestry system. **Hunt et al.** reported on the impact of five mechanical site preparation treatments on three year survival and growth of six pine stocktypes in southeastern Queensland, Australia. Survival was not influenced by site preparation but it was significantly affected by stocktype (73 to 98%). Site preparation significantly affected height (4.2 to 5.1 m) and diameter (7.2 to 9.1 cm) growth but the impact of stocktype was even greater for height (4.0 to 5.8 m) and diameter (7.0 to 9.8 cm).

Technical Session 10 - "Silviculture and biodiversity conservation", moderated by Sylvie Gourlet-Fleury (France/CIRAD-Forêt), featured 5 speakers presenting papers dealing with the long-term preservation of forests and tree populations across a wide range of ecological conditions in Europe, central Africa, southern Asia and North America.

Two papers focused on the impact of management practices on the genetic diversity of tree populations. **Lourmas et al.** examined the question of whether selective logging for timber in the tropical forests of Cameroon resulted in an increase of selfing and a decrease in gene flows in the timber species *Entandrophragma cylindricum* (Meliaceae), while **Klumpp** investigated how grading operations in nurseries, aiming at selecting the strongest plants for afforestation could result in genetic erosion in the species *Pinus cembra* (Pinaceae). In both cases, experiments lead by the authors, using microsatellites and isozymes technologies brought negative answers, but it is recognised that in this field of research, international results are contradictory, depending on the species studied, the experimental conditions and the efficiency of the markers used.

The three other papers presented in the session focused on the set of conditions needed to preserve, artificially regenerate and/or enhance the productivity of tree species. **Devall et al.** reported on various *in* and *ex-situ* observations and studies undertaken in the southern Mississipi Delta to determine the biological and ecological factors most influencing survival and development of *Lindera melissifolia* (Lauraceae), a species endangered by habitat destruction and alteration, with the aim is to help develop management plans for the species at the regional scale. **Nair et al.** discussed habitat destruction and over-exploitation, the main causes of the depletion of various man-used species populations in the monsoon forests of India, and reported on their *in-situ* and *ex-situ* studies used to assess the best technical ways of artificially regenerating five widely used species: *Calophyllum polyanthum* (Clusiaceae), *Dysoxylum malabaricum* (Meliaceae), *Garcinia gummi-gutta* (Clusiaceae), *Melia dubia* (Meliaceae) and *Vateria indica* (Dipterocarpaceae). Their work has resulted in technical prescriptions and user-friendly guides on the collection, storage and processing of seeds, as well as for nursery and plantation practices. Finally **Shutov & Zhigunov** reported on field trials conducted in the North West and Central European part of Russia, in order to determine the best set of conditions for the growth and yield of *Picea abies* and *Pinus sylvestris* (Pinaceae); their results demonstrate that plantations can be highly productive (more than natural ancient forests) and productive enough to supply the Russian forest market. The development of such plantations could help preserve the highly ecological value of the boreal forests.

THE THEORETICAL BASIS OF MINING –QUARRIES LAND RECULTIVATION IN TAIGA ZONE IN RUSSIAN NORTH-WEST

Evgeniy V. Abakumov[1], Olga V. Lisitsina[2] and Elvira I. Gagarina[1]

Dep. of Soil Science and Soil Ecology[1], Dep. of Geobotany and Plant Ecology[2],
St-Petersburg State University, St-Petersburg, Russia, 198504, Oranienbaum rd., 2,
Tel: +7-812-427-7061, E-mail: e_abakumov@mail.ru

Introduction

Anthropogenic destruction of ecosystems and forest decline are very important problems in the North-West and North Russia. The area of destroyed soil-plant cover is now estimated to be about 0.5–1.0% of the North-West region, but approximately 4-8% of these landscapes are remediated and recultivated.

The general conception of plant-soil cover regeneration in regions with severely degraded landscapes (posttechnogenous territories of mining-quarries complexes) and less severely damaged ecosystems (deforested, burned, and acidified by rainfall) must be based on results of investigation of regeneration potential and mechanisms of young ecosystems evolution in natural conditions. The main goal of landscape regeneration is the creation of stable ecosystems which are carrying out all the ecological functions (Androchanov et al, 2000, Archegova, 2003). This is especially important in Russia, because all soil remediation and restoration technologies in our country were established on the principles of "fast return" of these lands for different land uses. However, during the last decades, there has been intensive degradation of the lands that were restoried by the "fast return technology": i.e., phytoremediation, fertilizing, plantation of crops and coniferous trees (Kapelkina, 1996, Abakumov et al, 2003). That is because that artificial "soil-plant" systems that were established cannot be stable and support its ecological functions without further human intervention and improvement. Therefore, it is very important to use the natural regeneration ability of Podzol taiga ecosystems to create a stable landscapes in the extensive territories of North-West Russia.

Methodology

The aim of this work to compare the advantages and specific features of two strategies for ecosystems rehabilitation, natural restoration and land recultivation, in Russian north-west taiga environments. The methodological basis of investigation is monitoring of revegetation and soil evolution in chronoserises of posttechnogenous ecosystems development on the different-age surfaces of quarries in taiga zone. In addition, we generalize data about the rates and tendencies of regeneration processes over the wide spectrum of quarries in Russia's taiga North-West.

Results and discussion

The complex investigation of initial podsolization during the primary succession of coniferous and deciduous plant communities on the different parent materials, and the study of the pedological evolutionary trends in organic matter transformation, show that the natural processes of ecosystem regeneration are effective for restoration under bioclimatic conditions of North-West of taiga zone. The process of natural restoration is slower than recultivation, but it results in the formation of stable ecosystems due to combined evolution of soil and biocenotic components of ecosystems.

The main mechanism of natural ecosystems regeneration is development of plant community by the way of ecogenetic succession. The characteristic feature of this type of succession is that for each stage of plant cover development there are specific corresponding changes in the soil system. Ecogenetic succession on sandy-textured parent material consist of following stages: 1) primary (0-5 years) rare mossy cover with primitive microsoil with low humus content; 2) young (5-10 years) pine rare forests with dense herb cover, soil with deep (0-5 cm) humus horizon; 3) 10-20 years old pine forests with dense mossy cover, soil show first features of local podzolisation in A horizon, which is show trends to degradation; 4) 30-60 years pine-fir forest with embriopodzolic soil, which are characterizes by thick (7 cm) E horizon; 5) 60-100 years old pine forests, typical for taiga shows the tendencies to succession by way of pine changing to fir, the thickness of E horizon increases rapidly up to 12 cm. So, 100-years is sufficient time for the formation of close-to-mature ecosystems on the sands and till-textured parent materials. Similar processes in ecogenetic succession were published by Emmer (1995) for sand dunes of Holland.

The basis for soil-plant interaction on the initial stages of regeneration are the processes which are closely connected with organic matter accumulation and transformation. For example: weathering of soil mineral part, formation of colloids and structure, optimization of water and nutrient regime, and profile differentiation into horizons are closely depends from humus formation. Moreover, the organic matter system carries out the function of regulation of soil-plant interaction. Further investigations of mechanisms of this regulation must be basis of ecosystems rehabilitation paradigm.

The main feature of ecogenetic succession are that processes of plant regeneration induce the soil formation process (Razumovskiy, 1981). Evolution of soil characteristics leads to plant community development. It is a main feature of the natural regeneration process, which support the stability of young ecosystem. By another words, stability of soil-plant systems forms and develops simultaneously with evolution of soil and plant components. The features of soil organic matter adequately reflects changes in whole soil (Androchanov et al. 2000, Reintam et al, 2002). The natural evolution of humus formation process can be divided into following stages: 1) period of local reaching of soil by humus substances under rare plant cover, 2) period of intensive organic matter accumulation, 3) the stage of organic matter intensive transformation, which leads to the initiation weathering of mineral part of soil, 4) the stage of humus profile stabilization, including processes of differentiation of separate horizons. The total duration of these stages is very specific for different conditions and estimated between 30-100 and in rare cases as 200 years.

The positive feature of natural successional development on quarry sites is that they yield biodiversity and community structures that match ecotopic conditions, which can help increase landscape stability. The main difference between recultivation and natural regeneration is creation of more homogenous plant cover and parent material properties over large areas of severely degraded landscapes.

In the case of mine recultivation, involving soil amendment with organic matter and fertilization, and planting of coniferous trees, we observe more rapid restoration of soils through development of humus and well-structured upper horizons. Due to these soil properties, plant cover develops rapidly in the early stages. However, the resultant "plant-soil" system is unstable because the mail ecosystem processes are not balanced in their development.

However, recultivation is often characterized by "catastrophic" successions of plant communities. The weed grasses are the most dominant component during the initial period. This vegetation has an important ecological function – accumulation of ash elements and nutrients in biomass – and helps to prevent intensive leaching of these elements. This function is very important especially in fertilized recultivated landscapes. The second specific feature of artificial regeneration is a rapid transformation of organic-mineral mixtures, which are usually applied to the site for quick improvement of destroyed lands. For example, dry turf-sandy mixture loses about 70% of initial organic component; clay admixture to this substrate leads to decreasing of losses to 30%. After 10-15 years, the role of weed herbs decreases, and zonal species of plants became more active in succession. Abovementioned specific features of recultivation decrease the stability of young ecosystems.

So, we discuss in brief the influence of biological component on soil regeneration. The second factor (which is very important) of posttechnogenous ecosystems is physical properties of surface mining-quarry grounds. The following characteristics are limiting for stable existence of plant-soil cover: 1) stratified structure of parent material, when clay is covered by sand, can lead to bogging, gleyformation and death of planted forests; 2) low resistance of grounds to water and wind erosion. Due to these features landscapes which were regenerated by recultivation degrade rapidly. The abovementioned properties of mining grounds usually were not included in the modern classification of mining grounds in Russia, but it can be limiting and dangerous even where all agrochemical properties are optimal.

The very important feature of present stage of Earth evolution is that (human) technological impacts on nature are increasing in severity, and that virtually all ecosystems on the surface of Earth are influenced by humans. One of consequences of this influence is a decrease in the natural regeneration potential of mature ecosystems (Dobrovolskiy, Nikitin, 2000). Further, the natural restoration potential of degraded ecosystems will be decreased due to degradation of "ecosystems immunity" and stability, and a decrease in the area represented by natural ecosystems, which are main source of plant seeds and biological diversity required for natural restoration of degraded lands. To increase the stability of posttechnogenous ecosystems it is necessary to include the recultivation mechanisms of soil and plant cover improvement in a way consistent with the natural way of regeneration. This improvement cannot be applied at once, and must become sequential, corresponding to stages of succession, so that it will be similar to natural mechanisms of ecogenetic succession.

Today the main paradigm of land recultivation in Russia is the formation of stable posttechnogenous landscapes with ecologically balanced soil-plant systems. It seems that former methods that were based on separate restoration of different parts of landscapes (ground optimization, soil improvement and plant growing) which cannot give effective results unless they incorporate information about mechanisms and processes natural restoration of destroyed lands in the design of regeneration technologies.

References

Abakumov E.V., Gagarina E.I., 2003. Fundamental physical studies in soil science and amelioration. Proceedings of conference, Moscow, Moscow State University: 262-263.
Androchanov O.V. et al. 2000. Thechnozems: properties, regimes and functions. Novosibirsk.
Archegova I.B. 2003. Dokuchaev Soil Science Society Congress, V 2: 283-284.
Dobrovolskiy G.V., Nikitin Ye.D. Preservation of soil as indispensable component of biosphere: functional and ecological aspects. Moscow, 2000.
Kapelkina L.P. 1996. Dokuchaev Soil Science Society Congress, V 2: 278-279.
Emmer I.M. 1995. Humus form and soil development during primary succession of monoculture *Pinus sylvestris* forests on poor sandy substrates. Amsterdam.
Razumovskiy S.M. 1981. Principal peculiarities of ecosystems dynamics. Moscow, Nauka.
Reintam L. et al. 2002. Geoderma. 171: 191-198.

Acknowledgements

The authors wish to acknowledge the great assistance of the Russian foundation for Basics Research and INTAS foundation for their partial financial support of this work.

MODELLING RESPONSE TO MIDROTATION THINNING AND FERTILIZATION IN LOBLOLLY PINE PLANTATIONS

Ralph L. Amateis

Department of Forestry, Virginia Tech, Blacksburg, Virginia, USA 24061
Tel: +1-540-231-7263 E-mail: ralph@vt.edu

Introduction

Midrotation applications of nitrogen (N) and phosphorus (P) have become a common silvicultural practice to increase stand productivity. These midrotation fertilizer treatments, when combined with thinning, provide intermediate economic returns leaving high quality fast growing crop trees to occupy the site until final harvest.

While efforts have been made to model individual midrotation fertilization and thinning treatments (Amateis 2000; Amateis et al. 1996; Amateis et al. 2000), comparatively little has been done to model the effects of multiple treatments. The objective of this paper is to summarize work accomplished toward developing response models appropriate for multiple treatments of thinning and fertilization of loblolly pine plantations applied at any point during the rotation.

Methodology

Data from a Southwide set of fertilizer response trials were available for modeling response of top height and stand basal area to N and P fertilization. This study was established in loblolly pine plantations and employed a factorial study design of combinations of N and P treatments (NCSFNC 1995a).

At the stand level, this response can be modeled as a cumulative increase above an untreated baseline. For top height response, a model utilizing the hyperbolic tangent function was specified that drives response quickly toward an asymptote depending on the inherent site index, amount of N applied and whether or not P was applied. For basal area response, a combined power and exponential function was used that models a rapid increase in response to a maximum and then asymptotically diminishes toward zero. The shape of the response is strongly influenced by its parameters which are functions of N, P, site index, basal area at time of application and years since treatment.

To account for multiple fertilization treatments it is assumed that the basal area response to separate treatments is independent and additive. That is, total basal area response at any age following fertilization will be the cumulative response, evaluated at that particular age, of all the separate previous fertilization responses that have occurred (Jokela and Stearns-Smith 1993). When a thinning occurs subsequent to fertilization it is assumed that the cumulative basal area response to the prior fertilization(s) that has been achieved up to the time of thinning will be removed in the thinning operation.

Results and discussion

The top height and basal area response models were fitted to the fertilizer response data using nonlinear least squares. All parameter estimates were significantly different from zero at the 95% confidence level. Tables 1 and 2 present residuals by treatment and years since application for top height and basal area response, respectively.

Table 1. Mean residual and observed mean response (in parentheses) of top height by treatment at 2, 4, 6, 8 and 10 yr after fertilization for the loblolly pine midrotation fertilizer study sites.

		Growing seasons after fertilization				
Treatment		2	4	6	8	10
Nitrogen (kg/ha)	Phosphorus	------------------------------------m------------------------------------				
0	Yes	-0.03(0.07)	-0.19(0.01)	-0.04(0.26)	-0.08(0.33)	0.34(0.85)
112	No	0.25(0.45)	0.06(0.44)	0.27(0.81)	-0.12(0.54)	-0.17(0.59)
112	Yes	0.13(0.69)	-0.14(0.94)	-0.29(1.23)	-0.46(1.40)	-0.31(1.81)
224	No	0.35(0.57)	0.16(0.57)	0.19(0.77)	-0.23(0.48)	-0.51(0.29)
224	Yes	0.21(0.84)	0.13(1.34)	0.11(1.81)	0.22(2.30)	0.56(2.94)
336	No	0.35(0.58)	0.13(0.56)	-0.17(0.43)	-0.19(0.55)	-0.18(0.67)
336	Yes	-0.15(0.52)	-0.05(1.23)	-0.09(1.71)	0.04(2.26)	0.21(2.73)

Table 2. Mean residual and observed mean response (in parentheses) of basal area by treatment at 2, 4, 6, 8 and 10 yr after fertilization for the loblolly pine midrotation fertilizer study sites.

		Growing seasons after fertilization				
Treatment		2	4	6	8	10
Nitrogen (kg/ha)	Phosphorus	------------------------------------m^2/ha------------------------------------				
0	Yes	-0.14(-0.11)	-0.03(0.03)	-0.01(0.08)	-0.04(0.09)	0.17(0.32)
112	No	-0.07(0.27)	0.07(0.59)	0.17(0.68)	0.01(0.41)	-0.25(0.03)
112	Yes	0.08(0.55)	0.12(1.15)	-0.07(1.32)	-0.02(1.52)	-0.24(1.27)
224	No	-0.14(0.44)	-0.09(0.83)	0.14(1.03)	0.14(0.84)	-0.30(0.19)
224	Yes	0.07(0.89)	-0.02(1.79)	-0.12(2.34)	0.04(2.77)	0.45(3.14)
336	No	-0.09(0.70)	-0.06(1.16)	0.09(1.28)	0.33(1.27)	0.04(0.70)
336	Yes	-0.02(1.09)	0.04(2.46)	-0.05(3.24)	0.14(3.78)	-0.44(3.14)

These equations capture the primary response relationships found in the data: (1) additional amounts of N will increase response at a decreasing rate, (2) adding N and P together has a synergistic effect, (3) response is greater on poorer sites, (4) for basal area, the magnitude of the response increases to a maximum after application and then diminishes, while for top height the response increases rapidly to a maximum asymptote. The magnitude of the basal area response is determined by the amount of nutrients applied, years since treatment, basal area at time of treatment and site index. The parameter estimates ensure that greater top height and basal area response will be achieved on poorer sites. Stands with greater basal area at time of treatment will exhibit greater response.

Because the equations are relatively simple and express response in terms of cumulative response since treatment, they can be used to simulate rotation-length management regimes. Figure 1 shows an example management regime where three fertilizations (225 kg/ha N plus P) have occurred at 6, 10 and 14 yrs and one thinning (removing 13 m^2/ha) at age 12. The first fertilization has almost reached its maximum response when the thinning occurs; the amount of fertilizer response accumulated since application is removed ("captured") in the thinning and by age 18 there is no more effect of the first fertilization. Only a small amount of the age10 fertilization (the amount accumulated from age 10 to age 12) is removed in the thinning and so it, along with the age14 fertilization, account for most of the total cumulative basal area response to fertilization after thinning. It is assumed that (a) the response to multiple fertilizations is additive prior to maximum leaf area being achieved, (b) response to fertilizations that occur prior to thinning will be removed in the thinning operation, and (c) following thinning, the remaining response to fertilization will occur on the residual basal area.

Figure 1. Basal area response to a simulated regime of nitrogen (224 kg/ha) and phosphorus fertilization at ages 6, 10 and 14 with a thinning (removing 13 m^2/ha) at age 12.

Obviously, once maximum leaf area has been achieved, adding additional nutrients will not produce a response. Similarly, if other nutrients or resources are limiting, then adding additional N and P will not elicit a response. Still, with these general models and appropriate assumptions, reasonable results can be obtained for a wide range of treatment alternatives.

References

Amateis, R. L. 2000. South. J. Appl. For. 24:17-22.
Amateis, R. L., P. J. Radtke and H. E. Burkhart. 1996. J. of For. 94(12):19-23.
Amateis, R.L., J. Liu, M.J. Ducey and H.L. Allen. 2000. South. J. Appl. For. 24: 207-212.
Jokela, E.J., and S.C. Stearns-Smith. 1993. South. J. Appl. For. 17:135-138.
North Carolina State Forest Nutrition Cooperative (NCSFNC). 1995a. North Carolina State For. Nutrit. Coop. Rep. No. 33. Coll. of For. Res. North Carolina State Univ., Raleigh, NC 200p.

Acknowledgements

The support of the Loblolly Pine Growth and Yield Research Cooperative at Virginia Tech and the Forest Nutrition Cooperative at North Caroline State University and Virginia Tech is gratefully acknowledged.

UNEVEN AGED MANAGEMENT EXPERIMENTATION IN EASTERN CANADIAN BOREAL FOREST

Hervé Bescond[1], Yves Bergeron[1], J. Morasse[2] et K. Harper[3]

[1] Chaire industrielle CRSNG-UQAM-UQAT en Aménagement Forestier Durable, Université du Québec en Abitibi Témiscamingue, Rouyn-Noranda, Canada H2P 2H6
Tel : +1-819-762-0971 #2546 E-mail : herve.bescond@uqat.ca
[2] Cégep de l'Abitibi-Témiscamingue, Rouyn-Noranda, Canada
[3] Chaire industrielle CRSNG-UQAM-UQAT en Aménagement Forestier Durable, Université du Québec à Montréal, Montréal, Canada

Introduction

The knowledge of the natural dynamics of the forests is considered more and more in silviculture and forest management, in particular in the context of durable development (Attiwil 1994; Angelstam 1998; Bergeron and Harvey 1997; Seymour and Hunter 1999). In the boreal forest, fire is the main natural disturbance (Johnson 1992; Payette 1992; Weber and Flannigan 1997). The forest fires are generally destroying and they initiate succession, and create a mosaic of forest stands of different ages and compositions (Gauthier et al, 1996). In the black spruce feathermoss, the natural dynamics of the forests indicates that an even-aged management with, principally invovlving clearcutting, does not allow maintainance of the whole of the composition and the structure of the stands of the natural forest mosaics (Gauthier et al., 1996; Bergeron et al., 1999; Bergeron et al., 2002). Indeed, taking into account the cycles of very long natural fires, a significant portion of the forest stands evolve to irregular structures and uneven-aged which largely exceeds the proportion of stands to structure even-aged. As the age of forest revolution economic seldom exceeds 100 years, it follows a constant reduction in stands to irregular structure or uneven-aged in the landscape (Bergeron et al.. 2001; Harper et al., 2002). A promising alternative consists of a mixed installation (even-aged and uneven-aged) founded on a diversification of the forestry practices in managed territories. Among these practices, the partial cuts are seen like cuts of succession which, in arranged forest, could reconstitute the structure of the out of date and old stands of the natural mosaics. It is interesting to note that this step which has aims of maintenance of biological diversity is also convergent with a concern for the tree growers of making profitable in the irregular stands the abundance of stems of low dimension which would not be preserved at the time of clearcut.

Methodology

The study sites are located in the Matagami ecoregion (Saucier et *al.*, 1998). This region is part of Black Spruce Feathermoss bioclimatic domain, a sub region of the boreal forest of Quebec. The regional climate is continental with mean temperature ranging between -2,5 and 0 degrees Celsius. Mean annual precipitations are 1000mm. The ecoregion is located in the James By watershed and plains form the dominant landscape with some occasional hillocks and hills. The superficial deposits of the area are predominantly clays and silts associated with the Ojibway pro-glacial lake. Experimental tests of partial were carried out in pure or mixed uneven-aged stands of black spruce (*Picea mariana* [Mill.] B.S.P) in the boreal forests of Quebec. The system of harvest used is based on an entirely mechanized method usually used on the territory. This one includes a multipurpose power-driven circular saw and a conveyor on wheels. The composition and the structure of the residual stands were compared with what is observed in natural old-growth stands in which the transition towards uneven-aged stands was recently observed. For this, we use an inventory system established by the Quebec Ministry of Natural Resources composed of permanent and temporary plots (MRN, 1997), as well as the known fire history for the study sites in order to establish the characteristics of composition and structure of natural stands having already passed the moment of stand opening (Bergeron et al., 2001). In using these analyses of stand evolution and succession, the dendrometric characteristics of the stand was retained in order to estimate the degree of resemblance of the managed stands with the natural stands. The vascular and non-vascular understory species composition has been followed since the experimentation in partial cut, total cut and control. Multidimensional analyses were used in order to evaluate the characteristics of the treated stands compared to natural variability observed (Legendre and Legendre, 1983).

Results and discussion

The first results of the dendrological data suggest that partial harvesting (between 50 and 80% of merchandising volume) can successfully maintain the irregular stand structure associated with old growth forests. Similar results have been reported by MacDonell and Groot (1996) in diameter limit cuts performed in black spruce stands of the Ontario Claybelt. The change in the vascular and non-vascular understory composition is less important in the partial cut than in the total cut.

References

Angelstam, PK. 1998. J. Veg. Sci. 9 : 593-602.

Attiwill, PM. 1994. For. Ecol. and Manag. 63 : 247-300.

Bergeron,Y, Gauthier, S, Kafka, V, Lefort, P and Lesieur D. 2001. Can. J. For. Res. 31 : 384-391.

Bergeron, Y and Harvey B. 1997. For. Ecol. Manag. 92 : 235-242.

Bergeron, Y, Harvey, B, Leduc, A and Gauthier, S. 1999. For. Chron. 75 : 49-54.

Bergeron, Y, Harvey, B, Leduc, A and Gauthier, S. 2002. Sylva Fennica. 36 (1) : 81-95.

Harper, K, Bergeron, Y, Drapeau, P and Gauthier, S. 2002. Silva Fennica. 36 (1) : 249-263.

Johnson, EA. 1992. Fire and vegetation dynamics studies from the North American boreal forest. Cambridge Studies in Ecology. Cambridge University Press, Cambridge, 129p.

Legendre, L. et P. Legendre. 1984. Écologie numérique. Presses de l'Université du Québec. 260p.

MacDonnell, MR and Groot, A. 1996. Uneven-aged silviculture for peatland second-growth black spruce: biological feasibility. Canadian Forest Service. Technical Report TR-36.

MRN (1997) Normes d'inventaire forestier : les placettes-échantillons permanentes. Direction de la gestion des stocks forestiers, Service des inventaires forestiers, Édition provisoire, 248 p.

Oliver, C.D., et B.C. Larson. 1990. Forest Stand Dynamics. McGraw-Hill, New York. 467 p.

Payette, S. 1992. Fire as a controlling process in the North American boreal forest. Pages 144-169 in H.H. Shugart, Leemans, and G.B. Bonan editors. A systems analysis of the boreal forest. Cambridge University Press, Cambridge.

Saucier, J.-P., J.-F. Bergeron, P. Grondin and A. Robitaille. 1998. The land regions of southern Quebec (3rd version): One element in the hierarchical land classification system developed by the Ministère des Ressources Naturelles du Québec. Internal report, MRNQ, 21pp.

Seymour, RS and Hunter, ML. 1999. Principles of ecological forestry. In: Hunter, M.L. Jr. (Ed.), 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press. Cambridge, UK., 22-61.

Weber, MG. and Flannigan, MD. 1997. Environmental Reviews. 5: 145-166.

Acknowledgements

This work was made possible with the support of the Chaire industrielle CRSNG-UQAT-UQAM en aménagement forestier durable, the fonds de recherche sur la nature et les technologies and Programme Volet 1 from Ministère des Ressources Naturelles du Québec. We wish to acknowledge our industrials partners Tembec, Nobord and Abitibi Consolidated.

POTENTIAL FOR LEGUME INTRODUCTION IN SHORT ROTATION PLANTATION FORESTS AS A MEANS TO IMPROVE PRODUCTIVITY AND SOIL FERTILITY? THE NEED FOR COORDINATED RESEARCH.

Jean-Pierre_Bouillet[1], José Leonardo M Gonçalves[2], Jacques Ranger[3], Antoine Galiana[1], Jean de Dieu Nzila[4], Philippe Deleporte[5], Jean-Paul Laclau[6]

[1] Cirad-forêt, Campus International de Baillarguet, TA /C, 34398 Montpellier Cedex 5, France.
Tel: +33-04-67-59-38-66; E-mail: jean-pierre.bouillet@cirad.fr
[2] Esalq, Piracicaba, Brazil
[3] Inra, Biogéochimie des Ecosystèmes Forestiers, 54280 Champenoux, France
[4] Ur2pi, BP1291, Pointe-Noire, Congo
[5] Cirad/Ur2pi, BP1291, Pointe-Noire, Congo
[6] Cirad/Esalq, Piracicaba, Brazil

Introduction

As most tropical forest plantations are established on low fertility soils, there are concerns about their sustainability with respect to long-term production and maintenance of site quality. This question is particularly relevant when current emphasis on improved productivity and profitability leads to intensive silvicultural practices (i.e., improved genetic material, short rotations, change of species) supposed to increase nutrient demands on the site. In various tropical countries a conservative management of litter and slash residues leads to a better stand growth, due to an improvement in the physico-chemical properties of the top soil (CEC, base saturation,…), as well as in nutrient availability (N mineralisation,…). But even when residues are retained on the site, soil N pools are likely to decrease over successive stand rotations, since high amounts of N are removed every 7-10 years with stemwood. This pattern is worrying as N availability is often a major limiting factor of tree growth in tropical areas. The balance of N budget could be achieved through heavy N fertilizations. But nitrogen fertilizers are expensive and their application may lead to inadequate ratios in the tree tissues between N and the other nutrients and to strong negative environmental impacts. A second option is the introduction of N-fixing species. Even if numerous studies dealt with the introduction of legume cover crops in forest plantations, there is a deep need in scientific basis to evaluate the effects of perennial N-fixing trees (NFT) introduction on tree growth, stand production, atmospheric nitrogen fixation, and soil properties (Fischer and Binkley, 2000).

The objective of the communication is to provide an out line of a co-ordinated research project on short rotations mixed plantations and describe the possible objectives and experimental approach. Various aspects would be studied: 1) Growth and nutrient content of NFT and non-N-fixing trees. It is needed to quantify the balance between the positive (nitrogen input, …) and the potential negative effects of the legume (competition for water, ...) on the growth of the non-N-fixing trees ant net production of the stand, and on soil fertility, 2) Nutritional status of the non-N-fixing trees according to the density of NFT, 3) N_2 fixation by NFT, 4) Nutrient cycling, and 5) soil properties. The operational goal will be to define management options likely to be applied in short rotation forest plantations to maintain or increase stand productivity over successive rotations.

Tentative experimental protocols

Two management options might be considered:

- NFT as understorey species. The main objective of the understorey would be to increase N inputs in the plantation, without disturbing the silvicultural management of the commercial non-N-fixing species
- NFT as wood growing species harvested at the end of stand rotation.

NFT as an understorey species. A randomised complete block would be set up with 3 replicates or more, using plots of 9 x 9 trees, at least. The non-N-fixing trees would be planted at the same density, regardless of the treatments. Fertilisers would be applied at planting for the non-N-fixing tree, according to the current silvicultural practices. No N fertiliser would be further applied (except for treatment 3). Fertilisers (except N) would be applied for NFT, according to the current silvicultural practices.

The core treatments would be as following:
1) NFT, at the same density as that of the non-N-fixing tree
2) Non-N-fixing tree with current fertilisation (except N) throughout stand rotation
3) Non-N-fixing tree with current fertilisation (including N) throughout stand rotation
4) Mixture non-N-fixing tree with current fertilisation (except N) throughout stand rotation + NFT (25 % of non-N-fixing trees)
5) Mixture non-N-fixing tree with current fertilisation (except N) throughout stand rotation + NFT (50 % of non-N-fixing trees)

Different optional treatments could also be tested as higher densities of NFT, mixture agricultural legume + non-N-fixing tree, cutting NFT regularly to reduce competition between NFT and non-N-fixing trees, or mixture 50 % non-N-fixing trees + 50% NFT.

The traits and measurements would include:
- Growth and nutrient content of NFT and non-N-fixing trees: height and $C_{1.30m}$; biomass of the various components of the trees and nutrient content at 1 year, 3 years and at the end of the stand rotation.
- Biomass and volume tables established at 1 year, 3 years and at the end of the stand rotation for the two species.
- Nutritional status of NFT and non-N-fixing trees: foliar N, P, K, Ca and Mg concentration, every year.
- Nutrient cycling (NFT and non-N-fixing trees): litter fall collected every 2 months separating the two species; litter decay, sampled with litter bags every 3 months; forest floor accumulation, sampled every year.
- Assessment of N_2 fixation by NFT: N accretion before planting, at 3 years, and at the end of the rotation.
- Soil properties before planting, and at 1 year, 3 years and at the end of the rotation.

Optional measurements could be also performed, as climate data, LAI of NFT and non-N-fixing trees, carbon characterisation (lignin,…) of the litter according to the species, i*n situ* and/or potential N mineralization during stand rotation, assessment of N_2 fixation by NFT using ^{15}N natural abundance method, tree disease…
NFT harvested at the end of stand rotation. The same modalities would be applied except that stand density (including NFT and non-N-fixing trees) would be the same whatever the treatments. No optional treatments would be tested.

Discussion

Four experiments, testing mixed plantations of eucalypts and acacias, have been established for one year in Brazil and in Congo following the proposed experimental design. Preliminary results will be presented during the conference. In 2004, five more trials should be established in Brazil by Cenibra and VCP, that manage around 300,000 ha of eucalypt plantations. Therefore, a co-ordinated research program on this issue should being developed. It should yield relevant information pertinent to various issues.

N_2 fixation. A common set of estimations in various countries should provide informative data on the amounts of N_2 fixed within mixed plantations. The results should also lead to a better prediction of N_2

fixation according to soil properties. N_2 fixation is usually promoted by adequate nutrient supply, especially phosphorus, but there are no evidence concerning the effects of soil nitrogen on N_2 fixation.

Soil properties. The change of some key soil parameters as pH and organic matter should be quantified. A decrease in soil pH is generally observed in mixed plantations. One of the effects of the pH decrease could be the difficulty for the NFT to nodule and to fix N_2. But in some cases no change in soil pH may be observed because an increase in acidic compounds in the soil is likely to be balanced by an increase in base saturation of the exchange complex. Fischer and Binkley (2000) indicated that soil organic matter often increases under nitrogen-fixing-species, owing to the increase in pools of carbon from nitrogen-fixing-species litter. But the authors suspected also that the increase in soil nitrogen lowers the rates of decomposition of old soil carbon, and stimulate the decomposition of labile carbon, as well. The proposed experiment should give data on the changes in soil C and N dynamics according to the organic matter properties by quantifying the biomass and nutrient content of litter floor before planting, the biomass and nutrient content of the litter according to the species mixture, and by characterising the carbon of the litter according to the species.

Plantation diseases. Very little work has been done to examine the impact of legumes on diseases of non-N fixing species. Red alder is likely to reduce the incidence of root rot in *Pseudotsuga menziesii* plantations. By contrast some annual and perennial leguminous species are very sensitive to infestation by nematodes that can lower N_2 fixation and contaminate the associated non-N fixing species, as well.

Mixed plantation management The results obtained should help forest managers to assess the site conditions and the silvicultural practices (legume tree density, …) required to manage mixed plantations. But the best management options (mixed plantations *vs* monocultures) will be chosen owing to i) economic analyses balancing the benefits (lower fertilisation or weeding costs, multiple resource values, …) and the over-costs (seedling production,…) of N_2 fixation, but also ii) ecological studies taking into account the impact of mixed plantations on soil properties (CEC, organic matter content,…) and biodiversity (flora and fauna).

References

Fisher, R.F. & Binkley, D., 2000. Ecology and management of forest soils. 3rd ed., John Wiley & Sons, New-York, 489 p.

30-YEAR RESPONSE OF WHITE PINE TO RELEASE AFTER PARTIAL HARVESTING IN PINE MIXEDWOODS

Darwin Burgess[1], Craig Robinson[1] and Suzanne Wetzel[2]

[1] Forestry Research Partnership, Petawawa Research Forest, P.O. Box 2000, Chalk River, ON, Canada K0J 1J0; Tel: +1-613-589-9569; E-mail: dburgess@nrcan.gc.ca
[2] Natural Resources Canada, Canadian Forest Service, 1219 Queen St. East, Sault Ste. Marie, ON, Canada P6A 5M7

Introduction

Mixed-species forests, many of which contain hardwood and conifer species, are abundant in global forests. In some instances, mixed-species stands may be preferred or required (Matthews 1989). In North America, eastern white pine (*Pinus strobus* L.) grows in pure and mixed forests of eastern and central Canada, and in the central and northeastern United States. By the late1800's most of the vast pine stands had been logged (Wendel and Smith 1990), and many had burned as well. Logging and wildfires resulted in more mixedwood stands of eastern white pine with intolerant hardwoods, such as trembling aspen (*Populus tremuloides* Michx.) and largetooth (*P. grandidentata* Michx.) aspen, and white birch (*Betula papyrifera* Marsh.).

White pine is frequently the younger species in these mixed-species stands, where it typically occurs in the understorey before eventually outgrowing or outliving the hardwoods. Better quality white pine trees develop in the understorey because they are protected from attack by white pine weevil (*Pissodes strobi* Peck), which feed and kill terminal shoots in open-grown conditions (Hannah 1988). White pine is intermediate in shade tolerance. It survives in up to 80% shade, but reaches maximum height growth with 45% of full sunlight (Logan 1966). The pine is more economically valuable, although the commercial value of the hardwoods has increased.

The main aim of this study was to increase growth, yield and quality of white pine while maintaining all other forest values. Earlier papers provided a description of the study and some shorter-term results (Brace and Stewart 1974; Stiell 1984; Stiell et. al. 1994). This paper examines white pine growth and development 30 years after release by partial harvesting.

Methodology

Understorey white pines (mean age of 55 years) in natural pine mixedwood stands within the Petawawa Research Forest (45° 57' N, 77° 34' W) were released in 1971 from an 80-year-old overstorey of intolerant hardwoods. Released white pines were assessed under low, medium and high density (initial pine basal areas of 6.9, 11.5, and 16.1 m^2 ha^{-1} in control and harvested plots) using a randomized design with five replicates. Trees greater than 9.0 cm DBH were tagged, and all diameters were measured in fall 1971, 1981, 1991 and 2001. Height samples were taken at each measurement and Chapman-Richards nonlinear height-diameter equations (Huang et al. 1992) were calculated for each species. Total, merchantable (trees $\geq$ 9 cm DBH), and sawlog (trees $\geq$17 cm DBH) volumes were calculated from metric yield tables (Honer et al. 1983). Three 10 m x 10 m subplots were set up randomly in each treatment plot. All woody species greater than 1.3 m in height up to 9.0 cm DBH were tallied. Smaller subplots, 2 m x 2 m in size, were placed randomly in one corner of each large subplot, wherein the tree regeneration and other vegetation were surveyed. All estimates were summarized on a plot and per hectare basis and analyzed by ANOVA.

Results and discussion

Eastern white pine often grows in mixed-species stands and a significant proportion of these are probably two-storied, but forest inventories are typically not designed to identify this stand-type. In the Lake States, for example, the area of white pine has increased in more recent forest inventories as significant portions of mixed, two-storied stands have succeeded and now appear as white pine types (Spencer et al. 1992). In competition with light-foliaged species such as the aspens and white birch, white pine can establish and eventually gain dominance on some sites, if a white pine seed source is available. White pine is a long-lived species commonly reaching 200 years of age or older if undisturbed, and its natural recruitment can take place throughout a relatively long period of time including several decades (Abrams and Orwig 1996). The nature of the aspen clones probably affects the distribution and abundance of white pine in mixedwood forests. Aspen's competitive influences on white pine growth and survival can be significant, both above and belowground (Peterson and Squires 1995).

In this study, the approach increased the rate of succession by removing and utilizing the shorter–lived, aspen-birch overstorey. By partial harvesting, much of what would have been natural hardwood mortality in the last 30 years was utilized.

Fig. 1a

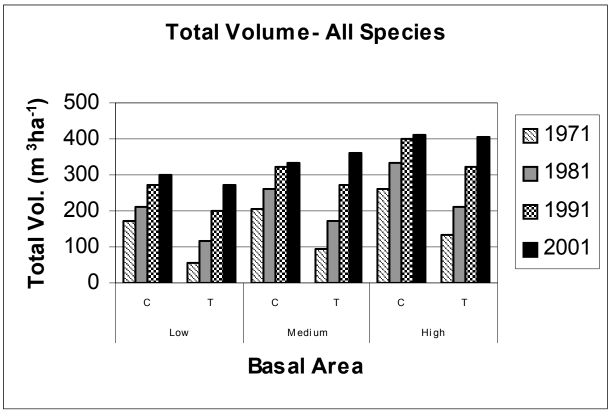


Fig. 1b

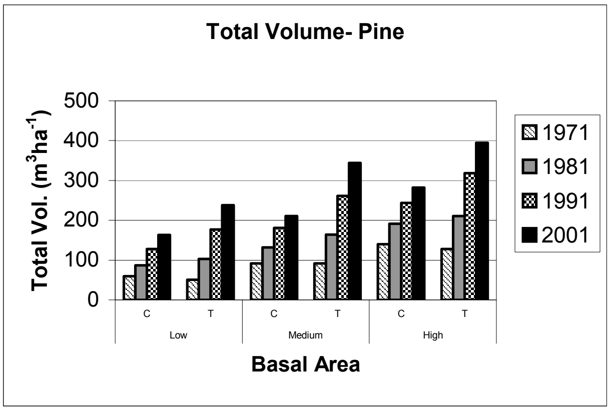


Fig. 1. Total volume (Fig. 1a) and pine volume (Fig. 1b) through time in non-harvested, control (C) and harvested, treated (T) plots. Initial pine basal areas in 1971 were low (6.9 m^2 ha^{-1}), medium (11.5 m^2 ha^{-1}), and high (16.1 m^2 ha^{-1}).

Even though an average of 123.2 m^2 ha^{-1} of mainly intolerant hardwoods was harvested in 1971 from the treated plots, their total stand volumes in 2001 were similar to those of the control plots (Fig. 1a). The growth responses of pine after release were significantly ($p<.001$) higher for all three basal area levels (Fig. 1b). When a higher initial pine basal area was retained, the periodic annual increment of pine was higher throughout the 30-year period after treatment. During the last decade, the annual increment of pine has declined, but in the harvested plots it still ranged from 6.1 to 8.3 m^3 ha^{-1} yr^{-1} being highest at the medium initial pine basal area. The increment overall within the control plots was very low during the last decade because of high losses to mortality of both aspen and white birch. The white pine increment also has remained lower in the control plots at about half that in the harvested plots (Fig. 1b).

The pine response to release depended on the nature of the competition and the length of time the pine had remained in the understorey. If white pine survives to the sapling stage, its ability to compete is greatly improved. In general, white pine responds well if it has been able to retain a healthy crown of sufficient size. In this study, effort was made to retain white pine, if possible, which had a crown length of at least one-third of total tree height.

Height-diameter ratios of white pine decreased after release ($p<.001$), indicating that stability as well as growth can be influenced by release (Puettmann and Saunders 2000). However, they were increased by higher initial pine basal areas ($p<.001$). In 2001, the height diameter ratios varied by initial pine basal area in the control and released plots respectively, from 84.1 to 71.9 (low), 92.6 to76.5 (medium), and from 96.8 to 88.5 (high). Partial harvesting probably increased resource availability, while higher initial pine basal areas had an opposing effect, increasing intraspecific competition and reducing resource availability.

The partial harvest operations had little impact on the stand's aesthetic attributes, based on an earlier study using a numerical index to quantify aesthetic impacts (Smyth and Methven 1978). Herb diversity was higher in treated plots and browse potential was not affected (Stiell et. al. 1994). Aspen is managed for a variety of forest products and although its economic value will probably remain lower than that of white pine, managers have the option of managing mixed-species stands with a higher component of aspen or of using a system of crop rotation, as long as sufficient white pine are retained to provide an adequate supply of seed.

The treatments examined here increased white pine growth significantly while working with the natural succession pathway in these stands, but without further management activities or wildfire, the study area will succeed again towards the economically lower-valued hardwoods. Red maple (*Acer rubrum* L.) and other hardwood species, and balsam fir (*Abies balsamea* (L.) Mill.) are now the most common species of sapling size in the stands included in this study. White pine is a fire-adapted species and with the effective fire suppression programs of today, a variety of silvicultural methods will be needed to maintain, enhance or in some cases, restore white pine and pine mixedwood forests.

References

Abrams, MD and Orwig, DA. 1996. J. Ecol. 84: 353-363.
Brace, LG and Stewart, DJ. 1974. Pulp Pap. Mag. Can., Aug., pp.1-7.
Hannah, PR. 1988. North. J. Appl. For. 5: 70-77.
Honer, TG, Ker, MF and Alemdag, IS. 1983. Can. For. Serv., Rep. M-X-140. 139p.
Huang, S, Titus, SJ and Wiens, DP. 1992. Can. J. For. Res. 22: 1297-1304.
Matthews, JD. 1989. Claredon Press, Oxford, U.K. 284p.
Peterson, CJ and Squires, ER. 1995. J. Ecol. 83: 449-457.
Puettmann, KJ and Saunders, MR. 2000. North. J. Appl. For. 17 (3): 89-94.
Smith, JH and Methven, IR. 1978. Dept. Environ., Can. For. Serv., Rep. 0-X-270. 12p.
Spencer, JS, Jr., Leatherberry, EC and Hansen, MH. 1992. University of Minnesota. Rep. NR-BU-6044-S, pp. 44-53.
Stiell, WM. 1984. For. Chron. 60: 3-9.
Stiell, WM, Robinson, CF and Burgess, D. 1994. For. Chron. 70: 385-394
Wendel, GW and Smith, HC. 1990. U.S.D.A. For. Serv., Agr. Handbook 654, Washington, DC, pp. 476-488.

Acknowledgements

We thank Natural Resources Canada (Canadian Forest Service) and the Forestry Research Partnership in Ontario for their financial support.

SUSTAINABLE DEVELOPMENT OF FOREST RESOURCES IN SRI LANKA: A VILLAGE-BASED APPROACH

Mangala De Zoysa

Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka
E-mail: mangala@agecon.ruh.ac.lk

Background

During the classical period, village households lived in harmony with the forest environment. Forest Ordinance of the colonial rulers in 1907 provided constitution of village forests. The land policy in 1930 classified and allotted village forestlands for the requirement of village households (Troup, 1940). Even several decades ago rural households sustained itself with small village forests (Kariyawasam, 1996). “Village forests” were set apart under District Secretariat on section 12 of the Forest ordinance (UNDP, 1995). Presently, the “village forest” is disappearing as a result of the eliminating “common property rights” (Bogahawatte, 1986). The demand for forest produces has outstripped the productive capacity of the forest resources and the benefits from forest resources are not equitably distributed. The recent community forestry and participatory forestry have not gained ground. The proposed “peoples forestry” requires a defined manageable geographical area (FPU, 1996). Hence, “the village” would be the most appropriate manageable geographical area to promote forest in a sustainable basis under a controlled system. The paper review the literature and attempts to promote a sustainable village-based forest development approach in Sri Lankan context through intense scrutiny and refinement to address concerns of village livelihoods and forest users, uses and sources of forest products, and revitalization of village forest resources.

Livelihoods and forest users

Livelihoods: The livelihood pattern of the village is consisted with farming, non-farming and landless households. Most of them are farmers who own small farmlands and heavily depend on forest to obtain inputs for farming activities. The non-farming households have the main sources of income from cottage industries, local business or service employment supplement with some farming activities. The households who are engaging in cottage industries are dependents on timber and / or non-timber forest products. Landless households depend mainly on non-land based activities such as laboring in farming and non-farming activities, artisan work, collection of non-timber forest products and also contract laboring in illicit timber felling.
Forest users: Three types: regular, Occasional and incidental forest users could be distinguished in a rural village. The regular forest users depend on forest products daily or weekly and take responsibility for protection and management of “village forest” (FPU, 1996). The occasional forest users visit less frequently and collect fewer products required for small-scale cottage industries and agricultural activities without damaging forest eco-system. The incidental forest users severely exploit forest resources to cater large-scale business and urban needs creating irreparable damages to the village forest.

Uses and sources of forest resources

Uses of forest resources: Village forests provide a variety of products and services including grass, fodder, timber, fuel-wood, foliage, small poles, fence-sticks, medicinal herbs and other non-timber forest products as well as aesthetic and recreational amenities. The use of forests as places of refreshment and relaxation is a very ancient tradition (Kariyawasam, 1996).
Sources of forest resources: Supply of timber and non-timber forest products in a village is highly location and person specific (Howes and Endagama, 1995). Village forest trees supply many timber and non-timber forest products for the village households. A large part of annual requirement of

timber (1 million m^3) and fuel-wood (55 million m^3) comes from plantations, agricultural residues and home-gardens (Nanayakkara, 1985). Farmers and craftsmen need wood for tools and construction timber partly comes from farm or home-gardens. Agro-forestry is a successful long tradition of village households (FPU, 1996).

Misuses of forest resources and conflicting issues

Misuses: The 80,000 ha of village forests have disappeared due to alienation, encroachments and clearing for shifting cultivation (Perera, 1977). The forests remaining has reached a critical level and threatened the sustainability of livelihoods (FPU, 1996). Pressure of population and land-use practices cause widespread destruction of forests. Lack of capacity to protect forests creates an "open access" situation. Most fertile forestlands have been converted into agricultural lands. Out-grower plantations has encroached village forest reserves (UNDP, 1995). In most cases local businessmen misuse forests for short-term benefits (FPU, 1996). Urban people buy large amount of fuel-wood, which is supplied in ways contributing to deforestation (Howes and Endagama, 1995). Organized illicit timber felling creates drawbacks for village forest development. Further, mining in village forests has disturbed the vegetation (Gunatilleke and Gunatillake, 1983).

Conflicting issues: Lack of boundaries between forest reserves and villages is a main obstacle for village forest management and conservation (Karunanayake, 1994). Most policy issues reflect professional view leaving village households from decision making process (Hewage, 1996). The community forestry selects forest users and giving them limited responsibility without considering different livelihoods depend on different product flows. Some authors criticize the community forestry as a poor policy for poor people (Graner, 1999). Forest development projects failed where traditional users have not been consulted and involved (Evans, 1992). If the forests have revenues potential, government may not share the management with households (Springate, et. al., 2003). The village households are often little aware of government ambitions. It is difficult to distinguish the intended end-users in the village or the purpose to supply urban markets (Howes and Endagama, 1995). The diverse users are unable to base a working relationship on common understanding or interest. The farm forestry benefits the rich misusing subsidies, and fails to deliver social and environmental benefits (Foley and Barnard, 1984).

Revitalization of forest resources

Assessment of forest needs: Forest users have different needs from different village based forest resources. The main task of village forestry development is to provide the needs of the village households and to increase income and employment generation through integration of forest management with the local economy. The pattern of users' product needs and expectations is complex and depend on household livelihood pattern and wealth, forest type and product availability. Men and women also have different priorities as they have different responsibilities. Therefore, the village forestry development strategies need holistic livelihood development activities.

Improvement of flow of forest products: The village forest approach has to reverse forest degradation and households have to benefit from improved forest product flows. Supply of forest products required by households has to be considered in policies and strategies to development village forestry resources. The Forest Policy in 1996 has stressed the homesteads and agro-forestry as a main strategy to supply forest products for the village households' and market needs (FPU, 1996). Tree planting on barren lands, agricultural lands and home-gardens are the very important alternatives. Growing trees in agricultural lands add main benefits providing timber, fuel-wood and fodder, so reducing pressure on natural vegetation. Sustainable forest product flows could be improved by improving condition of the forest resources through protection of forest from illicit tree felling, unregulated extraction of forest products and forest encroachment. Conducting appropriate silvicultural operations such as thinning and pruning could reap the full potential benefits from forests and trees available in non-forest lands in the village.

Corporate Governance: The National Forest Policy in 1996 has recognized the roles of all the forest stakeholders in the development of forest resources (FPU, 1996). Effective forms of partnership with stakeholders not only could manage the forest resources sustainably but also promote more equitable distribution of benefits. A greater responsibility is given to village households, organized groups, cooperatives, industries, and other private bodies involving in commercial forest production, industrial manufacturing and marketing. If assured of financial benefits in return and authorized by the government, the village households protect forest resources even from encroachers. The forest protection activities should be improved by addressing illegal cutting and unmanaged utilization of forest resource using a combination of awareness-raising and allocating protection responsibilities. The villagers must be aware of their rights and proper processes for transparent and inclusive decision making. The new initiatives could be tested with co-management model in which stakeholders consultations are conducted.

References

Bogahawatte, C. 1986. Agric. Ad. 23, 191-199
Evans, J.1992. Ox. Uni. press, UK.
Foley, G. and Barnard, G. 1984. Nat. Pub. India.
FPU (Forestry Planning Unit) 1996. Min. of Agric. Lan. and For. Col. Sri Lanka.
Graner, E. 1999. Freib. Stud. in Geog. Saarbrucken
Gunatillake, IAUN. and Gunatillake, CVS. 1983. The Sri Lan. Fores. 16, 1 and 2, pp. 39 ~ 56.
Hewage, T. 1996. Eco. Rev. April 1996. Pp. 6 ~8.
Howes, M. and Endagama, P. 1995. Int. Tec. Pub. London.
Kariyawasam, D. 1996. Eco. Rev. vol. 22, No. 01, April 1996. Pp. 3 ~ 5.
Karunannayake, MM. 1994. IUCN.
Nanayakkara, VR. 1985. Sri Lan. Fore. 1985, Vol. 15 3-4, pp. 75 ~ 79.
Perera, WRH. 1977. The Sri Lan. Fore. Vol. XIII, No. 1 & 2, Jan ~ Dec, 1977 pp. 5 ~ 8.
Springate, OB. Yadav, N. Dev, OP. and Soussan, J. 2003. J of for. and liv. Ru. Dev.3(1)
Troup, RS. 1940 Ox. Uni. Pre. UK
UNDP 1995. UNDP project report – SRL /89/011

STUDIES ON THE ENDANGERED PONDBERRY (*LINDERA MELISSIFOLIA* [WALT] BLUME)

Margaret Devall[1] Nathan Schiff[1], Tracy Hawkins[1], Kristina Connor[2], Craig Echt[3], Emile Gardiner[1], Paul Hamel[1], Ted Leininger[1] and A. Dan Wilson[1]

[1]Center for Bottomland Hardwoods Research, P.O. Box 227, Stoneville, MS 38776, USA, Tel. 662/686-3161 E-Mail: mdevall@fs.fed.us
[2]G.W. Andrews Forestry Sciences Laboratory, 520 Devall Drive, Auburn, AL 36849
[3]Southern Institute of Forest Genetics, Harrison Experimental Forest, 23332 Highway 67, Saucier, MS 39574, USA

Introduction

Pondberry (*Lindera melissifolia*) is a woody plant that occurs in seasonally flooded wetlands, and on the edges of sinks and ponds. It is a rhizomatous, clonal shrub that grows to a maximum of two meters in height (Devall, Schiff and Boyette 2001). The species is dioecious, with small yellow flowers that bloom in spring before leaf-out. Stems flower in the second to fourth year of growth, but flower and fruit production are highly variable (Morgan 1983, Tucker 1984, U.S. Fish and Wildlife Service 1993). Approximately thirty six populations are known in several southern states. The species was listed as endangered by the U.S. Fish and Wildlife Service in 1986 (U.S. Fish and Wildlife Service 1986) and a recovery plan was written in 1993 (U.S. Fish and Wildlife Service 1993). Pondberry has probably always been rare, and knowledge of its ecology, physiology and genetics is sparse. Also lacking is information about environmental factors required to sustain the viability of populations. The species has been affected by habitat destruction and alteration, especially timber cutting, clearing of land, and local drainage or flooding of wetlands, and stem dieback is widespread. Flood control measures proposed for the southern Mississippi Delta have raised concern about the survival and persistence of the species in this region.

Methodology

The following research efforts are being conducted in order to address the concerns about the species. Tissue culture techniques are being used to mass-produce pondberry for use in these studies. We are collecting ecological data and measuring environmental variables to thoroughly describe the current status of the species in Mississippi, to detect future changes in the populations, and to assess the potential impact of altered hydroperiods on native pondberry colonies. We are investigating the influence of abiotic factors on the competitive abilities of pondberry, initially to differentiate competitive abilities of male and female plants, then to determine whether flooding regime and light availability influence interspecific competitive abilities. Experiments are being conducted with pondberry seeds on thermogradient tables in order to learn the best temperatures for pondberry germination. Seeds are depulped, dried and stored for various lengths of time in order to learn the best drying and storage methods. Pondberry pollen is being examined and germinated. Dispersal opportunities for pondberry were investigated by observation of five fruiting colonies in the Delta National Forest. DNA-based genetic markers are being used to look at generational and geographic differences in the genetic diversity of pondberry populations on the Delta National Forest and on neighboring and distant sites. The pathology component of the project is focusing primarily on determining the identification of fungi responsible for pondberry dieback and stem canker, and documenting the effects of these fungi on pondberry growth and survival. We are planning to examine the interactions of soil inundation and light availability on physiology and growth of pondberry by varying soil moisture (flooding) and light intensity in a large-scale impoundment facility. The facility contains 12 bays that can be flooded or drained independently, and shade houses have been constructed in the bays. The plants to be used in the physiology study are in the greenhouse and will be outplanted at the facility in January 2005.

Results and Discussion

A baseline assessment of two pondberry sites in Mississippi has been completed. Based on importance values, the forest type at the Delta National Forest was sweetgum dominant (*Liquidambar styraciflua* L., IV = 98.8) with sugarberry (*Celtis laevigata* Willd., IV_{300} = 36.1), red maple (*Acer rubrum* L., IV_{300} = 30.1), and Nuttall oak (*Quercus texana* Buckley, IV_{300} = 28.5) sharing secondary importance. Forest type at the Bolivar County site was *Quercus* dominant (*Q. texana*, IV_{300} = 66.8 and *Q. phellos*, IV_{300} = 57.3). Subcanopy (dbh, 2.54 cm – 10.15 cm) composition was similar between the two forest transects, and was primarily composed of shade tolerant species (red maple, sugarberry, green ash (*Fraxinus pennsylvanica* Marshall), and American elm (*Ulmus americana* L.). *Lindera melissifolia* occurred in 38.2% and 28.9% of plots sampled at Delta National Forest and the Bolivar County site, respectively (Hawkins et al, *unpubished results*).

Pondberry seeds are 'orthodox', meaning that they can be dried before storage. However, we do not know the best moisture content at which they should be stored. The supposition that they are of little value in stand establishment, while an accepted truism, has not been supported by experimental evidence. These are the first results of research on pondberry seeds. Pondberry pollen is sticky, difficult to stain and difficult to germinate. Additional methods will be tried. 35% of the pollen collected in Arkansas germinated, but only 15% of the pollen collected on the Delta National Forest germinated.

Two years of work on the observational study of fruits on marked clones of the plants resulted in identification of Hermit Thrush (*Catharus guttatus*) as a short-range disperser for the plant (Smith et al., 2004). We are testing the tentative hypothesis that black bears may be another disperser for the plant.

Pondberry colonies are composed of multiple stems, but it is not usually known how many genetic individuals are present. Genetic analysis of one pondberry colony with multiple stems indicated that approximately half of the stems were of each of two genotypes, with two stems of two additional genotypes. Information about gene flow, seed migration, inbreeding and genetic diversity within and between pondberry sites will be used to define self-sustaining populations and to implement management plans.

Preliminary studies investigating the causal agents of pondberry dieback have indicated that the causal agent of pondberry dieback and stem canker is the fungal pathogen *Botryosphaeria ribis*, a tentative identification based on the *Fusicoccum* sp. anamorph (Wilson et al., 2004).

References

Devall, M, Schiff, N and Boyette, D. 2001. Natural Areas Journal 21: 250-258.
Morgan, S 1983. Natural Areas Journal 3:62-67.
Smith, CG, Hamel, PB, Devall, MS, Schiff, NM. 2004. Castanea 69(1):.1-8.
Tucker, GE 1984. Provided under contract to the U.S. Fish and Wildlife Service, Southeast Region, Atlanta, GA. 41 pp.
U.S. Fish and Wildlife Service. 1986. Federal Register 51: 27495-27500.
U.S. Fish and Wildlife Service. 1993. U.S. Fish and Wildlife Service. Atlanta, Georgia, USA. 56 pp.
Wilson, AD, Schiff, NM, Devall, MS, Connor, KF, Hamel, PB, Gardiner, ES, and Leininger, TD. 2004. Phytopathology 94(suppl.):110.

Acknowledgements

We thank the U.S. Army Corps of Engineers for funding this study.

SILVICULTURAL MEASURES FOR CONSERVATION OF DUNE LANDSCAPES IN RUSSIA

Anton V. Doroshin and Anatoliy V. Zhigunov

Federal St. Petersburg Forestry Research Institute, St. Petersburg, Russia
Tel: +7 (812) 552-80-28 E-mail: adoroshin@AD10039.spb.edu

Introduction

Dune sands represent a very special landscape. In Russia they can be found on the Caspian Sea, White Sea, and Baltic Sea coasts. The Southeast coastal dunes of the Baltic Sea of the Kaliningrad region are among the highest in Europe (up to 70 m. in height). They are a part of the Curonian and Visla Spits, which are gigantic drift sand deposits. There are two types of coastal dunes at the Spits: 1) man-made dunes (Foredune Ridge), which are mostly covered by vegetation, and 2) dunes of natural origin (the Great Dunes), which consist of open drift sands and those with vegetation. The Foredune Ridge was created in the 19th century as a barrier to prevent drift sands from moving into the continent. Before the 19th century, till the construction of the ridge, catastrophes occurred many, such as massive sand drifts over transport lines and sand deposition in inhabited areas. Later, in the 20th century, the disasters repeated again after partial to full destruction of the Foredune Ridge. In the last few centuries, extensive experience in methods fighting against sand drift has been gathered in the Netherlands, France, Denmark, and Germany, and also in Lithuania and the Kaliningrad region itself (the most west region of Russia).

The artificially created landscapes still prove to be fragile. In order to preserve the dunes, to take care of the unique environment and to develop the scientific and recreational potential, the Curonian Spit obtained in 1989 the status of “National Park”. Additionally the Curonian Spit got more support as protected natural area being included into the List of the World Heritage of UNESCO in 2000. It was recognised as an area of unique cultivated landscape. Various ecological and social factors determine the low potential of the park’s landscape stability, i.e. the ability of the landscape to maintain in stable balance with the environment and human society (Tepliakov, Rylkov, 2003). Many factors intensify the negative effect of each other. This is particularly true for the open sand dunes, which account for 10 % of the Spit territory.

Methodology

The silvicultural research discussed in this paper has been carried out on a landscape basis at the Curonian Spit National Park. Since 1999 specialists of our Institute, jointly with the Russian State Pedagogic University, the Institute of Oceanology (Atlantic Division), and Kaliningrad State University have been monitoring 14 permanent lateral profiles. The research aimed on the development of techniques increasing biological and morphological dune sustainability. The research involves:

- The morphological characteristics and dynamics of the Foredune Ridge and Great Dunes (monitoring them 3 times per year);
- Landscape and ecological studies, including the research on microclimates, detailed landscape structure characteristics, forest stands, ground and vegetation cover characteristics, as well as the influence of vegetation cover on the dune stability;
- Development of effective and ecologically-sound technologies and strategies for the afforestation and restoration of the Foredune Ridge and the stability of the Great Dunes.

The Foredune Ridge is the main object of research; its preservation ensures the landscape stability, what is of importance for the biodiversity and for the regional population in general.

Results and discussion

The landscape elements of the Curonian Spit change from the West to the East. The landscape of the Spit in cross-section includes the following landscape elements: 1) the Baltic Sea beach zone; 2) the Foredune Ridge, so called “avantdune”; 3) a sea sand plain — “palve”; 4) a blow-out remnants area — “kupstyne”; 5) the Great Dune Ridge — “animate” drifting dunes; 6) the Curonian Lagoon.

After monitoring the Spit sea coast, 8 emergency-state sites were distinguished. At these locations the avantdune was completely destroyed. Within the boundaries of these sites, the largest 45 blown-out kettleholes of various configurations are found. Fortunately, most of them are still reasonably small (a volume of less than 4000 m^3 and an area smaller than 1000 m^3). The kettleholes in total cover an area of 44176, 94 m^2 and account for a sand volume of 112655, 34 m^3.

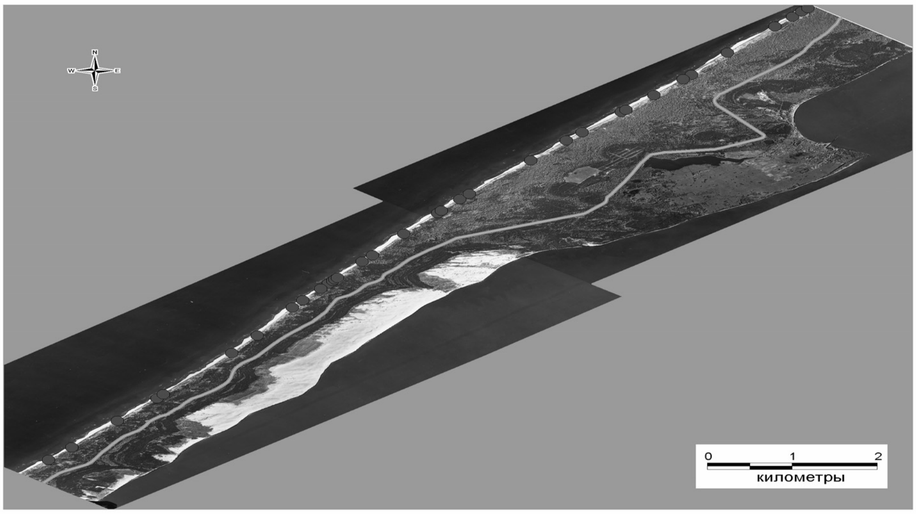


Fig. 1. A satellite image of the key monitoring sites of the Spit. The blown-out kettleholes that require protective silvicultural techniques are marked by dots.

A classification of coast types has been developed, which was compiled by using morphological and vegetation structure and composition characteristics. It includes 3 types (stable, transitional and destroying) and 7 intermediary subtypes. Effective measures for afforestation of drift sands have been developed which are based on the results of the experiments for the defined coast types. It is recommended that accumulation of natural sand on coastal sites with wide beaches (30-50 m) should be intensified by simultaneous planting of willow cuttings (*Salix acutifolia Wild*., *S. daphnoides Vill., S. purpurea L., S. triandra L., S. cinerea L.* etc.) and rootstock grasses (*Elymus giganteus Vahl*. and *Ammophila arenaria (L.) Link*). This method allows formation of cliff terraces on the sea beach sides of dune slopes, in order to reduce the destructive impact of waves. The observations show that sand accumulation on the dune surface is most intensive when grass psammophytes amount to 100-200 per m^2. On the emergency sites with intensive abrasion and destruction of the avantdune slope, work on afforestation should be combined with artificial coast-protection constructions. A system for inwashing wave-cut beaches and hydro-technical constructions has been developed especially for the Curonian Spit (Nikolaev, 2002). It was build at two emergency sites and successful during the last decade.

Openwork protection by willow cuttings and stakes should be used to stabilize drift sands and accumulate sand in the kettleholes. The plants root quickly and form a tracery “frame” of young shoots which fix depositing sand. As a result, a kettlehole is filled with sand gradually up to the top of the dune. The vegetative shoots spread out abundantly and stabilize sand over a short period.

Fig. 2. Openwork live protections of willow stakes for restoration of a destroyed foredune site in a kettlehole.

It is necessary to study the behavior and development of several conservation measures at this National Park to preserve the remarkable and unique phenomenon of drift "animate" dunes. Furthermore, a 2-3 km cableway is to be built to limit foot traffic in the park.

References

Tepliakov, G. & Rylkov, O. 2003. Natural and cultural heritage of the National Park "Curonian Spit". State and challenges of management. Challenges in investigation and protection of the natural and cultural heritage. NIA-Priroda, Moskow: 4-12. (In Russian).

Nicolaev, A. 2002. Advance of environmental solutions for creation of the in-washing coasts. Dissert. for degree of Cand. of Sciences. St. Petersburg State Tech. Univ.: 52 p. (In Russian).

Acknowledgements

This research has been carried out in the framework of the following projects: «Development of methods and technologies for coastal drift sand stabilization and afforestation in the Kaliningrad region, Russia» (2000-2001) and «Development of technical and biological methods for conservation of dune landscapes on the Curonian Spit, considering undesired natural and human impacts» (2002-2004), sponsored by the Russian National Park "Curonian Spit". We acknowledge the administration of the National Park for their organizational help. Furthermore, the authors would like to thank Dr. Nina Zhigunova and Ph.D.-student Rens Hartkamp for revising the English Language.

EFFECTS OF STRIP CUTTING AND SINGLE-TREE SELECTION CUTTING ON BIRDS AND THEIR HABITAT IN A SW QUEBEC EXTENSIVE NORTHERN HARDWOOD FOREST

Frédérik Doyon[1], Daniel Gagnon[2] and Jean-Francois Giroux[2]

[1]Institut Québécois d'Aménagement de la Forêt Feuillue,
Ripon, Qc, J0V 1V0, Canada. Tél :+1-819-983-2206, E-mail : fdoyon@iqaff.qc.ca

[2] Université du Québec à Montréal, Montréal, Québec, H3C 3P8, Canada.

Introduction

Managing the forest for timber affects bird communities at the stand level by altering their habitat through the change of the vegetation composition (Holmes and Robinson 1981), vertical (MacArthur 1958) and the horizontal vegetation physiognomy (Freemark and Merriam 1986), and the availability of special habitat elements (Raphael and White 1984). Many studies have looked at the effects of timber harvesting on songbirds in northern hardwood forests, particularly after clearcutting, and have related it to some dimensions of the habitat (Maurer *et al*. 1981). However, alternative silvicultural methods like gap clearcut systems and single-tree selection cutting, that have been proposed as alternatives to large scale clearcutting in northern hardwoods stands, have been much less investigated (Lent and Capen 1995, Whitcomb *et al*. 1977). Our objective was to assess the response of birds to strip cutting and selection cutting, twelve years after the timber harvest, when extensively applied in a northern hardwood forest. More specifically we wanted to: 1) identify key habitat variables, in terms of vegetation composition, vertical and horizontal structure, and special habitat features modified by the two harvesting systems; 2) determine which bird species were affected by the harvesting systems; 3) associate species presence/abundance to habitat variables in order to; 4) verify if any species' response to the harvesting system effect was related to a modification of habitat conditions

Methodology

Fieldwork was conducted in the Gatineau Experimental Forest, a 36 km^2 forest located in sw Quebec, 65 km north of Ottawa (45°45'N, 76°05'W). The vegetation of this extensively forested region (≈95%) is dominated by northern hardwood stands on acid-rock glacial tills. The Doyley Lake Forest (≈ 1100 ha) was strip cut and about half of Isabelle Lake Forest (≈ 2500 ha) was selection cut (single-tree) between 1982 and 1985. The other half of the Lake Isabelle Forest was left intact and served as a control in this study. We sampled 270 plots randomly located across the three treatment forests. Each vegetation plot measured 60m x 60m and consisted of 5 80-m^2 circular micro-plots, located at the four corners and at the center. Such design allowed the estimation of the horizontal heterogeneity. In each micro-plot, we measured the dead and live vegetation and site conditions of the habitat. At these 270 sampling plots, birds were censused in 1993 and 1994, twice during the breeding season using the fixed-radius point count method (Blondel *et al*. 1970). Differences in habitat structure variables and bird species abundance among the three treatments were compared using ANOVA. Discriminant analysis was used to detect which variables contributed the most in differentiating the three treatments. We then used logistic regression to identify habitat variables that could explain the presence/absence of each bird species.

Results and discussion

Ten years after harvesting, basal area was still smaller in the treated forests than in the control (by 16%). The reduction of the upper vegetation layer cover has facilitated the development of understory layers; upper shrub cover was considerably higher in the two treated forests (Table 1). However, these two differed from each other in the percent cover of the two lowest vegetation layers. Herb layers benefited from the type of openings executed in the strip cut while the lower shrub layer was more developed in the selection cut treatment. At the micro-plot level, vertical profile was less diverse in the strip cut forest than in the two others although it was not significantly different among the three when assessed at the plot level (Table 1). This is explained by a greater horizontal heterogeneity in habitat structure in the strip cut treatment (Table 1); of the 5 vegetation layers, 4 had a greater horizontal heterogeneity in the strip cut treatment. The treated forests had a snag basal area lower than in the untreated forest by 39% (Table 1). Harvesting has probably contributed to accelerate the felling of standing snags, resulting in the greater volume of DWD measured in the treated forests (Table 1).

Table 1. ANOVA comparisons for habitat structure variables in a strip cut, a selection cut and an untreated forest in Gatineau Experimental Forest, southwestern Québec

Variables	$P \leq$	Strip cut	Selection cut	Unmanaged
Basal area (m^2/ha)	0.001	21.1 ±0.9[a]	21.8 ±0.6[a]	25.7 ±0.8[b]
Upper tree layer % (> 12m)	0.001	50.5 ±1.8[a]	65.8 ±1.8[b]	72.4 ±1.9[c]
Low tree layer % (6-12m)	0.001	44.0 ±1.8[1a]	43.7 ±1.7[a]	53.0 ±1.8[b]
Upper shrub layer % (1-6m)	0.001	52.3 ±1.8[a]	49.7 ±1.8[a]	30.4 ±1.9[b]
Low shrub layer % (0-1m)	0.001	29.0 ±1.67[a]	49.5 ±1.64[b]	39.7 ±1.74[c]
Herb layer %	0.001	35.9 ±2.05[a]	19.0 ±2.00[b]	22.3 ±2.13[b]
Micro-plot vertical diversity	0.001	1.31 ±0.016[a]	1.37 ±0.009[b]	1.36 ±0.011[b]
Plot vertical diversity	N. S.	1.55 ±0.012	1.53 ±0.010	1.53 ±0.011
Horizontal heterogeneity index	0.001	5.52 ±0.15[a]	4.75 ±0.13[b]	4.72 ±0.13[b]
Snag basal area (m^2/ha)	0.001	2.0 ±0.26[a]	2.0 ±0.25[a]	3.3 ±0.27[b]
Stand DWD volume (m^3/ha)[2]	0.05	46.8 ±12.5[ab]	60.7 ±7.1[a]	36.2 ±13.0[b]

[1] Mean ± 1 S.E. Means followed by different letters indicate differences between treatments.

[2] ANOVA on the log-transformed (log(x+1)) variable.

These differences in vertical profiles, horizontal heterogeneity and coarse woody debris were also expressed in the canonical discriminant functions. 78.5% of the plots were correctly re-classified in their respective treatment using the discriminant functions. Most of the misclassified plots were either plots in selection cut forest classified as untreated.

About half of the studied species (11 species in 1993 and 8 in 1994) have responded to the forest treatment effect in at least one year ($P \geq 0.05$). Of these 11 species, five were more abundant in the strip cut treatment (*Setophaga ruticilla, Mniotilta varia, Dendroica pensylvanica, Pheucticus ludovicianus and Catharus fuscescens*) than in the untreated forest, and four were more abundant in the selection cut treatment (*Setophaga ruticilla, Dendroica cearulescens, Dendroica pensylvanica* and *Catharus ustulatus*) than the untreated forest. *Dendroica virens*, *Seiurus aurocapillus* and *Sitta carolinensis* were more abundant in the untreated forest at least one year. *Empidonax minimus* had a tendency to avoid managed forests, but the differences in abundance were not significant.

Adequate logistic regression models were established for the 20 most frequent species, with a $\tilde{R}^2$ ranging between 10 to 46%. Birds that had a greater abundance in the strip cut forest were usually seen in habitat with a reduced tolerant hardwood upper tree cover and a greater percentage of hardwood upper shrub cover. Birds that had a greater abundance in the selection cut forest did not show a clear pattern of common habitat variables but seemed to be more associated with a denser low shrub cover and greater horizontal heterogeneity of vegetation layer variables. Finally, birds observed in high abundance in the untreated forest were positively associated with hemlock density, tree diversity and tolerant hardwood upper tree cover.

This study has demonstrated that three major changes in habitat structure were observed between the three treatments: an increase in lower vegetation cover in the treated forests, a modification of the habitat horizontal heterogeneity, and a change in the availability of essential habitat elements such as snags and downed woody debris. The observed differences in bird species corteges seemed to result from the systematic application of a disturbance system that creates recurrent habitat conditions, which benefit some species of the regional avian assemblage at the expense of some others. As vertical vegetation profile was the most important for predicting avian assemblages, management systems can be seen as toolbox of recurrent habitats classified in terms of vertical structure. Forest landscapes then can be managed using a mix of systems to provide all the required types of habitats in a targeted proportion as proposed by Annand and Thompson (1997). Even-aged systems, with the different stand development stages they create, are obviously more flexible while planning for providing habitats for different species. However, there is a risk of using a rotation period so short that optimal suitability for late-successional species is never reached. Selection cut forests may maintain habitat conditions closer to late-successional species requirements. However, as detected in this study, it may not be sufficient for species specializing on the extreme of the stand development gradient (*Dendroica virens Empidonax minimus, Seiurus aurocapillus,* and *Sitta carolinensis*). Such forest condition is usually abundant in a landscape under the gap phase natural disturbance regime of the northern hardwood forest (Runkle 1990). Considering selection cut forests as habitats suitable for these species can be pernicious. We suggest that systematically and extensively applying single-tree selection cutting, without addressing the concerns discussed above, could result in an impoverishment of regional avian diversity.

References

Annand, E. M. and F. R. Thompson, III. 1997. Journal of Wildlife Mangement 61:159-171;
Blondel, J., C. Ferry, and B. Frochot. 1970. Alauda 38:55-71;
Freemark, K. E., and H. G. Merriam. 1986. Biological Conservation 36:115-141;
Holmes, R. T. and S. K. Robinson. 1981. Oecologia 48:31-35;
Lent, R. A. and D. E. Capen. 1995. Ecography 18:97-108;
MacArthur, R. W. 1958. Ecology 39:599-619;
Maurer, B. A., L. B. McArthur, and R. C. Whitmore. 1981. American Birds 35:11-13;
Raphael, R. G. and M. White. 1984. Wildlife Monographs 86:1-66;
Runkle, J. R. 1990. Canadian Journal of Forest Research 20:632-641;
Whitcomb, B. L., R. F. Whitcomb, and D. Bystrak. 1977. American Birds 31:17-23.

Acknowledgments

Funding and logistic support were provided by the IQAFF, the Natural Sciences and Enginering Research Council of Canada, FCAR of the Québec Government, the Canadian Wildlife Service, the Groupe de Recherche en Écologie Forestière of the Université du Québec à Montréal and the ministère de l'Environnement et de la Faune du Québec.

IMPLICATIONS OF LEGAL AND POLICY REGULATIONS ON RURAL DEVELOPMENT: THE CHALLENGE OF SILVOARABLE AGROFORESTRY IN EUROPE

Christian Dupraz [1], Fabien Liagre[2], OdetteManchon[3] & Gerry Lawson[4]

[1.] INRA, UMR-System, Equipe d'agroforesterie, 2, place Viala, 34060 Montpellier, France.
Tel : +33 4 99 61 23 39; Dupraz@ensam.inra.fr
[2.] French National Council of Agriculture Chambers, (APCA), Paris, France
[3.] French Ministry of Agriculture, Paris, France
[4.] Natural Environment Research Council, UK

Introduction

Silvoarable agroforestry (SAF) comprises widely spaced trees intercropped with arable crops. Most research on agroforestry systems was concentrated in the tropics until the early 90s (Van Noordwijk et al, 2003), but recent findings (Burgess et al. 2003, Dupraz, 1994, 2003, Gillespie et al. 2000, Zhu, 1991) indicate that modern temperate silvoarable production systems are very efficient in terms of resource use, and can be compatible with modern machinery. Dupraz and Newman (1997) suggested that agroforestry could be an innovative agricultural production system that will be both environment-friendly and economically profitable for Europe. Growing high quality trees in association with arable crops in European fields may improve the sustainability of farming systems, diversify farmers incomes, provide new products to the wood industry, and create novel landscapes of high value (SAFE, 2004).

However, during the late twentieth century, the advantages of agroforestry systems have been overlooked. Even traditional silvoarable landscapes, whose benefits are widely recognised, have received little attention from policy makers and research organisations (Manchon et al, 2002). Across Europe the integration of trees and arable agriculture is currently unattractive to farmers, simply because the available grant or subsidy schemes are designed for forestry or agriculture, and don't permit agroforestry. In some countries, agroforestry systems can actually be declared illegal, because they are a category, which is not recognised for taxation purposes. A mixed or combined status of agroforestry plots is currently not available, neither at the European level nor at the National level preventing both forest and agricultural grant policies to be applied to agroforestry systems.

Silvoarable agroforestry in the European Union

In recent years, the European Union has introduced a series of measures to promote the integration of trees within existing farm businesses. The 'Silvoarable Agroforestry for Europe' (SAFE) project (http://www.montpellier.inra.fr/safe/) is one example. The SAFE project will provide up to date appraisals of the productivity of tree-crop mixtures, based on extant experiments and progress in modelling of tree-crop interactions at the field scale (Dupraz et al, 2004). It will develop a computer model to compare the economics of silvoarable agroforestry with arable and forestry systems, so that the financial implications of silvoarable agroforestry for European farmers can be examined (Graves et al, 2004). A major finding so far is that the productivity of such silvoarable systems, as measured by their Land Equivalent Ratio (Willey and Rao, 1983, adapted to agroforestry systems by Dupraz, 1998), is very attractive: silvoarable systems with winter cereals and deciduous tree species would be above 1.3, which mean that the overall biophysical productivity of agroforestry exceeds those of separated farm and forest systems by 30% (Dupraz et al, 2004).

The environmental aspects of silvoarable systems in Europe are only starting to be explored. Such impacts may further favour the adoption of SAF, if their financial value is recognised through 'shadow' payments to farmers for environmental services. However, even if silvoarable systems are more productive than monocultures they will not be adopted by farmers if subsidy schemes distort totally the ‘level playing field’. This is the case in most European countries so far.

The French case

Agroforestry has been permitted since 2002 as a standard practice for French landowners and farmers. Grants are available for planting the trees, and the crop payments are available for intercrops, on a “cropped area basis”. The tree-planting grant is the same as for a forest plantation (a percentage of the total cost of planting and tending the trees during the first 3 years; the usual rate is 40%). Crops planted between the trees are eligible for CAP payments, but it is not possible to get these on a silvoarable plot obtained from clearing a forest, or planted on a parcel that was not eligible for CAP payments prior to tree planting.

In addition, a farmer that manages an agroforestry plot may apply to a specific agri-environmental scheme (second pillar of the CAP). The reason for this scheme is to promote agroforestry by compensating additional costs compared to a standard agriculture plot. The measure is contracted on a 5-year term, and two options are available: one for creating a new agroforestry and one for tending an existing silvoarable plot. This measure was approved by the European Union. However, the current reform of the CAP will induce large changes to this regulation. Will agroforestry still be allowed to farmers after January 1^{rst} 2005?

Agroforestry and the new European CAP

A crucial debate for the future of agroforestry in Europe is now on. Recent European regulations define the conditions for the Single Payment Scheme (SPS) that will be in force in the European Union as of January 1^{rst} 2005. Two possibilities are explored: either AF could be considered as a normal agricultural practice and AF plots could be fully included in the SPS (including the tree area); or AF plots could be considered as a mixture of agriculture and forestry, and only the agricultural part would be included in the SPS. A third possibility would be that AF is not included in the SPS at all, which would mean that AF has no future in Europe for the next decades.

Regulation 1782-2003 includes a provision that areas of 'woodland' should be excluded from the area of the farm eligible for SPS. Depending on the definition of ‘woodlands’, this may incite farmers to remove trees from farmed landscapes, which would not only induce landscape and environmental damage, but also prevent farmers from investing in new agroforestry systems. A recent Guidance Document (AGRI/2254/2003) recommends that the threshold of 'woodland' is 50 stems per ha, which would classify most agroforestry plots as woodlands, and exclude them from the SPS. This would prevent any agroforestry system with scattered trees from existing in Europe. However, Article 5 of Regulation 2419/2001 indicates that: 'a parcel that both contains trees and is used for crop production shall be considered an agricultural parcel *provided that the production envisaged can be carried out in a similar way as on parcels without trees in the same area'*. This is perfectly suited for agroforestry: in a carefully designed and managed agroforestry system, crop production can effectively be carried out in good conditions. Fortunately, this wording was retained in the most recent regulation (R796-2004, Article 8), which details how the SPS will be enforced.

If agroforestry is to be recognized as an accepted land use, a clear definition of an agroforestry plot should now be introduced. An informal working party of the SAFE project is currently suggesting that agroforestry systems could be defined by a tree plantation design and management scheme that allow significant crop or grass production (at least 50% of the reference yield without trees), and with a tree density of less than 200 trees/ha (only trees with a diameter at breast height above 15 cm are included). This suggestion is conflicting with the 50 trees/ha threshold of AGRI/2254/03. But the Guidance Document also states “the Commission services take the view that wood within this meaning should be interpreted as meaning areas within an agricultural parcel with tree-cover (including bushes etc.) preventing growth of vegetative under-storey suitable for grazing.” If this approach is extended to silvoarable systems, agroforestry is clearly not ‘woodland’.

Finally, agroforestry could now be recognized as a distinct land use system, and all European countries should be allowed to define a niche for agroforestry in their own taxation system. This would probably favour the mixed activity status of the plot, as land taxes paid on woodland or agricultural land are often very different. The Integrated Control System (IACS) and the Land Parcel Identification System (LPIS) should be designed to allow agroforestry systems to operate.

Conclusion

There is a need for a special 'agroforestry status' to be designed for the countries where tax policy and grant availability is dictated by land-use classes. Policies for agriculture and forestry grants should recognise that both silvoarable and silvopastoral systems are 'legal' forms of land-use which should be permitted and placed on a 'level playing-field' with conventional agriculture or forestry. From these elements, we can conclude that the adoption of a very new system of land use like modern agroforestry can simply be impossible if the rules for agriculture and forestry support ignore intercrops or low density tree plantations. This is true even if their productivity or environmental advantages are demonstrated and significant. In a world were subsidies may represent half the revenue of the farmer, agroforestry has no future if the crops are not included in the subsidy schemes, even if agroforestry is an excellent system for productivity and environmental benefits. On the contrary, in a world where the crops get no subsidy, agroforestry would be a very attractive system to most farmers. This is a clear example of legal and policy regulations exercising an unforeseen constraint on the implementation of innovative options for rural development and landscape enhancement.

Acknowledgements

This research was carried out as part of the SAFE (Silvoarable Agroforestry for Europe) collaborative research project. SAFE is funded by the EU under its Quality of Life programme, contract number QLK5-CT-2001-00560, and the support is gratefully acknowledged

References

Burgess PJ et al. 2003. The impact of silvoarable agroforestry with poplar on farm profitability and biological diversity. Final report to DEFRA AF0105, 73 pages.

Dupraz C., 1994. Le chêne et le blé : l'agroforesterie peut-elle intéresser les exploitations européennes de grandes cultures? *Rev. For. Fr.*, 46, n° spécial, 84-95.

Dupraz, C et al. 2004. Integrating tree-crop dynamic interactions with the HiSAFE model. Keynote paper, 1rst World Congress of Agroforestry, Orlando, USA.

Dupraz, C. 1998. Agroforestry Systems, 43(1/3): 35-48.

Dupraz, C. and Newman, S. 1997. Temperate agroforestry : the European way. In : A. M. Gordon and S.M. Newman (editors), Temperate Agroforestry Systems, CAB International, Wallingford, UK, 181-236.

Gillespie, AR et al. 2000. Agrofor. Syst. 2000, 48: 25–40.

Graves, AR Burgess, PJ Liagre, F Dupraz C. Terreaux JP. 2004. Accepted for pub. in Agrof. Syst.

Manchon, O., Dupraz, C., Cabannes, B., 2002. Agroforesterie : les arbres sortent de la forêt. Revue POUR n°174, 46-50.

Safe, 2004. Second annual report http://www.montpellier.inra.fr/safe/english/index.htm

van Noordwijk et al. 2003. Agroforestry is a form of Sustainable Forest Management. UNFF meeting on the role of planted forests in sustainable forest management. New Zealand, 24-30 March 2003.

Willey, RW and Rao, MR 1980. Exp. Agric. 16, 117–125.

Zhu, Zhaohua *et al.* 1991. Agroforestry Systems in China. IDRC. Singapore, 216p.

CONNAÎTRE LE TEMPÉRAMENT DES ESPÈCES POUR PRÉVOIR L'ÉVOLUTION DE LA COMPOSITION DES FORÊTS EXPLOITÉES

Eric Forni

Département forestier du CIRAD, TA 10/D, Campus international de Baillarguet, 34398 Montpellier Cedex 5, France
Tel: +33-04 67 59 38 67 E-mail: eric.forni@cirad.fr

Introduction

Les législations forestières d'Afrique Centrale sont en cours d'évolution depuis les années 1990 et ont placé l'aménagement des forêts de production au cœur de leur dispositif. Un critère important de ces aménagements est la nécessité de reconstituer spécifiquement les stocks exploités. Sur plusieurs rotations, cela implique nécessairement d'avoir des connaissances sur la régénération des espèces commercialisées. Au Gabon, différentes études ont établi que les perturbations occasionnées par l'exploitation de l'okoumé (*Aucoumea klaineana* Pierre), espèce héliophile pionnière, n'étaient pas suffisantes pour permettre sa régénération (Doucet, 2003; Fuhr et al., 2001). Cette constatation amène Fredericksen et Putz (2003) à proposer d'intensifier les perturbations, lors de l'exploitation des forêts tropicales, dans le but de régénérer les espèces commerciales qui sont héliophiles pour la majorité d'entre elles. L'objet de cet article est de vérifier sur les principales espèces exploitées au Cameroun, (i) si l'exploitation telle qu'elle est pratiquée permet aux espèces les plus héliophiles de se régénérer (ii) et si la connaissance de leur tempérament permet effectivement de prédire l'évolution de leur population.

Méthode

Un dispositif d'étude synchronique de la régénération a été installé en forêt semi-décidue dans l'Est du Cameroun. Trois sites ont été retenus en fonction de la date de leur dernier parcours par l'exploitation. : Foddi : Exploitation actuelle (5 mois); VC 1112 : Exploitation récente (4-5 ans); et Bayong : Exploitation ancienne (25 ans). L'impact de l'exploitation est comparable pour chacun des sites et a occasionné une perturbation au sol de 7% correspondant au prélèvement d'environ une arbre à l'hectare (Astorg et Laurent, 1974; Forni, 1997). Les tiges des espèces commerciales de DHP > 20 cm ont été comptées en plein sur des parcelles de 100 ha dans chaque site et leur régénération dans un sous échantillon (0,3%) réparti sur l'ensemble des parcelles.

La classification des tempéraments est empruntée à Hawthorne. Cette classification est basée sur le comportement des espèces vis-à-vis des trouées dans la canopée, des perturbations et de la lumière. Sont distinguées essentiellement les espèces : pionnières (Pioneer), héliophiles non pionnières (Non Pioneer Light Demander) et tolérantes (Shade-bearer). Hawthorne établit le tableau suivant :

Tableau 1 : Guilde de régénération : Les gaulis ont un diamètre compris entre 1-5 cm

	Gaulis absents ou rares sous couvert	**Gaulis fréquents sous couvert**
Jeunes semis absents sous couvert, ou alors très rares	Pionniers (P)	Pionniers cryptiques
Jeunes semis fréquents sous couvert	Héliophiles Non Pionniers (HNP)	Tolérants (T)

Source : Hawthorne (1995)

Les espèces étudiées sont deux espèces pionnières, *Terminalia superba* Engl & Diels, (Limba) et *Triplochiton scleroxylon* K. Shum, (Ayous), deux espèces héliophiles non pionnières

Entandrophragma cylindricum (Sprague) Sprague (Sapelli) et *Mansonia altissima* (A. Chev.) A. Chev. (Bete), enfin une espèce tolérante *Guarea cedrata* (A. Chev.) Pellegr.

Résultats

L'évolution de la régénération des espèces, est variable dans le temps en fonction de leur tempérament.

Tableau 2 : Densité à l'hectare des semis, plantules et tiges de diamètre supérieur à 20 cm pour les 5 espèces étudiées

Foddi (dernière exploitation : 5 mois)						
Espèce	**Tempérament**	**tiges/ha**	**Semis/ha**	**Ratio**	**Plantules/ha**	**Ratio**
		D > 20 cm	**H < 30 cm**	**semis/tiges**	**H > 30 cm**	**plantule/tiges**
Terminalia superba	P	1,00	77,14	77,14	45,71	45,71
Triplochiton scleroxylon	P	2,00	28,57	14,29	17,14	8,57
Entandrophragma cylindricum	HNP	0,36	40,00	111,11	14,29	39,68
Mansonia altissima	HNP	1,09	37,14	34,08	11,43	10,48
Guarea cedrata	T	0,57	245,71	431,08	34,29	60,15
VC 1112 (dernière exploitation : 5 ans)						
Espèce	**Tempérament**	**tiges/ha**	**Semis/ha**	**Ratio**	**Plantules/ha**	**Ratio**
		D > 20 cm	**H < 30 cm**	**semis/tiges**	**H > 30 cm**	**plantule/tiges**
Terminalia superba	P	1,12	3,33	2,98	20,00	17,86
Triplochiton scleroxylon	P	1,88	0,00	0,00	6,67	3,55
Entandrophragma cylindricum	HNP	0,32	3,33	10,42	0,00	0,00
Mansonia altissima	HNP	1,68	20,00	11,90	56,67	33,73
Guarea cedrata	T	0,32	200,00	625,00	23,33	72,92
Bayong (dernière exploitation : 25 ans)						
	Tempérament	**tiges/ha**	**Semis/ha**	**Ratio**	**Plantules/ha**	**Ratio**
Espèce		**D > 20 cm**	**H < 30 cm**	**semis/tiges**	**H > 30 cm**	**plantule/tiges**
Terminalia superba	P	3,59	2,04	0,57	4,08	1,14
Triplochiton scleroxylon	P	1,74	0,00	0,00	0,00	0,00
Entandrophragma cylindricum	HNP	1,02	144,90	142,06	69,39	68,03
Mansonia altissima	HNP	3,35	67,35	20,10	6,12	1,83
Guarea cedrata	T	0,42	69,39	165,21	34,69	82,60

Les résultats de la régénération des principales espèces commercialisables confirment en particulier la quasi absence de régénération des espèces pionnières malgré une densité importante de ces espèces dans le peuplement adulte et une bonne régénération observée quelques mois après la perturbation. *A contrario*, la régénération de l'espèce tolérante est assurée 25 ans après exploitation. Les résultats sont contrastés pour les deux espèces héliophiles non pionnières. Le groupe des héliophiles non pionnières est un groupe intermédiaire entre deux extrêmes de tempéraments clairement déterminés. Il comporte de ce fait un très grand nombre d'espèces qui se positionnent dans un continuum entre ces deux pôles. On constate que le Sapelli se rapproche du comportement de l'espèce tolérante - ce caractère est aussi mis en évidence par Hall et al. (2003) - alors que le Bété montre une tendance plus héliophile.

Discussion

Il est toujours difficile d'analyser des résultats provenant d'une étude synchronique car elle suppose des conditions théoriques qui ne sont presque jamais entièrement vérifiées :(i) l'uniformité du climat, du substrat, et de l'environnement de toutes les stations étudiées ;(ii) le même degré et la même nature de la perturbation jouant sur les écosystèmes, (iii) l'existence d'une pression constante sur toutes les parcelles.(Lepart et Escarre 1983)

L’uniformité du climat et surtout de l’environnement ne pourra jamais être démontrée. Cependant, la proximité des sites étudiés, distants d'au maximum 15 km les uns des autres, minimise les risques liés à cette contrainte. Les deux dernières contraintes semblent mieux maîtrisées dans le type d’analyse que nous avons effectué. L’origine de la perturbation est unique, c’est l’exploitation forestière. Sa mise en œuvre et son intensité n'ont que peu varié entre la première exploitation réalisée en 1974 et la plus récente.

La classification sommaire en trois classes de tempéraments proposée par Hawthorne (1995) permet d'avoir une bonne idée de l'évolution des populations d'arbre pour les deux classes extrêmes. La classe intermédiaire devrait être affinée pour être utilisable.

L'exploitation, telle qu'elle est pratiquée au Cameroun et plus généralement en Afrique centrale ne crée pas une perturbation suffisante pour assurer la régénération des espèces pionnières. Les espèces à tendance tolérante se régénèrent correctement puisque de nombreux gaulis sont toujours observés 25 ans après exploitation. Il serait cependant abusif de conclure à leur survie sur plusieurs rotations, car d'autres facteurs rentrent alors en ligne de compte, dont le plus évident est le maintien d'un nombre suffisant de semenciers.

Sans intervention, les espèces les plus héliophiles semblent condamnées à disparaître, ceci indépendamment de l'exploitation. Les solutions pour les maintenir sont coûteuses en moyen et en temps et s'apparentent à des travaux sylvicoles de grande envergure, que l'on choisisse d'assister la régénération naturelle comme le préconise Doucet (2003) ou la voie artificielle de l'enrichissement, solution préférée par Fickinger (1992). Mais faut-il agir contre cette probable extinction naturelle, qui est le signe de phénomène plus globaux ?

References

Astorg, D et Laurent, D. 1974. Centre Technique Forestier Tropical ; Rapport interne

Doucet JL 2003. Thèse de doctorat, Faculté Universitaire des Sciences Agronomiques de Gembloux, Belgique

Fickinger H. 1992. Göttinger Beitrage zur Land-und Forstwirtschaft in den Tropen und Subtropen, Göttingen, vol. 75

Forni, E. 1994. Rep. du Cameroun, rapport technique API Dimako, 12 p.

Fuhr, M, Nasi R and Delegue MA. 2001. For. Ecol. Manage. 140: 117-132

Fredericksen, TS and Putz, FE. 2003. Biodiversity and Conservation 12: 1445-1453

Hall, JS, Medjibe, V, Berlyn, GP et Ashton, PMS. 2003. For. Ecol. Manage. 179, 135-144

Hawthorne, WD. 1995. Tropical Forestry Papers, vol. 29

Lepart, J et Escarre, J. 1983. Bull. Ecol. 14, 133-178

GROWTH AND SPECIES INTERACTIONS IN MIXED PLANTATIONS OF *EUCALYPTUS GLOBULUS* AND *ACACIA MEARNSII*

David Forrester[1], Jürgen Bauhus[1,2] and Annette Cowie[1,3]

[1] School of Resources, Environment and Society, The Australian National University, Canberra, A.C.T. 0200, Australia, and Cooperative Research Centre for Greenhouse Accounting, GPO Box 475, Canberra A.C.T. 2601, Australia.
Tel.: +61-2-6125-2623, E-mail: David.Forrester@anu.edu.au
[2] Institute of Silviculture, University of Freiburg, Tennenbacherstr. 4, 79106 Freiburg, Germany.
[3] Forest Research and Development Division, State Forests of New South Wales, PO Box 100, Beecroft, N.S.W. 2119, Australia.

Introduction

Mixed species plantations of eucalypts and acacias have the potential to improve stand productivity over that of respective monocultures through the facilitative effect of nitrogen-fixation by acacias, and increased resource capture through above- and belowground stratification. However, the selection of species for mixtures is difficult and while there are several examples of increased growth in mixtures (Khanna, 1997; Binkley et al., 2003; Bauhus et al., in press), there are also examples where one species has suppressed the growth of the associated species (Turvey et al., 1984; Hunt et al., 1999). In addition the interactions between species in mixed stands are influenced by site factors, which must also be considered.

Methodology

Eucalyptus globulus ssp. *pseudoglobulus* and *Acacia mearnsii* were planted at 5 species proportions: 100% *E. globulus* (100E), 75% *E. globulus* + 25% *A. mearnsii* (75E:25A), 50% *E. globulus* + 50% *A. mearnsii* (50E:50A), 25% *E. globulus* + 75% *A. mearnsii* (25E:75A) and 100% *A. mearnsii* (100A). This replacement series was planted in a randomised block design with four replicate blocks. The trial was planted in 1992 near Cann River, Victoria, Australia. Tree diameters and heights were measured up to age 11 years and used to estimate aboveground biomass and stem volume. Litterfall was collected every 1-2 months for two years from 9.25 to 11.25 years of age. Three litter traps (each 2.5 m in circumference) per plot were placed systematically within the plots so that the proportion of *E. globulus* and *A. mearnsii* surrounding the traps corresponded to the proportion of *E. globulus* and *A. mearnsii* in the plot. Rates of litter decomposition were estimated from the annual litterfall biomass divided by the forest floor mass. Total annual belowground carbon allocation (TBCA), which includes carbon in biomass and respiration, was measured between year 10.5 and 11.5. The TBCA was measured using a mass balance approach where TBCA = annual soil respiration C – annual litterfall C + annual changes in C in the soil, roots and the forest floor litter layer (see Raich and Nadelhoffer (1989) and Giardina and Ryan (2002)). The effect of soil phosphorus and nitrogen availability on the interactions between species was examined in a pot trial where *Eucalyptus globulus* was planted in pots with *Acacia mearnsii*. Pots contained two *E. globulus*, two *A. mearnsii* or one of each species. The trial was a factorial design containing two levels of nitrogen and two levels of phosphorus.

Results and discussion

Eucalyptus globulus and *A. mearnsii* heights and diameters, and stand volume and aboveground biomass were higher in mixtures from 3-4 years after planting. This difference in productivity between mixtures and monocultures generally increased with time up to age 11 years, when 1:1 mixtures contained twice the aboveground biomass than *E. globulus* monocultures (Forrester et al., in press). Greater growth in mixtures was due to a combination of factors. Nitrogen and phosphorus cycling through litterfall was significantly higher in stands containing *A. mearnsii* than *E. globulus* monocultures (Table 1). In addition rates of litter decomposition were lowest in *E. globulus* monocultures, highest in *A. mearnsii* monocultures and intermediate in 1:1 mixtures (Table 1). These results are consistent with other studies that have found higher rates of nutrient cycling in mixed stands of *Eucalyptus* species with N-fixing species than in *Eucalyptus* monocultures (Binkley et al., 1992; Parrotta 1999). This also shows the importance of selecting N-fixing species that capable of cycling nutrients quickly between the plant and soil and that have readily decomposable litter.

Table 1. Annual litterfall (kg ha^{-1} a^{-1}), forest floor litter mass, N and P content (kg ha^{-1}) and rates of decomposition (k) and N and P release from forest floor litter in the monocultures and mixtures of *Eucalyptus globulus* and *Acacia mearnsii* from age 9.25 to 11.25 years. Means sharing the same letter are not significantly different at $P < 0.05$.

	100E	75E:25A	50E:50A	25E:75A	100A	SED
Litterfall	2426a	3559b	3739b	3692b	3286b	278.2
N in litterfall	13.7a	31.6b	39.2bc	46.6cd	48.8d	4.082
P in litterfall	0.46a	0.68ab	0.80b	0.83b	0.74b	0.13
Forest floor litter mass	7316a		6270a		3532b	636.
Forest floor litter N	50.1a		49.6a		48.1a	4.15
Forest floor litter P	1.16a		0.94b		0.58c	0.041
k	0.32a		0.56b		0.85c	0.056
Rate of N release	0.27a		0.74b		1.01c	0.055
Rate of P release	0.39a		0.75b		1.22c	0.092

The total belowground C allocation was not signficantly different between mixtures and monocultures (Figure 1). However, since aboveground net primary production (annual biomass C increment plus annual litterfall C) was greater in 1:1 mixtures, the changes in nutrient availability appear to have increased productivity both above- and belowground, and reduced C allocation belowground in mixtures compared to *E. globulus* monocultures.

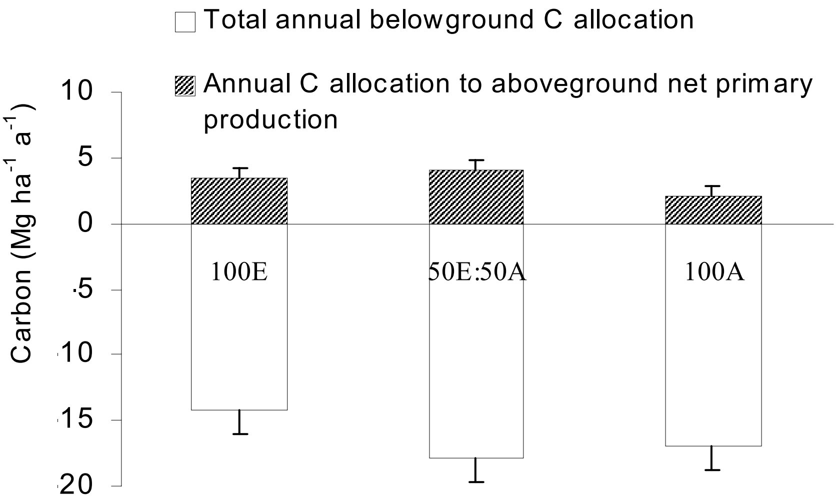


Figure 1. Annual carbon allocation in monocultures and mixtures of *Eucalyptus globulus* and *Acacia mearnsii* at age 10.5 to 11.5 years. Error bars are Standard Errors of Difference.

In the pot trial both species grew larger in mixture than in monoculture at low N levels, and mixtures were more productive than monocultures (Figure 2a). However, at high N levels, *E. globulus* suppressed *A. mearnsii* and mixtures were less productive than *E. globulus* monocultures (Figure 2b). Similar effects were found for high and low levels of P (data not shown). This shows the effect resource availability can have on the interactions and growth of mixtures.

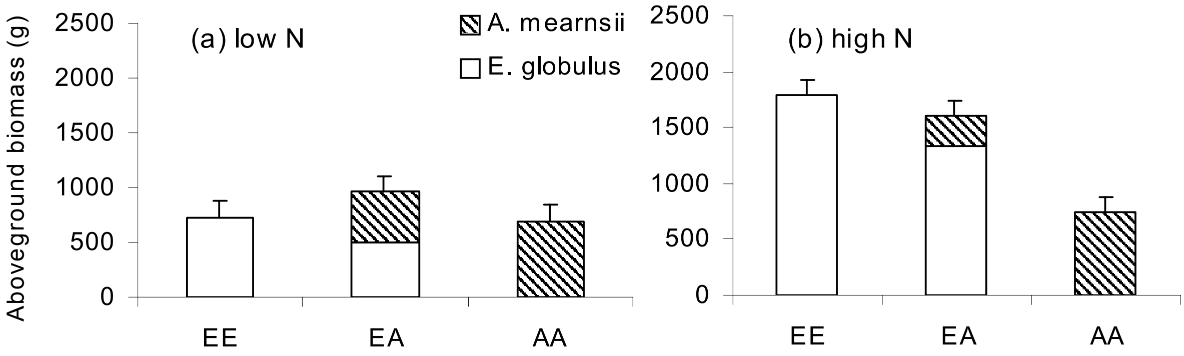


Figure 2. *Eucalyptus globulus* planted with *Acacia mearnsii* in a pot trial at (a) low and (b) high levels of nitrogen fertiliser. Error bars are Standard Errors of Difference.

While there are significant differences in the temporal and spatial aspects of pot trials in comparison to field trials, it can be assumed that similar interactions will occur in field situations when the availability of resources change, and that careful selection of sites is probably as important as the selection of species combinations. This study has demonstrated that given the right mixture of eucalypts and N-fixing trees, mixed stands can be an attractive silvicultural alternative to monocultures.

References

Bauhus, J., van Winden, AP. and Nicotra, AB. Can J For Res, in press.
Binkley, D., Dunkin, KA., DeBell, D. and Ryan, MG. 1992. For Sci 38: 393-408.
Binkley, D., Senock, R., Bird, S. and Cole, TG. 2003. For Ecol Manag 182: 93-102.
Forrester, DI., Bauhus, J. and Khanna, PK (in press). For Ecol Manag.
Giardina, CP. and Ryan MG. 2002. Ecosystems 5: 487-499.
Hunt, MA., Unwin, GL. and Beadle, CL. 1999. For Ecol Manag 117: 75-85.
Khanna, PK. 1997. For Ecol Manag 94: 105-113.
Parrotta, JA. 1999. For Ecol Manag 124: 45-77.
Raich, JW. and Nadelhoffer, KJ. 1989. Ecology 70: 1346-1354.
Turvey, ND., Attiwill, PM., Cameron, JN. and Smethurst, PJ. 1984. For Ecol Manag 7: 103-117.

Acknowledgements

Forest and Wood Products Research and Development Corporation provided funding for this project. David Forrester received a scholarship from the Cooperative Research Centre for Greenhouse Accounting. The experiment was established by CSIRO with DNRE providing the site and ACIAR providing some financial support.

PHYTOSOCIOLOGIE APPLIQUÉE À L'AMÉNAGEMENT DES FORÊTS: CAS DU SECTEUR FORESTIER DE TOFFO (DÉPARTEMENT DE L'ATLANTIQUE SUD-BÉNIN)

Jean Cossi GANGLO

Université d'Abomey-Calavi. Faculté des Sciences Agronomiques. Département d'Aménagement et de Gestion de l'Environnement. 01 BP 526 Cotonou.
E-mail : ganglocj@yahoo.fr

Nous avons fait des études phytosociologiques selon l'approche synusiale intégrée dans les plantations forestières de Toffo (6°51'-6°53' lat. nord et 2°05'-2°10' long. est) gérées par l'Office National du Bois (ONAB).

Ces travaux ont permis d'obtenir les principaux résultats suivants :

1. Au total, vingt et une synusies végétales sont décrites à Toffo.
   En stations mésophiles et mésohygrophiles, nous avons :
   - Trois synusies annuelles ;
   - Deux synusies rudérales ;
   - Trois synusies herbacées vivaces basses ;
   - Trois synusies herbacées vivaces hautes ;
   - Quatre synusies arbustives ou lianescentes ;
   - Une synusie arborescente.

   Dans les milieux hygrophiles et hydrophiles, nous avons obtenu :
   - Deux synusies herbacées vivaces basses ;
   - Une synusie lianescente ;
   - Une synusie arbustive ;
   - Une synusie arborescente.

2. Sur la base des relations spatio-temporelles des synusies, celles-ci ont été intégrées pour décrire et caractériser neuf phytocoenoses dont voici la typologie :
   En stations mésophiles et mésohygrophiles, nous avons décrit et caractérisé :
   - La phytocoenose herbacée vivace haute à *Chromolaena odorata.* Il s'agit d'une friche pionnière post culturale, hautement héliophile qui colonise les terrains vagues, les coupes rases, les jeunes plantations non fermées et les trouées des vieilles plantations ; elle est indépendante des types de sols ;
   - La phytocoenose arbustive a *Lecaniodiscus cupanioides.* Elle est assez caractéristique du sous-bois des plantations mises en place sur terre de barre lessivées ;
   - La phytocoenose à *Mallotus oppositifolius* et *Reissentia indica* est le fourré arbustivo-lianescent qu'on retrouve dans le sous-bois des teckeraies mises en place sur les replats sableux de Toffo ;
   - La phytocoenose à *Paullinia pinnata* et *Combretum hispidum* est la végétation lianescente qui se développe dans le sous-bois des plantations forestières mises en place sur les vertisols noirs mal drainés ;
   - La phytocoenose à *Cola millenii* et *Icacina tricantha* est le fourré arbustif mésohygrophile qui se met en place dans le sous-bois des plantations mises en place sur les bordures de cours d'eau.

En milieux hygrophiles et hydrophiles, nous avons décrit et caractérisé les phytocoenoses suivantes :

- La phytocoenose à *Nymphaea maculata* est la végétation herbacée des plans d'eau ;
- La phytocoenose herbacée vivace à *Leersia hexandra* et *Alternanthera sessilis* est la végétation pionnière hélophytique basse des cours d'eau ;
- La phytocoenose à *Cyclosorus striatus* est une végétation hélophytique haute à fougère ; elle se développe dans les marigots ;
- La phytocoenose à *Mitragyna inermis* et *Berlinia grandiflora* est la végétation arbustive des bas-fonds.

La carte des phytocoenoses est mise en annexe 1.

3. L'étude des niveaux de productivité des plantations forestières en fonction des phytocoenoses de sous-bois, a permis de retenir trois niveaux de productivité :

- Les plantations de la phytocoenose à *Mallotus oppositifolius* et *Reissentia indica* sont les plus productives. Leur indice moyen de productivité est de 25,7 m ; au seuil de probabilité de 5%, il est significativement plus élevé que les indices de productivité des autres phytocoenoses ;
- Les plantation de la phytocoenose à *Paullinia pinnata* et *Combretum hispidum* ont un indice moyen de productivité de 23,4 m ; ce niveau de productivité est intermédiaire et présente aussi une différence significative avec les niveaux de productivité des autres phytocoenoses ;
- Les plantations de la phytocoenose à *Lecaniodiscus cupanioides* et de celle à *Cola millenii* et *Icacina tricantha* ont respectivement pour indice moyen de productivité, 19,8 m et 18,8 m. Ces deux niveaux de productivité ne sont pas significativement différents au seuil de probabilité de 5% et permet d'affirmer que ces deux phytocoenoses appartiennent à la même classe d'équivalence biologique.

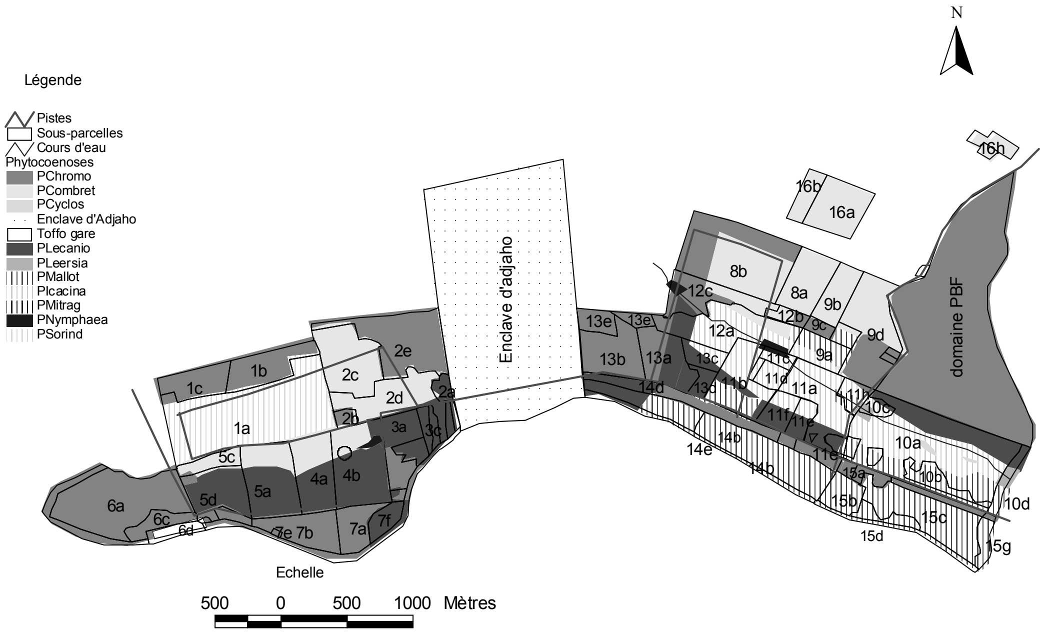
4. Les relations entre les phytocoenoses, les facteurs écologiques et la productivité des plantations, ont permis de définir et de cartographier cinq stations forestières :

- La station forestière à *Mallotus oppositifolius* ; elle convient à la production de bois d'œuvre de grande qualité ;
- La station forestière à *Combretum hispidum* et *Paullinia pinnata* ; elle est assez mal drainée et peut convenir à la production de bois d'œuvre de grande qualité à condition de faire des travaux sol (labour, billonnage) avant les plantations ;
- La station à *Lecaniodiscus cupanioides* est assez oligotrophe et nécessite des mesures d'accompagnement avant de convenir à la production ligneuse durable ; entre autres, il faut rechercher par exemple, à travers la protection du sous-bois contre les feux saisonniers, la production abondante de matière organique ;
- La station à *Cola millenii* et *Icacina tricantha* où les chablis de teck sont abondants (47%) ; ceci est lié au faible enracinement du teck, en raison de la présence dans cette station mésohygrophile, des horizons sous-jacents asphyxiants. On devra y promouvoir les espèces locales de valeur qui s'y développent déjà (*Cola gigantea, Sterculia tragacantha, Ceiba pentandra…*) ;
- Les stations hydromorphes à *Mitragyna inermis, Berlinia grandiflora, cyclosorus striatus, Leersia hexandra, Alternanthera sessilis* et *Nymphaea maculata ;* ces stations conviennent à la production ligneuse à partir des espèces locales de valeur qui s'y développent (*Cola gigantea, Sterculia tragacantha, Ceiba pentandra…*) et, à la production non ligneuse (cultures maraîchères, fruitières…).

Sur la base des potentialités et des contraintes de chacune de ces stations, nous avons préconisé des mesures d'aménagement.

Sur la figure annexée,

PChromo = Phytocoenose à *Chromolaena odorata*
PCombret = Phytocoenose à *Paullinia pinnata* et *Combretum hispidum*
PCyclos = Phytocoenose à *Cyclosorus striatus*
PLecanio = Phytocoenose à *Lecaniodiscus cupanioides*
PMallot = Phytocoenose à *Reissentia indica* et *Mallotus oppositifolius*
PIcacina = Phytocoenose à *Cola millenii* et *Icacina tricantha*
PMitrag = Phytocoenose à *Mytragyna inermis* et *Berlinia grandiflora*
PNymphaea = Phytocoenose à *Nymphaea maculata*
Psorind = Phytocoenose à *Cremaspora triflora* et *Sorindeia warneckei*



Annexe 1 : Carte des phytocoenoses du secteur forestier de Toffo.

USING MODELS FOR PREDICTING RECOVERY AND ASSESS TREE SPECIES VULNERABILITY IN LOGGED TROPICAL FORESTS

Sylvie Gourlet-Fleury[1], Guillaume Cornu[1], Sébastien Jésel[1], Hélène Dessard[1], Jean-Gaël Jourget[2], Lilian Blanc[2] & Nicolas Picard[3]

[1] Département Forêts du CIRAD, TA 10 / D, Campus International de Baillarguet, 34398 Montpellier Cedex 5, France. Tél : +33 4 67 59 38 83. E-mail : sylvie.gourlet-fleury@cirad.fr

[2] Département Forêts du CIRAD, Campus Agronomique de Kourou, Guyane française

[3] Département Forêts du CIRAD, Bamako, Mali

Introduction

Matrix models of forest dynamics allow a time-projection of diameter-class distributions, useful to estimate the time needed, after logging, to recover a given part of the stock of valuable trees above the diameter cutting limit (DCL) and assess felling cycles (Mengin-Lecreulx, 1990, Vanclay, 1994, Favrichon, 1998, Debroux, 1998, Alder et al., 2002, Sist et al., 2003). Once calibrated on permanent sample plots, those models can easily be used by managers as they only require, as input parameters, the diameter structure of the population(s) under scope, generally available from classical forest inventories (Durrieu de Madron et Forni, 1997, Alder et al., 2002). However, such models must be used with caution (Vanclay, 1994, Alder et al., 2002). Easy to build, they are limited by the quantity of data available, especially when working on a species basis: (i) a lot of species have very few individuals and must be grouped with others in order to be described; (ii) in most cases, only trees ≥ 10 cm dbh are surveyed on permanent sample plots. This has two major drawbacks for modelling the recruitment of new trees: recruitment over 10 cm dbh is a rare event and it can hardly be linked to the presence of mother trees (too much time elapsed since seed dispersal). This causes matrix models to become highly questionable when used to predict the behaviour of the species after two or three felling cycles, when the feeding of upper classes becomes highly dependent on the way the feeding of the first class has been modelled.

In this article we compare long-term simulation results provided by StoMat, a non-regulated matrix model, and Selva, a single-tree distance dependent model. These models were designed for different purposes and independently calibrated, resp. on a limited data set and an extended one, derived from the 12 permanent sample plots of the Paracou site in French Guiana. We focus on the major timber species *Dicorynia guianensis* Amshoff (Caesalpiniaceae), logged with a DCL of 60 cm dbh, under 40 years felling cycles.

Methodology

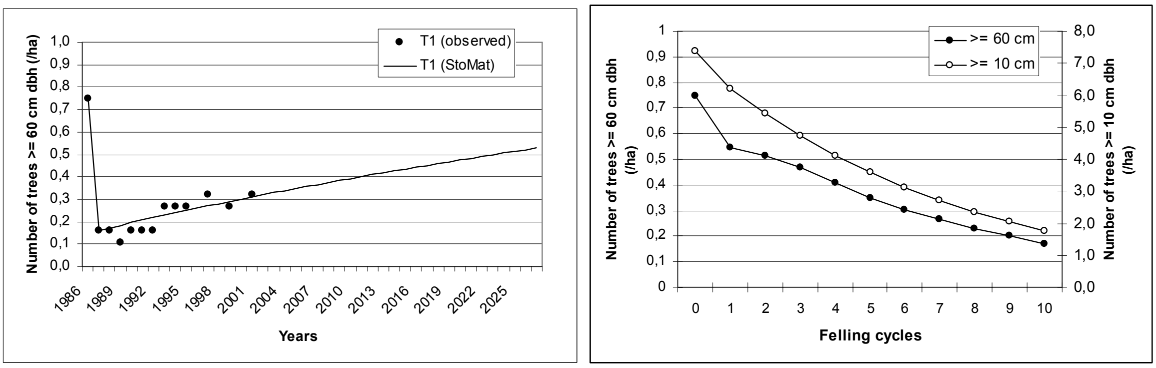
StoMat is a non-regulated matrix model, designed to be calibrated with limited data sets in order to help managers predict the recovery of the valuable stock of trees after felling. For *Dicorynia guianensis*, trees were broken down into 6 diameter classes (from 10 cm dbh to ≥ 60 cm dbh). The parameters of the 6×6 transition matrix were obtained by sampling inside diameter increment distributions in each diameter class, and inside variation intervals observed for mortality rates (Gourlet-Fleury et al., 2004). Recruitment rate was taken as a fixed proportion of mature trees.

Selva is a single-tree distance dependent model (Gourlet-Fleury et al., 2004), built and calibrated for research purposes, in particular the study of the long-term spatial behaviour of species, and gene flows at the local scale. In Selva, the fate of each tree (growth, mortality and recruitment) is predicted, depending on its local neighborhood. For *Dicorynia guianensis*, the model benefited from 4 years of intensive field work on regeneration processes and the complete life cycle was implemented, including fruiting, dispersal, early stages survival till 1 cm dbh, individual survival and growth above 1 cm dbh.

First, we assessed the individual performance of the two models, regarding the purpose for which they were built. Then, we simulated on a 36-ha area the effect of repeated logging with a felling cycle of 40 years. We compared the outputs of the two models for two main variables: total number of trees ≥ 10 cm dbh and total number of trees ≥ 60 cm dbh.

Results

As illustrated on Fig.1(a), StoMat predicted well the evolution of the number of *D. guianensis* trees >= DCL in the stands where logging took place in 1987. According to the model, repeated logging of exploitable trees every 40 years would be unsustainable: more than 50% of the population would disappear within 200 years (Fig.1(b)).

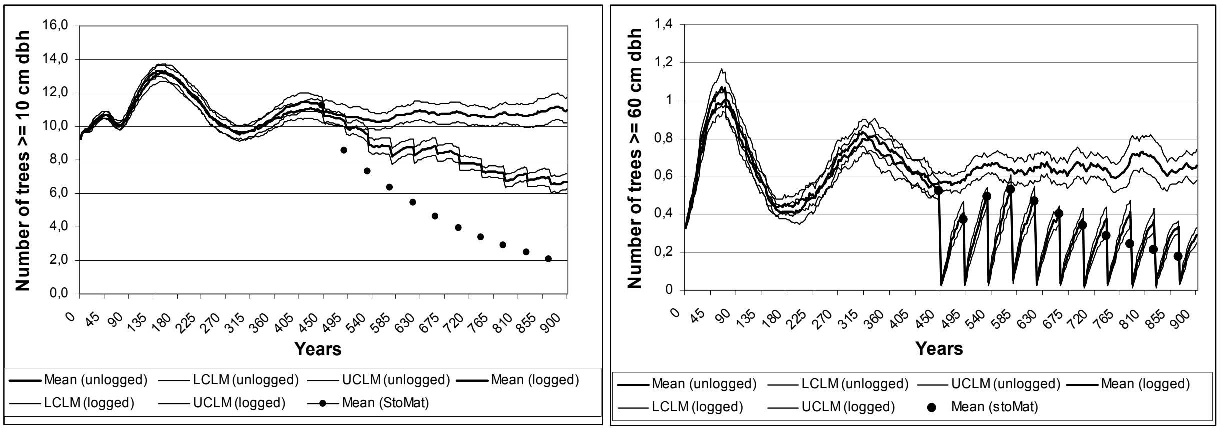


(a) (b)

Fig.1. Evolution of the population of *Dicorynia guianensis* after felling, as simulated by StoMat. (a) number of trees ≥ 60 cm dbh, comparison with data observed in exploited stands. (b) Number of trees resp. ≥ 10 cm dbh and ≥ 60 cm dbh when logging is repeated according to 40 years felling cycles.

Selva reproduced the global characteristics of the population in terms of demography and structure (total number of trees ≥ 60 cm dbh, total number ≥ 10 cm dbh, number of juveniles, basal area) and spatial pattern (strongly aggregated). However, it generated a turnover above 10 cm dbh about tenfold higher than that observed in real stands. As a consequence, small size trees (10-15 cm) tended to be over-represented, and medium-size trees (25-50 cm) under-represented.

To compare the two models, we started from an initial state generated by Selva after a first 450 years period of stabilization, on the 36 ha area where the regeneration studies took place. Repeated logging operations were then simulated for ten 40 years felling cycles. The compared evolution of the two variables of interest is illustrated on Fig.2(a) and (b).



(a) (b)

Fig.2. Compared evolution of the population of Dicorynia guianensis when repeated felling is performed under a 40 years felling cycle. The behaviour of the undisturbed population is shown for comparison. LCLM and UCLM

are the 95% lower and upper confidence limits of the mean of 20 repetitions performed with Selva. (a) Trees ≥ 10 cm dbh). (b) Trees ≥60 cm dbh.

Selva predicted the decline of the population, as did StoMat, but with twice a slower pace than the matrix model. For the trees ≥ 60 cm dbh, the predictions were very similar till the 6^{th} felling cycle when the decrease in total number generated by StoMat began to strongly affect the feeding of the classes above the DCL.

Discussion

While the two models were very differently built, calibrated using only partially common data sets, and performed inequally, they give partly convergent information on the possible behaviour of *D. guianensis* under a repeated felling regime, enlightening, in addition, their respective limitations.

When long-term simulations are performed, StoMat logically proves to be very sensitive to the recruitment rate. Here, the rate was taken as the observed ratio between recruitment above 10 cm dbh and the number of trees ≥ 40 cm dbh in undisturbed plots, and kept constant: we checked that, with Selva, the same ratio only slightly increases between undisturbed and disturbed simulations. This behaviour is due to the buffer effect of the young stages: those stages attenuate, over time, the impact of the systematic elimination of seed-trees ≥ DCL upon the population of trees ≥ 10 cm dbh. This also explains the differences observed between Selva and StoMat for the simulated evolution of the total number of trees ≥ 10 cm dbh (Fig.2(a)): the logging impact is very strong, in the second case, due to the direct link that was established between the largest trees and the recruitment rate.

Those results simply illustrates the necessity to take into account, in matrix models, as small diameter classes as possible in order to reproduce the buffer effect of young stages. But they also help to relativize this conclusion: StoMat was able to predict, on a 240 years period, the same evolution of the number of trees ≥ DCL than the complex and heavy-parameterised Selva model.

Acknowledgments

The study of *Dicorynia guianensis* regeneration processes at Paracou was supported by the French Scientific Groupement ECOFOR, from 1999 to 2002.

References

Alder, D, Baker, N, Wright, HL, 2002. University of Oxford, Oxford Forestry Institute. http://www.myrlin.org.

Debroux L., 1998. Thèse de doctorat de la Faculté Universitaire des Sciences Agronomiques de Gembloux, Belgique. 283 p. + ann.

Durrieu de Madron, L. et Forni E. (1997). *Bois et Forêts des Tropiques*, 254(4): p. 39-50.

Favrichon V.,1998. *Forest Science* 44(1): 113-124.

Gourlet-Fleury S., Cornu G., Dessard H., Picard N. et Sist P., 2004. *Bois et Forêts des Tropiques* 280(2): 41-52.

Mengin-Lecreulx P., 1990. Rapport SODEFOR (Côte d'Ivoire) – CTFT, 51 p.

Sist P., Picard N. and Gourlet-Fleury S. (2003). *Annals of Forest Science* 60: 803-814.

Vanclay J.K.,1994. CAB International, Wallingford (UK). 280 p.

APPLICATION OF FREE SELECTION IN MIXED FORESTS OF THE INLAND NORTHWESTERN UNITED STATES

R.T. Graham & T.B. Jain

USDA Forest Service, Rocky Mountain Research Station
1221 S. Main, Moscow, Idaho USA
E-mail: rtgraham@fs.fed.us; Phone: +1-208-883-2325; Fax: +1-208-883-2318

Forest management

Throughout the western United States fire exclusion, grazing, timber harvesting, exotic species introductions, and climate shifts all contributed to changing the forest structures and compositions from those common before 1900. Since 1900 the area burned by wildfires in the western United States decreased until the 1960s, and then the trend reversed, with the number of hectares burned each year increasing. It has been estimated that over 77 million hectares of forests would benefit from actions that would reverse these trends while protecting communities from wildfire. Moreover, the forests of the West are valued for their aesthetics, wildlife habitat, water production, and are prized locations for homes and communities. To address the issue of wildfire hazard while protecting other forest values, the Healthy Forests Restoration Act of 2003 (HFRA) was enacted affecting forest management throughout the United States.

The Act contains provisions to expedite hazardous-fuels reduction on Federal lands that are at risk of wildland fire while providing long-term benefits to threatened and endangered animal and plant species. The law provides management direction but particular treatments and forest conditions meeting the intent of the law, is dependent on forest type and biophysical setting. A common management theme occurring within all forests is to address hazardous conditions in the wildland-urban interface, municipal watersheds, and areas in which insects and/or diseases threaten ecosystem sustainability. The Act also stressed that treatments should contribute towards the restoration and maintenance of old growth structure and composition, characteristic of forests before successful fire exclusion.

Reference conditions

Reference conditions can be defined many ways but those that appear most appropriate for creating forest conditions resilient to wildfire and those meeting the desired conditions outlined within the HFRA are those based on conditions that existed prior to European settlement and reflected the kind and amount of native disturbances as well as anthropogenic disturbances of native peoples. There is evidence that the dry forests, those historically dominated by *Pinus ponderosa*, were frequented by low intensity non-lethal surface fires at relatively frequent intervals (most often less than 20 years). Mesic forests, historically dominated by *Pinus ponderosa*, but also containing *Pseudotsuga menziesii* , *Abies grandis* and/or *Abies concolor* were historically burned by a mix of non-lethal and lethal fires occurring at intervals of 20 to 70 years but large lethal fires often occurred at intervals extending to 300 years. In addition, endemic amounts of insects and diseases interacted with these fires to create a mosaic of forest conditions. These landscape mosaics of structural stages ranging from stand initiation to old forest occurred in patches and groups of vegetation ranging from single trees to many differential structures and compositions. The resulting historical dry forest landscapes contained clumpy and irregular forest structure dominated by large old trees with high crown base heights and minimal amounts of shrub and lower tree vegetation (ladder fuels). Snags, decadence, and down logs were also major forest components. The clumpy structure of *Pinus ponderosa* in the southwestern United States contained groups ranging in size from 0.02 to 0.30 ha with 3 to 40 trees per group and their ages ranging from 100 to 400 years. In the inland northwestern United States there is evidence that a mosaic of structural stages (grass/forb shrub, early seral, mid seral, late seral single-storied and late seral multi storied) were dispersed across landscapes in an irregular fashion. Often groups and patches of *Pinus ponderosa* dominated these structures however *Pseudotsuga menziesii*, *Abies grandis* and/or *Abies concolor* were associates and frequently dominated the mid and lower canopy layers especially on mesic sites and/or when the fire return interval reached its maximum.

The moist forests of the inland northwestern United States are the most productive of those occurring east of the Cascade Mountains (Oregon and Washington) and those occurring in the northern Rocky Mountains. Fire historically played a role in regenerating and maintaining the moist forests but also weather, insects, and diseases played major roles. Non-lethal fires historically burned approximately 25 % of the moist forests while mixed fires burned approximately 50% and lethal fires burned approximately 25 % of these forests. The disturbances gave rise to a variety of forest structures and compositions in a variety of group and patch sizes. However, because of lethal fires, large (> 20 ha) vegetation patches often occurred. Historically, these mosaics ranged from early seral single storied structures (e.g., *Pinus monticola*, *P. ponderosa*, *P. contorta*) to multi-storied multi-species structures (e.g., *Pinus monticola*, *P. ponderosa*, *P. contorta*, *Abies grandis*, *Tsuga heterophylla*, *Thuja plicata*). The median tree diameter in the early seral structures was often greater (i.e. 38 cm) than in the multi-storied forests (i.e. 20 cm) because of the high proportion of small, tolerant trees occupying the lower canopy layers. To develop and maintain forest structures and compositions similar to those that historically occurred and most likely meet the intent of the HFRA in both the dry and moist forests, we propose that a selection silvicultural system be used that develops and maintains these irregular, patchy, clumpy, often multi-species structures.

Free selection

Since their inception in the late 1800s silvicultural systems, for the most part, have been designed to produce wood products. Stand establishment and tending practices in these systems were developed to produce optimum quantities of boards and fiber. Although they were originally designed for timber production, the concepts and methods inherent to both even-aged and uneven-aged systems can be used for developing and maintaining functioning forests that meet multiple objectives and in particular the intent of the HFRA.

We propose by combining elements from even-aged and uneven-aged silvicultural systems, a system can be developed that maintains a variety of structural stages, tree densities, patch sizes, compositions, tree sizes etc. across landscapes reminiscent of those that historically occurred. Such systems need to be cognizant of snags, decadence, down wood, and other often overlooked forest components (e.g., interlocking crowns, interspersion of structural stages etc.) that may be relevant in some forests. We call such a hybrid system “free selection.” Free selection can be used to manage both the moist and dry forests in the western United States to address hazardous conditions within the wildland-urban interface and to restore and maintain old forests and other structures that meet the objectives of the HFRA.

We have applied selection systems based on diameter distributions (q-factors), residual basal area per hectare, and target tree size. In doing so we found that intensive stand inventories are needed to develop “excess tree” lists and often multiple passes through a stand are required to approach the artificial diameter distribution defined by a “q.” This approach emphasizes trees being removed rather than the residual composition and structure. Often, the composition and structure presented in a stand does not conform or readily adapt to hypothetical stand structures. Different “qs” only change the distribution of basal area concentration from one tree size to another, and do not define other structural attributes such as stem grouping, crown continuity or discontinuity, vertical structure, etc. Stand structures, so defined, tend to homogenize the forest and remove diversity. Also, people applying the prescription tend to concentrate more on the “book keeping” of the prescription rather than observing the silvics and ecology of the forest as they apply the treatments.

Vision

Based on our experience we believe that presenting a free selection system in the form of a "vision" based on silvics and ecology is preferred to highly technical stand descriptors that may have limited practical use. A "vision" incorporates the desired forest structure and composition and its trajectory. The "vision" and application of free selection requires the integration of silvical and ecological knowledge about the forest being managed. Free selection utilizes multiple tending and regenerating entries at various intervals to develop and maintain desired forest conditions. Similar to traditional uneven-aged systems, the full range of silvicultural methods ranging from regeneration to thinning can occur at each entry if needed, emulating fine scale disturbances such as non-lethal fires and weather events (e.g., wind throw, snow breakage) ensuring that regeneration occurs and all tree, forest floor, and other forest components are tended. Free selection also contains elements of even-aged systems such as creating patches of sufficient size to regenerate early seral species (e.g., *Pinus monticola*, *Larix occidentalis*) but not necessarily provide them optimum growing space initially. Subsequent treatments would be used to tend these regenerated cohorts. Because, free selection incorporates multiple entries, patience can be exercised in developing the desired forest structures and trajectories.

Free selection application

When we applied the system, we continuously integrated autecological factors such as wind firmness, disease resistance, tree crown architecture and its relations to tree development, tree shade tolerance, potential tree longevity, a tree's response to wounding, regeneration requirements (e.g., opening size, seed bed conditions), fire tolerance, potential root grafting, groups of trees functioning as a unit, etc. Not only do these factors need to be considered for the current treatment but they need to be considered in the context of future forest dynamics and future forest treatments that are implicit in selection systems. These elements were continually being evaluated in context of what structures and compositions were presented in the forest being treated. Most often a guiding principle was to create and allow for the maintenance and development of a "functioning forest" (i.e. one that has all of its parts and resilient to native disturbances). Using a "vision" to plan and implement forest treatments on the surface appears to be extremely complex but we have found that experienced foresters, technicians, contractors, and even novices all have the ability to grasp, understand, and apply forest treatments when a "vision" is thoroughly articulated and effectively communicated.

In a wildland-urban interface, in a moist forest in northern Idaho we applied free selection to decease the wildfire hazard. After three entries over a 10-year period we decreased the fire hazard (e.g., raised crown base heights, reduced canopy bulk density and continuity) while maintaining a functioning forest containing *Pinus monticola, Larix occidentalis, Pseudotsuga menziesii, Pinus ponderosa, Pinus contorta, Thuja plicata, Tsuga heterophylla*. The resulting 100 year-old high canopy structure after treatment is arranged in an irregular fashion. The clumps of high canopy contain a mix of tree species, tree sizes, snags, and decadence. The surface fuels were mechanically treated (to reduce potential surface fire intensity) by piling and burning, chunking, and lopping. After these treatments the forest floor was covered with 10 to 20 Mg per ha of course woody debris and a rich organic layer 3 to 7 cm in depth. Abundant (10s to 100s of thousands of trees per ha) regeneration ranging from *Pinus monticola* to *Thuja plicata* has developed which will be tended (e.g., cleaning, weeding overstory removal) in future entries to ensure that all representative species develop and the clumpy irregular forest structure is maintained.

We also applied free selection to restore a 150 to 400 year-old *Pinus ponderosa* pine forest in southern Idaho in which fire has been excluded for over 100 years. Prior to treatment large (over 130 cm in diameter) *Pinus* were clumped across the landscape with *Pseudotsuga menziesii* ground level and mid-story trees providing ladder fuels that would allow either wildfire or prescribed fire to threaten the remnant *Pinus*. In addition because of fire exclusion uncharacteristically deep layers of organic material accumulated at the base of the large *Pinus* in which fine feeder roots developed. One harvest entry and 2 mechanical and/or prescribed fire forest floor treatments have been applied. The clumpy nature of the old, yellow *Pinus* has been maintained and the large amount of forest floor surrounding the large trees has been reduced. Cleaning operations reduced the ground level and mid-story *Pseudotsuga menziesii* trees. Future prescribed fires are planned after the forest floor surrounding the large *Pinus* has been reduced to a level at which fire will not damage the roots nor cambial tissue of these trees.

We believe free selection and using a “vision” to define free selection is very appropriate and applicable for managing the moist and dry forests of the western United States and its use can adequately address objectives of the Healthy Forests Restoration Act of 2003. Moreover, its use is very applicable when environmental, fiscal or other constraints indicate that extensive forest management is preferred for managing forests for a wide range of objectives.

CLOSE-TO-NATURE SILVICULTURE: AN EXAMPLE FROM ITALY'S EASTERN ALPS

G. Grassi[1], G. Minotta[2], R. Giannini [3] & U. Bagnaresi[1]

[1] Dip. Colture Arboree, University of Bologna (Italy). E-mail: grassi@agrsci.unibo.it
[2] Dipartimento AGROSELVITER, University of Turin (Italy)
[3] Istituto di Genetica vegetale (IGV), CNR – Florence (italy)

Introduction

A major challenge facing modern silviculture regards the development and the refinement of close-to-nature silvicultural systems, as they may allow environmental as well as productive aspects of forest management to be combined (Schütz 1997, Nyland 1998).

During the past centuries, several conifer stands in Central Europe have been subjected to traditional management systems in which regeneration regimes mimic the patterns and sequences of phase development of natural forests (Leibungudt 1982, Mayer 1986). A traditional selection cutting ("Cadorino" cutting system), which leads to irregular structures even at small scales, had been largely applied over the last four-five centuries in Comelico (BL, Veneto), in Italy's eastern Alps (Susmel 1980). At the present, these forests represent one of the best examples of close-to-nature silviculture in Italy and are highly prized for their productive, environmental and aesthetic aspects.

A better understanding of the structural dynamics of stands managed with close-to-nature silvicultural systems is important for their correct application (O'Hara 1998), the assessment of their sustainability and the evaluation of their ability to provide multiple products and services. The overall aim of the present study is to describe the structural dynamics, both in space and in time, of an uneven-aged coniferous stand in Comelico managed with the silvicultural approach described above.

Methodology

In a representative selection of Comelico's forests, we analysed the structural dynamics in space and in time as affected by silvicultural practices. Structural dynamics was studied in six different plots (1.5 ha in total, between 1400 and 1450 m a.s.l.), with the main species being Norway spruce (*Picea abies* Karst., 79%) and silver fir (*Abies alba* Miller, 17%), by distinguishing four different developmental phases (innovation, early aggradation, late aggradation and biostatic, see Fig. 1) following Oldeman (1990). Each phase was characterised for: average duration in time, total area, number of trees of different heights and PPFD (photosynthetic photon flux density) in the understorey (for further details, see Grassi et al. 2003).

Results and Discussion

As the examined plots are actively managed, structural dynamics is characterised by several peculiarities, both in time and in space, as compared to natural or near-natural forests. Because of the relatively frequent and moderate silvicultural interventions, forest dynamics in time is characterised by a relatively short cycle and forest structure in space results in an extremely fine-grained shifting mosaic, with all the developmental phases being represented in small areas (see Fig. 2 for a representative example).

The average age of the oldest trees in the biostatic phase found in our plots (165 years, Fig. 3) is considerably less than the potential duration of the life cycle in the absence of human intervention (about 300-350 years for Norway spruce, Susmel 1980, Korpel 1982). As a consequence, the dynamics of our forest are dominated by the aggradation phase (55% of the total duration), whereas in natural or near-natural forests most of the area is typically occupied by the biostatic phase (Susmel

1980, Emborg et al. 2000). The relatively young age of economically mature trees enables high growth rates to be maintained throughout the cultural cycle. Furthermore, the human-induced spatial fragmentation has the important effect of enhancing natural regeneration, which develop successfully mainly within small gaps or at the margin or medium-sized gaps (Bagnaresi et al. 2002).

The maintenance of a highly fragmented structure, however, requires frequent and moderate cuttings, which should be regulated in time and space in order to assure an appropriate equilibrium between the different developmental phases throughout the stand. Delayed interventions may favour the creation of big mono-layered patches derived from the progressive fusion of small neighbour patches under which seedlings are scarce and scanty. On the other hand, heavy cuttings may favour the creation of big gaps, in which the competition with herbs and shrubs may markedly limit and delay the establishment of natural regeneration, thereby prolonging the duration of the pre-innovation phase.

By comparing the temporal and spatial attributes of the forest mosaic (Fig. 3), i.e., by matching the duration of each phase to the area covered by each phase, it is possible to evaluate whether the structural dynamics approaches steady-state (Susmel 1980, Koop 1989, Emborg et al. 2000). As the area covered by each developmental phase is close to being proportional to its duration in time, the examined forest appears to be close to a structural steady-state. The fact that this structural steady-state was approached even in the relatively small areas examined is explainable by the extremely fine-grained mosaic of our forest, largely determined by the frequent and moderate harvests.

The pattern of seedling recruitment in the different phases follows the pattern of light availability in the understorey, which decreases from the innovation to the late aggradation phase and then slightly increases in the biostatic phase (Grassi et al. 2003), and suggests an important role of the advance regeneration for the maintenance of the current silvicultural equilibrium. This information will be useful both for the correct management of Comelico's forests and as a reference for close-to-nature silvicultural systems in the Eastern Alps.

References

Bagnaresi U., Giannini R., Grassi G., Minotta G., Paffetti D., Pini Prato E., Proietti Placidi A. M. (2002) Stand structure and biodiversity in a mixed, coniferous forest in the eastern Alps. Forestry 75: 357-364.

Emborg, J., Christensen, M. and Heilmann-Clausen, J. (2000). The structural dynamics of Suserup Skov, a near-natural temperate deciduos forest in Denmark. For. Ecol. Manage. 126, 173-189.

Grassi G., Minotta G., Giannini R., Bagnaresi U. (2003) The structural dynamics of managed uneven-aged conifer stands in the Italian eastern Alps. Forest Ecology and Management 185/3, 225-237.

Koop, H. (1989). Forest dynamics. Springer-Verlag. pp. 229.

Korpel, S. (1982). Degree of equilibrium and dynamical changes of the forest on example of natural forests of Slowakia. Actra Facultatis Forestalis, Zvolen, Czechoslovakia 24, 9-30.

Leibundgut, H. (1982). Europaische urwalder der bergstufe, Haupt, Bern, pp.308.

Mayer, H. (1986). Europaische walder. Fisher, Stuttgart, pp. 385.

Nyland, R.D. (1998). Selection system in northern hardwoods. J. of Forestry 96, 18-21.

O'Hara, K., 1998. Silviculture for structural diversity: a new look at multiaged stands. J. of Forestry 96, 4-10.

Oldeman, R.A.A. (1990). Elements of silvology. Springer, Berlin, pp.624.

Schütz, J-Ph. (1997). Sylviculture 2 – La gestion des forets irregulares et melangees. Presses Polytechniques et Universitaries Romandes. Lousanne, pp. 168.

Susmel, L. (1980). Normalizzazione delle foreste alpine. Liviana, Padova, pp. 437.

Fig. 1. The developmental phases considered in the present study. In italics are indicated the human interventions that influence the structural dynamics.

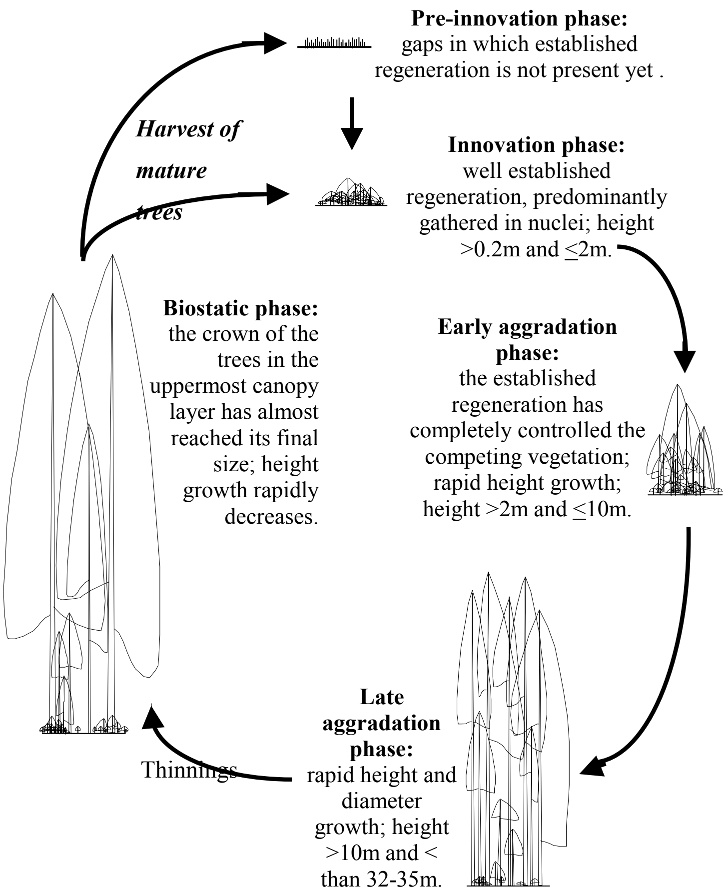
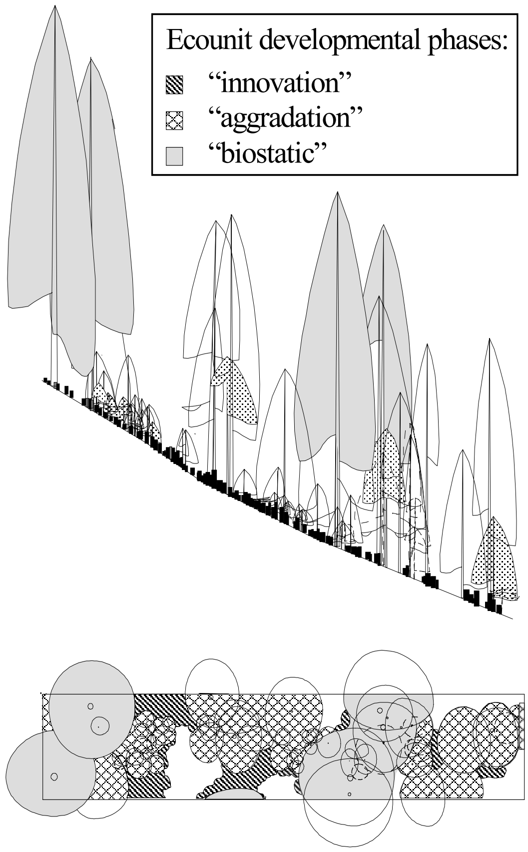


Figure 2. Examples of a single tree uneven-aged structure (50 x 10m transect) in Comelico.



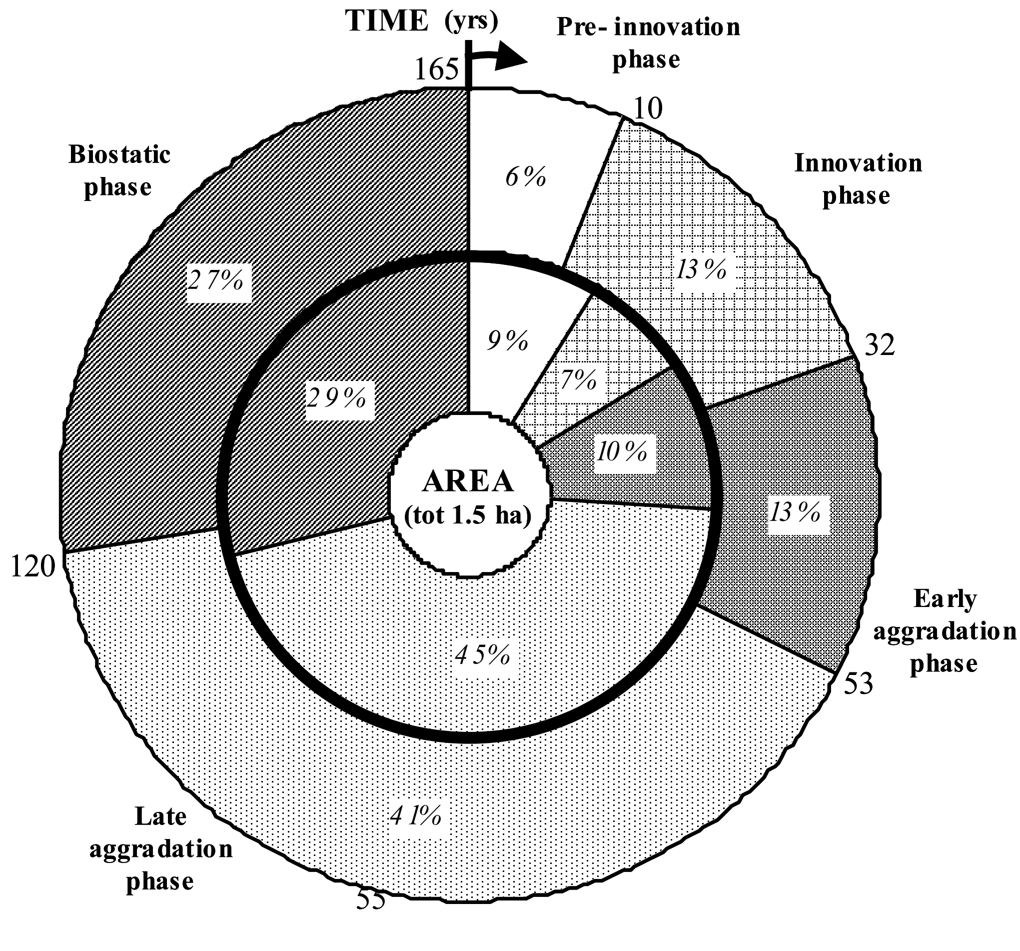


Figure 3. Synthesis of the temporal (outer ring) and spatial (inner ring) characteristics of each developmental phase. The % duration and % area of each phase are also reported.

A LIGHT-CAPTURE BASED STAND DYNAMICS MODEL FOR FORECASTING RESPONSE TO SILVICULTURAL PRACTICES

Arthur Groot[1] and Jean-Pierre Saucier[2]

[1]Canadian Forest Service, Great Lakes Forestry Centre, 1219 Queen St. E.,
Sault Ste. Marie, Ontario, Canada P6A 2E5
Tel: 705-541-5624 E-mail: agroot@nrcan.gc.ca

[2]Division classification écologique et productivité des stations, Direction des inventaires forestiers,
Ministère des Ressources naturelles, de la Faune et des Parcs, 880, chemin Sainte-Foy, 4e étage,
Québec (Québec), Canada G1S 4X4
Tel: +1-418-627-8669 ext. 4279 E-mail: jean-pierre.saucier@mrnfp.gouv.qc.ca

Introduction

Silvicultural practices are changing across Canada in order to achieve a better balance among economic, ecological and social values. These changes are generally increasing the complexity of stand structure, and existing stand dynamics models are not well suited to forecasting the development of such stands.

We are developing a stand dynamics model based on light capture by individuals trees in order to provide robust, long-term forecasts of stand development in response to a wide variety of silvicultural treatments, as well as to natural disturbances. A module to compute light capture by tree crowns has recently been completed (Groot 2004), and the objectives of this paper are to (i) examine the relationship between light interception and tree growth for *Picea mariana*, (ii) to develop models of crown dynamics, and (iii) to discuss further needs for model development.

Methodology

We obtained stem volume increment (I_V) and growing season light interception (L) data from three study sites located in *Picea mariana* forests in Ontario, Canada. At one site, we estimated light interception by individual trees using the CORONA model (Groot 2004). At the other two sites, we obtained stand level estimates of volume increment and light interception and converted them to individual tree estimates. We fitted the following model to these observations:

$$I_V = a_0\left[1 - e^{-a_1 L}\right]$$

We fitted a tree height increment (I_H) model using *Picea mariana* stem analysis data from boreal forests in Ontario and Québec, Canada:

$$I_H = \frac{(b_1)}{(b_1 - b_2)}\left(e^{-b_2 H} - e^{-b_1 H}\right)\left(1 - e^{-b_3 I_D{}^{b_4}}\right)$$, where H is height and I_D is diameter increment.

Finally, we derived a crown radial growth (I_{CR}) model that satisfies two conditions: (i) the profile (convexity) of a tree crown is constant, and (ii) the increase in crown radius decreases exponentially with distance from the tree apex (as proposed by Mitchell 1975):

$$I_{CR} = CR \ln\left[\frac{L + I_H + c}{L + c}\right]\left[\ln\left(\frac{L}{c} + 1\right)\right]^{-1}$$, where CR is crown radius, and L is crown length.

Results and discussion

Stem volume increment was strongly related to light interception at all three study sites (Figure 1), and the relationships were similar despite differences in site quality and stand history. For the individual tree data set, we tried, unsuccessfully, to account for residual variation in volume increment with variables such as tree height, crown radius and stem diameter. Some of the residual variation is undoubtedly attributable to error in estimating stem volume increment from general timber volume tables and light interception from a model.

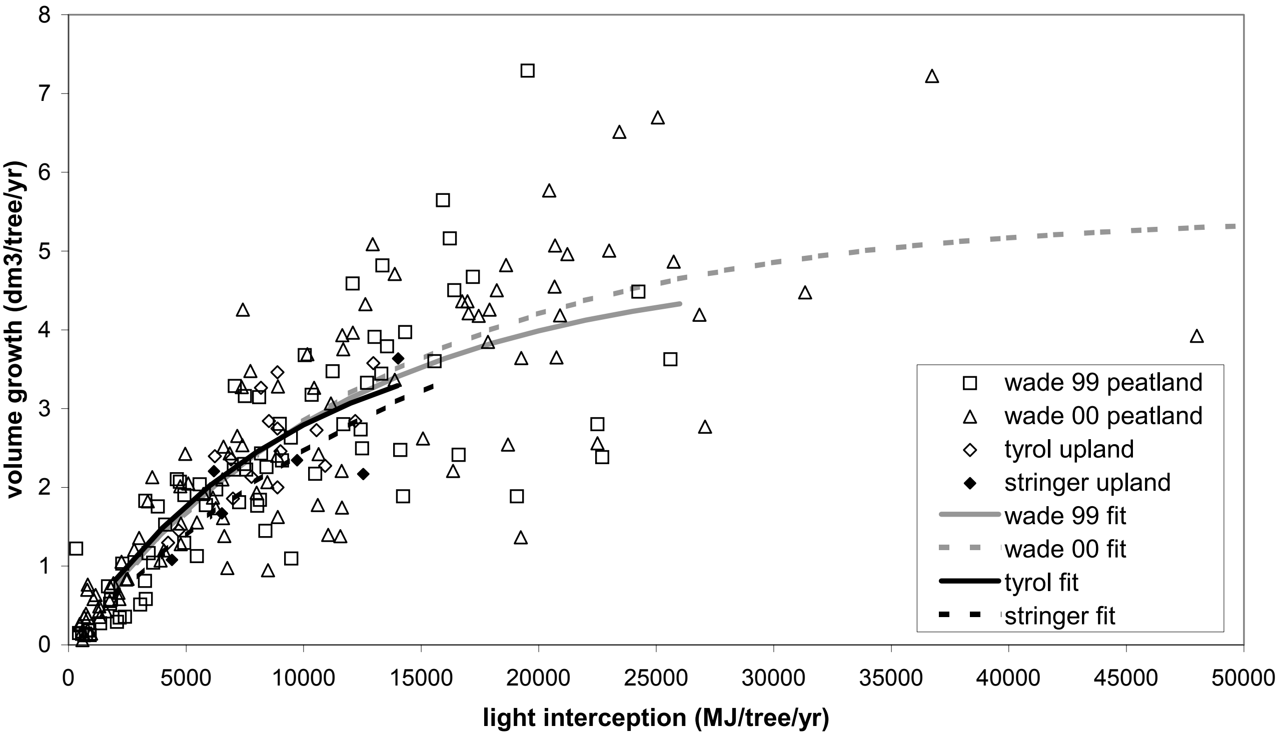


Figure 1. Relationship of black spruce stem volume increment to growing season light interception for four data sets.

The similarity in light use efficiency (*LUE*) among study areas suggests that forest productivity variation results largely from differences in growing season length at the regional scale, and from differing site limitations on maximum light capture at the local scale. Such a result is consistent with previous research on environment controls of forest productivity (e.g., Runyon et al. 1994), but requires further confirmation in our area.The general decrease in *LUE* with increasing light interception is consistent with a generally observed decrease in productivity in taller or older stands. This decline may be due to greater allocation to tree branches, respiration, hydraulic constraints, or ageing (Ryan et al 1997).

Our estimates of mean LUE for the three study sites ranged from 0.00026 to 0.00031 dm^{-3} MJ^{-1}. Our conversions of other estimates of black spruce *LUE* to a consistent stem volume increment and global shortwave radiation basis agreed closely with these estimates. The converted values from Whitehead et al. (1994) and Goetz and Prince (1996) were 0.000275 and 0.000281 dm^{-3} MJ^{-1}, respectively.
Our results support the conclusion from other research that light interception is a practicable basis for individual tree growth models (Brunner and Nigh 2000, Courbaud et al. 2001, McFarlane et al. 2002). Using the relationship between stem volume increment and light interception as the core of a stand dynamics model has a number of advantages: (i) competition is inherent in the relationship, and no

additional measures of competition are required, (ii) light is a physically-limited resource and effectively constrains aggregated stand-level growth, (iii) it appears that site quality can be accounted for by growing season length and biophysical site limitations on stand-level light capture, and (iv) it is possible to incorporate knowledge gained from other research in forest production ecology.

Crown dynamics is central in stand dynamics models driven by light capture, since changes in crown dimensions govern changes in stem volume increment, and height increment is the most important element in crown expansion. The height increment model accounted for most of the observed variation in our stem analysis observations, and accounts for the effects of site quality through the *SI* variable, and competition through the I_D variable. Estimates from the crown radial growth model compared well with results obtained from allometric models of crown dimensions.

We will combine the relationship between stem volume increment and light interception with the two component models of crown dynamics into a dynamic individual-tree growth model. This model will be coupled with models of regeneration and mortality to provide long-term forecasts of stand dynamics in response to a wide variety of silvicultural treatments and natural disturbances.

References

Brunner, A, and Nigh, G. 2000. Tree Phys. 20: 323-332.
Courbaud, B, Goreaud, F, Dreyfus, P, Bonnet, FR. 2001. For. Ecol. Manage. 145:15-28.
Goetz, SJ and Prince, SD. 1996. Agric. For. Meteorol. 78: 149-179.
Groot, A. 2004. Can. J. For. Res. 34: 789-799.
McFarlane, D, Green, EJ, Brunner, A and Burkhart, HE. 2002. Can. J. For. Res. 32: 1970-1983.
Mitchell, KJ. 1975. For. Sci. Monogr. 17.
Runyon, J, Waring, RH, Goward, SN, and Welles, JM. 1994. Ecol. Appl. 4: 226-237.
Ryan, MG, Binkley, D, Fownes, JH. 1997. Adv. Ecol. Res. 27: 213-262.
Whitehead, D, Gower, ST, Linder, S, Kellomaki, S, Koppel, A, Kull, O, Stenberg, P, and Smolander, H. 2001Tree Phys. 21: 925-929.

Acknowledgements

The Sustainable Forest Management Network and the Lake Abitibi Model Forest supported this work.

THE POTENTIAL OF USING WOOD ASH AND PEAT ASH AS FOREST FERTILIZER ON PEAT SOILS IN SWEDEN

Björn Hånell

Dept of Silviculture, Swedish University of Agricultural Sciences, SE-901 83 Umeå, Sweden.
E-mail: Bjorn.Hanell@ssko.slu.se; Phone +46 90 786 8297; Fax +46 90 786 7669

Introduction

The largest proportion (about 10 Twh) of the renewable fuel currently used in Sweden originate from the forest. Nutrients removed when branches and tree-tops are harvested as fuel can be returned to the site by recycling the remaining wood ash after the burning. This compensation measure is presently not carried out to any appreciable extent (cf. Anon 2001), partly because there is no economic incentive for the landowner. In sites where this measure has been applied, only on mineral soils (e.g. moraine) until now, greater margins for sustainable maintenance of the long-term site productivity can be expected. The ash contains all elements required for tree growth except for nitrogen (N). Therefore the ash amendment does not result in increased stand growth on these soils because the most important element for a growth response (N) is missing (Sikström 1992, Jacobsson 2001). In contrast, on organic soils N is often abundant whereas the amounts of other mineral nutrients are small. Thus, the elements lacking in the soils of peatland forests are available in the ash (Magnusson & Hånell 1996). This is especially true for phosphorus (P) and potassium (K). This means that peatland forests provide an opportunity for ash amendment in order to increase forest production. Old fertilization trials using wood ash show that the growth increase can be very large. The aim of this study was to calculate the area of peat-covered land that with respect to stand growth responses could be regarded as most suitable for bio-ash (wood ash and peat ash) fertilization. Peat ash, although not as much studied, also has potential to be used to provide nutrients for increasing peatland forest growth.

Methodology

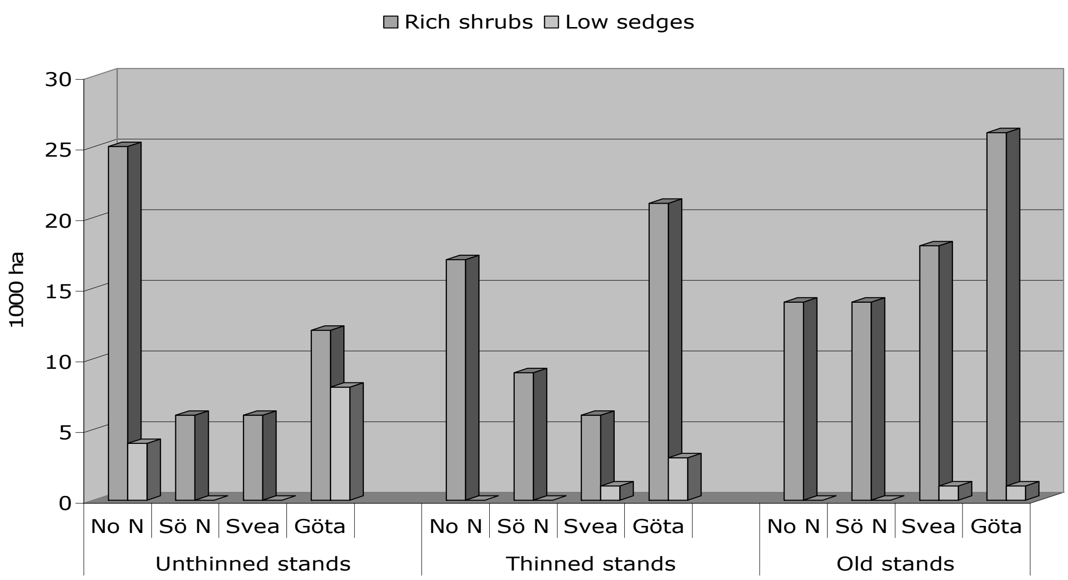
Most of the area calculations were based on data from the Swedish National Forest Inventory (SNFI) 1997-2001, cf. Anon (2000). Sites were selected with guidance from existing knowledge about ash fertilization effects on tree growth and with the aid of registrations made in SNFI regarding peat depth, site productivity, drainage, condition of drains, dominating field vegetation, and degree of stand development. Additional calculations were made concerning the area of abandoned peat fields ready for after-use by afforestation (Hånell et.al 1996; Magnusson & Hånell 2000, 2001). The main part of the site selection was made in five steps (Table 1). First, the non-productive sites (which produce less than 1 m^3 ha^{-1} yr^{-1}) were rejected. Also sites with peat cover shallower than 30 cm were excluded. In the next step it was decided to restrict the ash fertilization to areas with drains in good condition, and to sites where the field vegetation was dominated by ”rich shrubs” (*Vaccinium myrtillus, V. vitis idaea, Equisetum silvaticum*, and tall sedges) or ”low sedges” (*Eriophorum vaginatum, Scirpus caespitosus*, and other low Cyperaceae plants). Finally, open areas, seedling stands, and young forests were rejected in favour of un-thinned and thinned mid-rotation, and mature and old stands. According to these selection criteria the most suitable sites for ash fertilization are drained, productive peatlands characterized by mid-rotation stands or older stands where the field vegetation is dominated by rich shrubs or low sedge plants.

Results and discussion

The selection comprises 190 000 ha (Fig. 1). Most of these areas are located in Northernmost and Central-North Sweden (90 000 ha), whereas Central-South and South Sweden accounted for 30 000 ha and 70 000 ha, respectively. In addition to this, 2000-3000 ha of abandoned peat fields ready for afforestation should be added within a period of about 5 years.

The requirement for phosphorus when peatland forests are fertilized is 40-50 kg ha^{-1} (Paavilainen & Päivinen 1995). From this, and from studies on the variation of phosphorus content and bulk density of wood ash of various origin (Paarlahti 1980), it can be calculated that a proper ash fertilization dose would be 3-5 t ha^{-1}. The nutrient content in the ash may however often prove lower than in the reported studies, in which case larger doses than 5 t ha^{-1}would be required. The present annual production of bio-ash in Sweden is about 250 000-300 000 tonnes (Bjurström et.al 2003). If it was desired to amend all sites (190 000 ha) identified in this study by using 5 tonnes per ha, it would use up 3-4 years of annual production of bio-ash.

Figure 1. Selection of most suitable sites for bio-ash forest fertilization in Sweden – drained, productive peatlands covered by mid-rotation or older forests characterized by rich shrubs or low sedge plants in the field layer. Unit: 1000 ha. *Key to regions*: No N: Northernmost Sweden (Norra Norrland); Sö N: Central-North Sweden (Södra Norrland); Svea: Central-South Sweden (Svealand); Göta: Southernmost Sweden (Götaland)



References

Anon. 2000. Forest data 2000. Current data on Swedish forests from the National Forest Inventory. Theme: Growth and drain. Swedish Univ. Agr. Sci., Dept Resource Management and Geomatics, Umeå. 110 pp.

Anon, 2001. Recommendations on forest fuel harvesting and compensation fertilization. Swedish National Board of Forestry; Jönköping. Message 2-2001, 21 pp. (In Swedish).

Hånell B, Svensson J and Magnusson T 1996. Reclamation of peat winning fields - a literature review with special reference to the establishment of forest stands. Reports in Forest Ecology and Forest Soils, Report 70, 34 pp. (In Swedish with English summary).

Jacobsson S 2001; Fertilization to increase and sustain tree growth in coniferous stands in Sweden, SLU, Uppsala, Acta Universitatis Agriculturae Sueciae, Silvestria 217.

Magnusson T and Hånell B 2000. Wood ash for afforestation of abandoned peat winning fields effects on plant nutrient conditions, heavy metals and water quality. STEM, Report ER 18, 47 pp. (In Swedish with English summary).

Magnusson T and Hånell B 2001. Nutrient conditions in afforestation experiments on peat winning fields. Swedish Peat Research Foundation, Stockholm. Project Report 45, 34 pp. (In Swedish with English summary).

Paarlahti K 1980. Production of ash and ash properties. Muhoksen tutkimusas tied 20: 13-15. (In Finnish).

Paavilainen E and Päivänen J1995. Peatland forestry, ecology and principles, Springer Verlag, Berlin. Ecological studies 111, 248 pp.

Sikström U 1992. Stem growth of Scots pine and Norway spruce following low doze liming, nitrogen fertiliation, and wood ash amendment. Institutet för Skogsförbättring, Uppsala. Report 27, 22 pp. (In Swedish).

Table 1. Selection of sites for forest fertilization using wood and peat ash (unit: 1000 ha)

Peat-covered wetlands in Sweden			10 000
of which	Peatlands	6 300	
	Wet mineral soils	3 700	
Selection 1: Reject non- productive areas. Then remains			
Forest land with peat cover			5 000
of which	Peatlands	1 800	
	Wet mineral soils	3 200	
Selection 2: Reject undrained sites and shallow peat. Then remains			
Drained forest land, peatland			560
of which	Functioning drains	440	
	Non functioning drains	120	
Selection 3: Reject non- functioning drains. Then remains			
Drained forest land, peatland, functioning drains			440
of which	Herbs	199	
	Rich shrubs	191	
	Low sedge plants	25	
	Poor shrubs	20	
Selection 4: Reject herbs and poor shrubs. Then remains			
Drained forest land, peatland, functioning drains, rich shrubs, low sedges			217
of which	Open forest land	4	
	Seedling and sapling stands	23	
	Unthinned mid-rotation stands	61	
	Thinned stands	56	
	Old stands	73	
Selection 5: Reject open forest land, seedling and sapling stands. Then remains			
Drained forest land, peatland, functioning drains, rich shrubs, low sedges, mid-rotation and old forests			190
of which	Unthinned stands	61	
	Thinned stands	56	
	Old stands	73	

COMMUNITY-BASED FOREST MANAGEMENT IN NORTHERN THAILAND

Minna Hares

Viikki Tropical Resources Institute, P.O.Box 28, 00014 University of Helsinki, Finland
Tel. +358-9-19158634; E-mail: minna.hares@helsinki.fi

Introduction

In Thailand, the national logging ban on natural forests (in 1989) has shifted the emphasis of forest policies towards community-based forest management (Poffenberger 2000). Despite the ban, however, deforestation has continued: In the study area, it is estimated that forest loss has been up to eight percent during the last decade (ICRAF 2001). It is hypothesised that in order to conserve the remaining forests and apply more sustainable practices local views should be taken into account in forest management decisions (management in a broad sense). The aim of the research is to investigate local views on forest management, causes and effects of deforestation and ways for conservation. This paper focuses on management systems in rural communities of Chiang Mai Province, northern Thailand, and examines how traditional and introduced systems are integrated.

The research area in Northern Thailand is the most heavily forested region in Thailand; lands classified as forest cover about 57 percent of the land area which is mostly upland (RFD 2001). Most of the study area is classified as protected watershed under the Watershed Classification Act and protected forest area under the National Parks Act which prohibits all forms of land-use. The population in the study area is composed of the lowland Thai, ethnic majority of Thailand, and upland ethnic minority groups, of which the Karen form the largest group, and the Hmong, Lawa and Lisu make the rest of the upland ethnic minority population.

Methodology

For this study, six villages were selected. The main criteria in selecting the fieldwork villages were the quality and type of the surrounding forest area, and ethnic group. Four ethnic groups are included in this study: the Karen, Hmong, Lawa and Thai. Their views of the forest were studied mainly through semi-structured individual interviews with open-ended questions. The interviewees were selected to include approximately as many women and men as well as people of different ages. Some thematic focus group interviews of men's and women's groups were also conducted. Altogether 70 interviews were conducted in the villages. In addition, NGO workers, academics, government officials from the district to the national level, and some representatives of international organisations were interviewed. The interviews in the villages and some other local level interviews were carried out with the help of an interpreter.

Results and Discussion

Forest management in the villages combines traditional systems that vary by community and ethnic group and the government interventions that are characterised by conservation aims. Some local management practices - division of land-use, village rules, village-based fire prevention, and reforestation - are common to each village although some variation occurs due to inclusion of local traditions. For the uplanders, traditions had their foundation on the fact that rotational slash-and-burn cultivation used to provide the main source of livelihood, which had an importance in determining the protected and utilisable areas. The reasons for protecting may have been spiritual or ceremonial.

Today, communities' forest management is based on division of land into three categories: conservation forest, usage or community forest and land for agriculture. Boundaries between land areas are marked by the villagers, or natural boundaries, such as rivers, are used to indicate the area. Each village is responsible for its own territory.

In the protected forest, logging is strictly prohibited but in some conserved areas people are allowed to gather non-timber forest products. The category of conservation forest includes government gazetted areas and also the forests that villagers have traditionally protected. Thus the forest continues to serve the traditional purposes for example as ceremonial area or burial ground. The inclusion of the traditional divisions of the forest produces in practice more detailed classifications than the three land-use categories. For example, in a Lawa village, protected forest areas are divided into five categories: conservation area, watershed, source of water, village yards, and burial ground. The total area of strictly protected forest is, however, now larger than in the traditional system. In particular, the national park areas have caused dispute between the villagers and the government because the villagers feel that national park with prohibition of all forest use threatens their livelihood through limiting agricultural land and their access to forest products.

The community forest may be used only by the members of the community who are also responsible for controlling its use. The community forest serves villagers' needs for wood and timber, and trees may be cut for own use, house construction for example. Cutting trees, however, requires permission from the village committee that determines the number of trees that are allowed to cut according to the size of a household. Gathering of non-timber forest products requires no permission for the villagers. The location of community forest, as that of conservation forest, may be selected after ecological criteria. For example, in a Karen village, the community forest, where cutting of big trees was prohibited, was situated along the river. The village's conservation forest was located in upriver of a stream. A buffer zone of community forest or reforested area usually separated protected forest and farming land. In addition, some villages used to have so called spare forest which was utilised when the community forest was inadequate.

Each village has its own village rule to control its forest area. The villagers formulate the rule with help of government officials or NGO staff. The rule varies from village to village and may cover various aspects. For example, in one village the rule covered not only natural resource use but also regulations concerning drugs, shooting, violence, gambling and participation, whereas the rules of some other villages concentrated more on environmental protection. The village rules are approved by sub-district, district and the Royal Forest Department officials while enforcement of the rules appeared to be primarily on the responsibility of village committees'. Sanctions are usually fines which are often used further to restore the damages for the environment or compensate other villagers for harm caused. In the traditional system, the sanctions for violating the rules of protected forest area were social, for instance, villagers refused to attend a funeral in a household.

In the past, the forest used to play a significant role in providing non-timber forest products, of which food, fuel, fodder and medicines were the most important. Today also, most of the interviewees gather some forest products although their significance for people's livelihood has decreased. In addition, construction wood is still obtained from the forest. Traditional uses of forest in Hmong villages also included letting domestic animals to forage in the surrounding forest. This is now forbidden in protected forest areas. Other present regulations of conservation areas also restrict forest use; for instance hunting, which used to be one of the basic uses of the forest, is now widely banned.

Many forest management activities, such as reforestation and fire management, are nowadays controlled from outside communities. The government expects communities to take actively part in fire management activities, such as making firebreaks and in fire control. Traditionally fire was prevented by digging firebreaks around buildings and using backfires to stop progression of fire (Makarabhirom et al. 2002). These traditional methods, however, were inadequate to protect the degraded forest. Recent campaigns by the government have promoted more efficient fire management practices in the villages, which seemed to succeed well. Another management practice the government promotes in the villages is reforestation of former swidden areas and opium poppy (*Papaver somniferum*) fields. For this, the government provides seedlings and organises the planting.

The research indicated that the villagers, particularly the upland forest dwellers, considered forest conservation essential for their livelihood. Both the upland groups and the Thai seemed to hold the view that they had started to conserve their forests on their own initiative before the government or NGOs came with their conservation projects. The central common feature of forest management appeared to be this emphasis on conservation (cf. Rerkasem et al. 2002, the study among three ethnic upland groups).

The existence of regulations is commonly appreciated in protecting the forest and villagers' rights over it. Cooperation within the communities and village networks is also regarded as important for forest management, especially for conservation. Although the role of the government was also recognised, the villagers were commonly of the opinion that they have the capability to manage the forests by themselves, basically in the same way as their ancestors. However, traditional systems of forest management were often based on lower population densities and a rotational cultivation system with extensive forest areas and restricted area of protected forest. These systems as such are largely inapplicable today due to environmental changes and government policy. Nevertheless, probably the best solution for forest management today is to combine traditional and introduced systems. The development of appropriate and sustainable solutions requires knowledge of local people's conceptions and practices of forest management.

References

ICRAF 2001. Transparencies 10.10.2001, Chiang Mai office, Thailand.

Makarabhirom, P., D. Ganz & S. Onprom 2002. In P. Moore, D. Ganz, L. Cheng Tan, T. Enters & P. B. Durst (eds.) *Communities in Flames: Proceedings of an international conference on community involvement in fire management*, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, pp. 10–15.

Poffenberger, Mark, ed. 2000. *Communities and Forest Management in Southeast Asia*, Forests, People and Policies, A Regional Profile of WG-CIFM, IUCN.

Rerkasem, K., N. Yimyam, C. Korshamphan, C. Thong-Ngam, B. Rerkasem 2002. Mountain Research and Development 22:4-9.

RFD 2001. Forestry statistics of Thailand 2001, Royal Forest Department.

Acknowledgements

I am grateful to the Chancellor of the University of Helsinki for granting me funding for this conference.

ECOLOGICAL AND ECONOMIC REASONS FOR RETAINING WHITE BIRCH IN INTERIOR SPRUCE PLANTATIONS

Chris Hawkins[1] and Thomas W. Steele[2]

[1]Mixedwoods, University of Northern British Columbia, 3333 University Way,
Prince George, BC, Canada V2N 4Z9
Tel: +1250-960-5614; E-mail: hawkinsc@unbc.ca
[2]Kemp Natural Resources Station, University of Wisconsin – Madison

Introduction

The current 'default' operational practice in the central BC interior is the elimination of the non-coniferous component of the stand. This also decreases diversity (2). There are no guidelines at present for managing mixed species stands. When managed, they tend to be managed poorly due to a limited understanding of stand dynamics (13) and a lack of predictive models. Recent work suggests 'default' practices may not enhance yields (11). Understanding of forest pest impacts in mixed species stands is also poor. For example, white pine weevil (WPW), *Pissodes strobi* (Peck) damage is reduced in the presence of deciduous overstorey (16, 17, 1, 11). However the density at which WPW attack and conifer growth is reduced is unknown. Many growth and yield models have been developed for mixed species stands (14) but none for central BC. To project stand growth and development, Lakes States TWIGS (9) has been used or modified in other jurisdictions (12, 8). We used TWIGS to project mixed species growth in central BC.

Methodology

A 90 ha area, 100 km east of Prince George, BC was winter logged in 1987-88, broadcast burned in spring 1988, and spring planted with 2+1 interior spruce (*Picea glauca* (Moench) Voss X *P. engelmannii* Parry ex Engelm.) in 1989. The site was grazed by sheep in summer 1992. In 1996, Glyphosate® herbicide was applied aerially to 24 ha. By spring 2000, a birch (*Betula papyrifera* Marsh)-spruce mixedwood existed in the untreated area where WPW attack was reduced and spruce growth promoted (Table 1). TWIGS (9) projections were done at SI_{50}=23 m based on Nigh and Love's (2000) work. Spruce projections were done in TIPSY (2000) at SI_{50}=23 m. As a result of TWIGS projections and earlier work (11), a range of birch (Pb) densities were established, holding spruce (Sx) density constant, using girdling, brush saw, and Release® herbicide approaches in summer 2002. A 0.1 ha measurement area was centered in each 0.5 ha treatment unit. Land expectation value (LEV) was calculated using a real discount rate of 3% and actual silviculture costs stated in 2002 $CDN. Data were analyzed in SYSTAT 10 with, $\alpha = 0.05$.

Results and Discussion

TWIGS indicated spruce yields were reduced in the untreated scenario (1200 Sx – 3300 Pb sph) and enhanced at 1200 Sx – 800 Pb sph (Fig 1). Spruce yields were similar for complete or no birch removal. Significant birch yields only occurred without spruce. A birch threshold above which spruce yields are reduced may exist around 2000 sph. This has been reported for southern BC stands (15). Enhanced spruce growth below the threshold could be a function of birch improving soil nutrient status (4). Projections of stand composition to 150 years are similar to adjacent unlogged stands. Spruce yields are similar at planned harvest for both models. Mortality needs to be defined for this stand (12, 6) as mortality functions differ between models.

Spruce growth was not different among birch density reduction approaches. Spruce 2003 dbh increment was correlated to birch density but birch dbh and both speceis' heights were not (Fig 2).

Table 1. Fall 2001 dbh, height and WPW attack for a 13 year-old glyphosate-treated and untreated stand. Spruce (*) and birch ($) are significantly different between treatments.

	Treated			Untreated		
	dbh, cm	Height, m	Weevil, %	dbh, cm	Height, m	Weevil, %
Spruce	6.4 (0.3)	3.14 (0.09)*	24 (6.3)*	6.6 (0.3)	3.96 (0.09)*	9 (1.4)*
Birch	2.6 (0.3)$	3.48 (0.15)$		4.8 (0.4)$	4.51 (0.09)$	

Fig. 1. TWIGS yield projections for untreated (UT), 1200 Sx-800 Pb, 1300 Sx-0 Pb, 0 Sx-1300 Pb, and 1300 Sx in TIPSY.

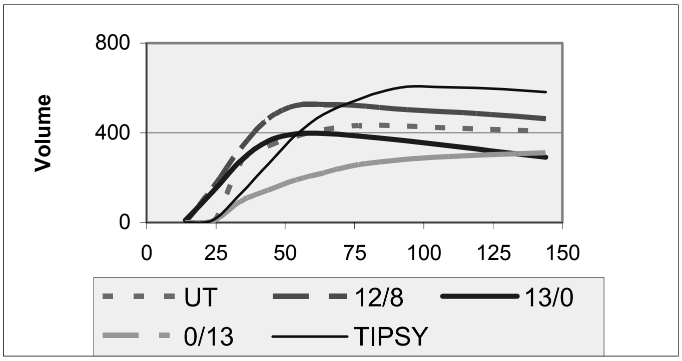
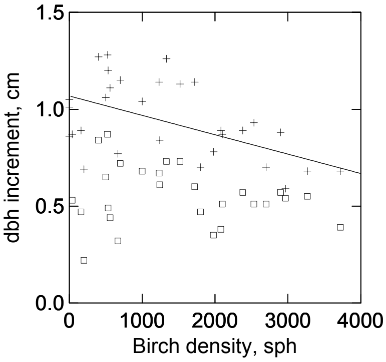


Fig. 2. Spruce (plus) and birch (square) 2003 dbh increments as a function of birch density. Regression dbh = 1.068 – 0.0001*sph; r^2=0.222.



There appears to be a density threshold near 2000 sph below which growth is promoted. For both species, dbh increment was positively correlated to species' fall 2002 dbh (Fig 3). It is important to eliminate original tree size as a driving force or competition effects may be over estimated (3). Our results are consistent with others (7) as dbh increment was more affected than height by competition. The data, even though first year, support TWIGS projections as does observed unlogged stand species composition. WPW attack was significantly greater in the glyphoste-treated area and was correlated to birch density (Fig 4). Attack appears to be greater at densities below 2000 sph. As trees fall, degree days will increase and leaders will be more visible. This should lead to increased WPW attack (16, 17, 1).

LEV were greatest at intermediate birch densities rather than at extreme densities (Fig 5). Mixed species' management may result in better site utilization through enhanced productivity, improved forest health, enhanced species and structural diversity, and greater economic returns. Our findings and interpretations may be over optimistic compared to European studies (5). However, there does appear to be a density threshold around 2000 sph above which WPW attack, growth, and LEV are reduced. This observation may result in a shift from the current operational 'default' to mixed species management for these stands in the central BC interior.

Fig. 3. Spruce (plus) and birch (square) 2003 dbh increment as a function of fall 2002 dbh. Regressions: Sx (solid line) = 0.245 + 0.0092* Sx dbh; r^2=0.275. Pb (broken line) = 0.0752 + 0.1157*Pb dbh; r^2=0.503

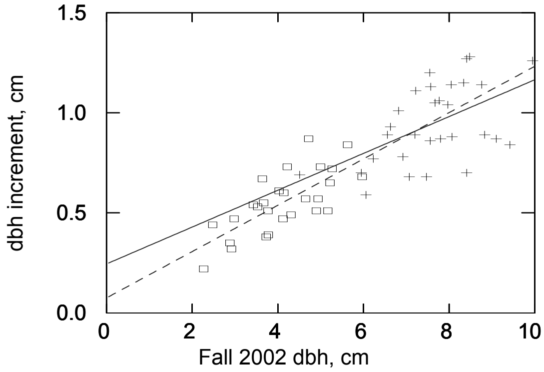


Fig. 4. 2003 WPW attack as a function of birch density.
Regression: attack =11.1857– 0.0024*sph; r2=0.131

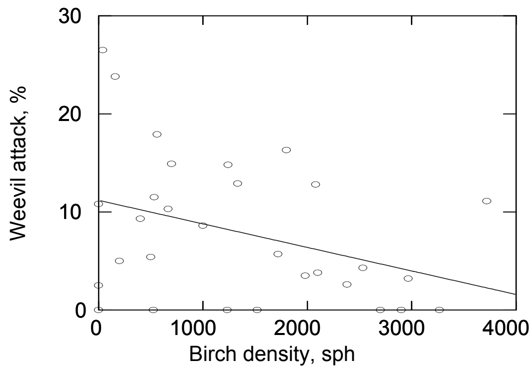
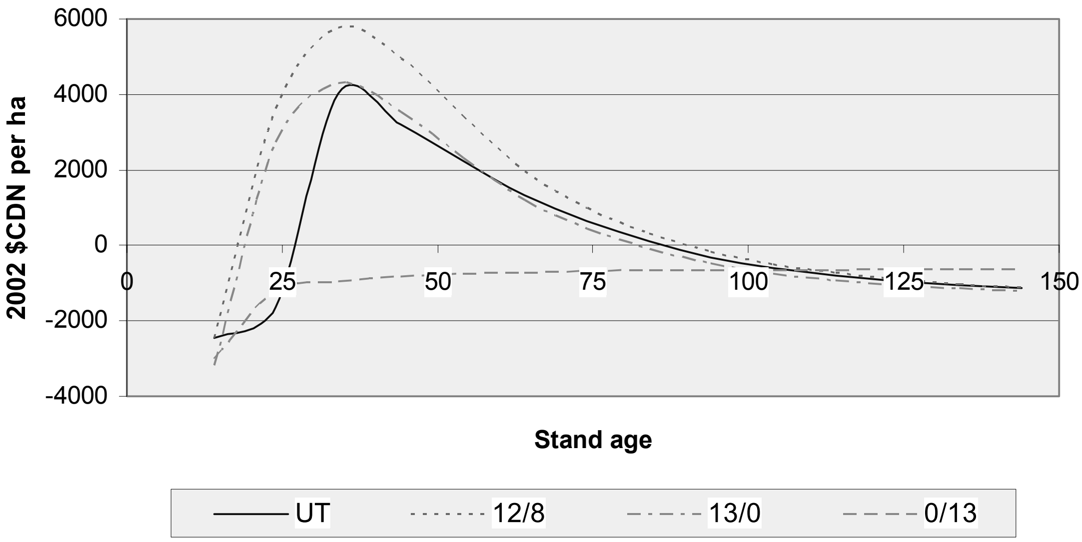


Fig. 5. LEV for TWIGS growth projections. Abbreviations as in Fig 1.



References

1. Alfaro, R. 1998. Natural Resources Canada, CFS-PFC Tech. Transfer Note No. 4.
2. Comeau, PG, TF Braumandl & CY Xie. 1993. Can. J. For. Res. 23:2044-2048.
3. Comeau, PG, JR Wang & T Letchford. Can. J. For. Res. 33:1962-1973.
4. Côté, B & JWFyles. 1994. Can. J. For. Res. 24:192-196.
5. Frivold, LH & T Holström. 1999. In Management of Mixed-species Forests (eds. A Olsthoorn et al.). IBN-DLO Wageningen. pp. 37-45.
6. Guertin, PJ & CW Ramm. 1996. N. J. Appl. For. 13:182-188.
7. Jobidon, R. 2000. For. Ecol. Manage. 130:77-97.
8. McKenney, DW, N Beke, G Fox & A Groot. 1997. For. Ecol. Manage. 95:141-152.
9. Miner, CL, NR Walters & ML Belli. 1988. USDA Forest Service, Gen. Tech. Rep NC-125.

10. Nigh, GD & BA Love. 2000. N. J. Appl. For. 15:117-121.
11. Nykoluk, SM. 2002. MSc thesis, University of Northern BC.
12. Payandeh, B & P Papadopol. 1994. N. J. Appl. For. 11:41-46.
13. Prévost, M & D Pothier. 2003. Can. J. For. Res. 23:2044-2048.
14. Robinson, AP & RA Monserud. 2003. For. Ecol. Manage. 172:53-67.
15. Simard, SW & KD Hannam. 2000. For. Ecol. Manage. 129:237-251.
16. Taylor, SP & RD Cozens. 1994. J. Entomol. Soc. BC 91:37-42.
17. Taylor, SP, R Alfaro, C DeLong, & L Rankin. 1996. Can. J. For. Res. 26:306-312.
18. TIPSY 2000. http://www.for.gov.bc.ca/research/gymodels/tipsy/.

Acknowledgements

Work supported by Forest Renewal BC, Forest Innovation Investment BC, Forest Science Program BC, Dow AgroSciences, FRBC-Slocan Chair of Mixedwood Ecology and Management.

SHOULD PLANTING OF BROAD-LEAVED SPECIES BE ENCOURAGED AT THE EXPENSE OF SPRUCE? AN ECONOMIC APPROACH TO A CURRENT SOUTHERN SWEDISH FORESTRY ISSUE

Per Holgén[1] and Göran Bostedt[2]

[1]Department of Silviculture, SLU, 901 83 Umeå, Sweden
Tel: +46(0)90-786 8438 E-mail: per.holgen@ssko.slu.se
[2]Department of Forest Economics, SLU, 901 83 Umeå, Sweden

Introduction

During the late 1900´s many broad-leaved forests of southern Sweden were converted to monocultures of Norway spruce (*Picea abies* L. Karst.) and other conifers at an accelerating pace. The main reason was that spruce plantation has been considered a superior economic alternative compared with cultivation of broad-leaved tree species. Consequently, today relatively uniform coniferous forests dominate the forest land of southern Sweden. Norway spruce and Scots pine (*Pinus sylvestris* L.) account for 70 percent of the standing volume (National Board of Forestry 2003) while 13 percent consist of oak (*Quercus sp.)* and beech (*Fagus sylvatica* L.). In order to retain the remaining southern Swedish broad-leaved forests for the future, an amendment to the Forestry Act in 1984 (National Board of Forestry 1984) prescribes that valuable broad-leaved forest (mainly oak and beech) that is final harvested, should be replaced by new such forest. One important reason is to save biodiversity. The southern mixed broad-leaved forest is known to harbor a considerable part of the total Swedish biodiversity, including tree species, forest plants, and higher as well as lower fauna (e.g. Drakenberg et al., 1991).

One major argument to choose the spruce monoculture alternative is that it yields interest of invested money at a relatively fast and safe rate. Fast because the growth is faster and the rotation is shorter than for most other possible tree species. Safe since spruce is used in large quantities in the forest industry and the forest owners have good opportunities to sell the timber when it is time to harvest. Hardwood timber of good quality and large dimensions can, on the other hand, yield a high net income per cubic meter when sold for production of e.g. veneer or furniture. Concerning forest regeneration, the production of spruce seedlings, as well as planting techniques, are better developed than for most broad-leaved species. Since broad-leaved seedlings often are browsed, it is necessary to fence the planted area, which is a costly operation. The risk of wind-throw can have severe consequences, especially in southern Swedish spruce stands (Valinger and Pettersson 1996). One additional risk connected to pure spruce stands is attacks of various pests, such as root and but rot (e.g. Rönnberg 1999).

Forest recreation studies have shown that the public rank broad-leaved forests above coniferous forests (e.g. Aakerlund 2000). Studies of recreation values in monetary terms are, so far, very few. Mattsson and Li (1994), Holgén and Lind (1995), and Holgén et al. (2000) are examples from northern Sweden, and Bostedt and Mattsson (1995) is one such study from southern Sweden. The main objectives of the current study were to model the timber value of different tree species alternatives at a typical southern Swedish forest site, and to include recreational values in that model.

Methodology

In the current study the long-term economics of three forest management alternatives, including either Norway spruce or beech, was evaluated. A hypothetical site on fertile soil (site index G 34, see Hägglund and Lundmark 1987) was chosen in Skåne, Sweden's southernmost county. Economic estimates are per hectare, using a discount rate of 3.0 percent.

In the first part of the study, site expectation values were calculated. This value is the present value of timber profits added silvicultural costs, for an infinite sequence of rotations. As the main tools, the traditional Faustmann model (e.g. Klemperer 1996) and the forest management program Plan33

(Ekvall 2001) were used. Starting with a hectare of bare land, the regeneration process included costs for scarification, seedlings, planting, non-commercial thinning, and fencing (one alternative). Thinnings and final harvest yielded revenues according to current timber price information. Here, Plan33 calculated the most profitable alternative by varying the timing and the intensity of thinnings and final harvest. These calculations were based on a site- and tree species specific algorithm from the National Land Survey of Sweden. A timber price reduction due to high risk of damage caused by wind-throw and pests was added to the spruce alternative.

The second part of the study focused on recreational values of the southern Swedish forest environment. These values include ”non-consumptive uses” (hiking, camping, etc.) as well as ”consumptive uses” (berry- or mushroom-picking, etc.). Note that, in this study, “recreational values” is used synonymously with “non-timber values” (or “non-market priced benefits”) which is, of course, a simplification. The most common method for economic valuation of non-market priced benefits is the Contingent Valuation Method (CVM). This method is based on constructed market scenarios and people’s responses to valuation questions, e.g. willingness to pay (WTP), in mail surveys or interviews (cf. Mitchell and Carson 1989). There are yet no such studies (known to the authors) on recreational values in southern Swedish forests. Since the actual preferences and WTP is not known, we can not at this stage estimate these benefits with any certainty.

Assume that the total value of a forest, from a socio-economic point of view, is the sum of the timber value (site expectation value) and the present value of non-timber benefits. Then the difference in site expectation value between the spruce and beech alternatives can be regarded as the minimum non-timber value required to justify an increase in broad-leaved forest area. This value can be transformed to a minimum (threshold) marginal WTP by multiplying with the number of hectares to be converted to broad-leaved forest, and then dividing by the affected human population.

Results and discussion

Costs of regeneration were calculated for three alternatives: Norway spruce, beech without fencing, and beech with fencing. The total regeneration cost (present value per hectare) was SEK 12 700 for the spruce alternative, SEK 19 930 for beech without fencing, and SEK 25 930 for beech with fencing.

Net revenues (per hectare) from thinnings and final felling totaled SEK 103 000 in the spruce alternative. Total timber volume removed was 715 m^3 and the final felling occurred 69 years since last final felling. The site expectation value (present value of costs and revenues) was SEK 1 700. The timber price of spruce was reduced by 20 percent to simulate losses caused by wind-throw and pests. In the beech without fencing alternative, net revenues from thinnings and final felling totalled SEK 72 400. Total timber volume removed was 584 m^3 and the final felling occurred 101 years since last final felling. The site expectation value was SEK -8 600. In the beech with fencing alternative, net revenue totalled SEK 77 850. Total timber volume removed was 615 m^3 and the final felling occurred 106 years since last final felling. The site expectation value was SEK -12 050.

Applying a formula for the present value of an infinite series, the beech forest must generate a non-timber value of at least SEK 308 (per hectare and year) higher than the spruce forest in the alternative without fencing. In the fencing alternative this value was SEK 412. To convert these figures to threshold levels of marginal WTP, a hypothetical project was specified. The county of Skåne has approximately 40,000 hectares of spruce forest in the productivity class G34 (National Board of Forestry 2003). Converting half of these spruce forests to beech would increase the area of “valuable broadleaves” in Skåne with about 25 percent. This area would be large enough to have a significant impact on the landscape, recreational opportunities and biodiversity. The threshold level of non-timber benefits that would motivate such a project was SEK 6.16 million per year in the no fencing alternative and SEK 8.24 million with fencing. Dividing these figures with the human population of Skåne (assuming that only residents of Skåne place a value on this landscape change), yielded a minimum marginal WTP of SEK 5.4 and SEK 7.2 per individual and year for the no fencing and fencing alternatives, respectively.

It must be emphasized that these figures do not tell us the actual preferences. However, some insight into the magnitude of WTP for forest recreation can be gained from a CVM study by Mattsson and Li (1993). This study concerned the WTP to “continue to visit, use and experience forest environments as you usually do” by residents in the county of Västerbotten in northern Sweden. The mean WTP was SEK 5856 per adult individual and year. Although this estimate of total forest recreation value in Västerbotten can not be interpreted as an estimate of marginal WTP for an increase of beech forest in Skåne, the size of the WTP figure in comparison to the threshold levels of WTP presented above is suggestive.

In the choice between broad-leaves and conifers in southern Sweden, forest landowners often favor the latter. According to the results of the present study, this is a rational choice. The site expectation value for beech in Skåne, Sweden’s southernmost county, was negative and much lower than the corresponding value for spruce. Obviously, the site expectation value does not tell the whole story from a welfare economic point of view. Can the beech alternative be motivated on other grounds than net timber profits, i.e. are the non-timber values associated with these forests high enough to compensate for the low long-term private profitability? Since no empirical studies of these non-timber benefits (in monetary terms) yet exist, this question can not be answered with certainty. However, the “back-of-the-envelope” calculation above reveals that the minimum marginal WTP required for a 20.000 hectare increase in beech forest area in Skåne is very small. Although the Swedish Forestry Act prevents broad-leaved forests from being converted to spruce, it does not promote an increase in the area covered with such forest. This is instead encouraged by extensive subsidies for regeneration of valuable broadleaves. In a sense, these subsidies can be viewed as a belief of the Swedish government that broad-leaved forests are (substantially) more valuable than conifer forests from a socio-economic point of view.

Based on the conclusions in this paper it is not very difficult to suggest a research agenda. Given that the timber profitability of beech and oak forests is much lower than for spruce, it is obvious that a reliable monetary value on the non-timber benefits of these broad-leaved forests is needed. These benefits exist in the form of recreation values as well as other use values and existence values, e.g. biodiversity values provided by the broad-leaved forest. Until we know more about these benefits, little more can be said in this context about the trade-off between broadleaves and conifers in southern Sweden. In our study we focused on increasing the area of forest types that are valuable from a recreational point of view. There are, however, other aspects of interest in the process to achieve an optimal forest recreation environment. One is the spatial distribution of these forests, i.e. how far people have to travel to use them for various recreation activities. Another important aspect is forest management activities. To what extent should recreation forests be managed for timber production and which silvicultural methods and systems are most cost-efficient in this context? These are all important issues to be addressed in research to come.

References

Aakerlund, NF. 2000. SØM publikation No. 36, Institute of Local Gov. Studies, Copenhagen.

Bostedt, G and Mattsson, L. 1995. Annals of Tourism Research 22, pp. 671-680.

Drakenberg, B. Ehnström, B. Liljelund, L-E and Österberg K. 1991. Rapport 3946, Naturvårdsverket, Stockholm.

Ekvall, H. 2001. Report 123, Dept. of Forest Economics, SLU, Umeå.

Holgén, P and Lind, T. 1995. J. Environ. Man. 45, pp. 177-187.

Holgén, P. Mattsson, L and Li C-Z. 2000. J. Environ. Man. 60, pp. 173-180.

Hägglund, B and Lundmark, J-E. 1987. Skogsstyrelsen, Jönköping.

Klemperer, WD. 1996. Forest Resource Economics and Finance. New York: Mc-Graw-Hill.

Mattsson, L and Li, CZ. 1993. Scand. J. For. Res. 8, pp. 426-434.

Mattsson, L and Li, CZ. 1994. J. Environ. Man. 41, pp. 79-88.

Mitchell, RC and Carson, RT. 1989. Washington D.C.: Resources For the Future.

National Board of Forestry. 2003. Statistical Yearbook of Forestry. Jönköping.

National Board of Forestry. 1984. Jönköping.

Rönnberg, J. 1999. Doctoral thesis. Southern Swedish For. Res. Centre, SLU, Alnarp.

Valinger, E and Pettersson, N. 1996. Forestry 69, pp. 25-33.

TAXON-SPECIFIC RESPONSES OF SUBTROPICAL *PINUS* TO SITE PREPARATION TECHNIQUE ON VERY WET SITES IN THE SOUTH-EAST QUEENSLAND COASTAL LOWLANDS

Mark A. Hunt[1], David O. Osborne[1], Ken Bubb[2] and Marks R. Nester[2]

[1]AFFS Forestry Research, Department of Primary Industries and Fisheries, Queensland, Australia 4570
Tel: +61-7-54820877 E-mail: Mark.Hunt@dpi.qld.gov.au
[2] DPI Forestry, Queensland, Australia

Introduction

Wet sites in the exotic pine plantations of south-east Queensland have been estimated to occupy up to 40% of the plantation area. The current prescriptions for site preparation and taxa allocation were developed during the first rotation. Changes to available genetic material, site preparation equipment and the attitude towards water and soil management have necessitated a review of operational practice. In particular, a review of site preparation techniques has been necessitated by a move away from debris removal to debris retention at harvest, for reasons of site nutritional sustainability, and more comprehensive standards dictating the management of overland hydrological flow.

Methodology

During January – June 2000, a large field experiment, 23 ha in extent, was established on a typical wet site in order to determine the relative merits (in terms of survival and growth) of five mechanical site preparation techniques on a site where the recent debris retention guidelines had been implemented. In addition to the control treatment of nil mechanical site preparation, the treatments included large and small continuous mounds (beds), intermittent mounds and strip cultivation. The site preparation treatments were imposed in a split-split plot design with six taxa/stock ideotypes using large measurement plots of 10 rows x 16 trees. Taxa treatments consisted of three container and three bare-root production systems using: *Pinus elliottii* var *elliottii* (PEE); *Pinus elliottii* var *elliottii* × *Pinus caribaea* var *hondurensis* F_1 hybrid back-cross *P. elliottii* var *elliottii* (BkX); *Pinus elliottii* var *elliottii* × *Pinus caribaea* var *hondurensis* F_2 hybrid (F_2); *Pinus elliottii* var *elliottii* × *Pinus caribaea* var *hondurensis* F_1 hybrid (F_1). A pluviometer and a network of bores and soil moisture sensors were installed across the site to monitor rainfall, the shallow perched water table, and to allow measurement and development of soil moisture profiles across the range of site preparation techniques.

Tree growth and survival characteristics were assessed and measured at three months, six months, one year, two years and three years of age, the three year measure being undertaken in June 2003. Following the three-month and one year survival assessments, spaces were refilled with F_1 hybrid cuttings stock. Growth and survival data were subjected to analyses of variance.

Results and discussion

Taxon (stock ideotype) rather than site preparation treatment was an important determinant of survival. At the June 2003 measure, the effect of site preparation treatment on survival was not significant. However, the effect of taxon on survival was very highly significant (Table 1), the F_1 container stock clearly being superior to the other treatments. In terms of growth, both site preparation and taxon treatments (as well as the interaction term) had significant effects on height

Table 1. Percent survival by taxon.

Taxa	June 2002	June 2003
Pee bare-root	85	85
Pee container	92	92
BkX bare-root	73	72
BkX container	75	75
F2 bare-root	74	74
F1 container	98	98
Significance	***	***
5% LSD	5.9	5.9

(Table 2, Table 3) and dbh (Table 4, Table 5). Notably, for both height and dbh, the strongest relationship was with taxon, rather than site preparation treatment.

Although the mounding techniques showed a significant growth (height) advantage over the non-mounded techniques (MB6>MB4=Spot>Nil=Strip), the relative differences were sufficiently small to warrant caution in extrapolating predictions based on growth results at this early stage in the rotation. However, it is apparent from the data that the differences are increasing over time and that the relative positions of the treatments are stable (for now).

Table 2. Mean height (m) by site preparation treatment.

Site preparation treatment	June 2002	June 2003
Nil	2.6	4.3
Strip (TP3)	2.5	4.2
Large (MB6)	3.2	5.1
Medium (MB4)	3.0	4.7
Spot	2.9	4.7
Significance	**	**
5% LSD	0.16	0.21

Table 3. Mean height (m) by taxon.

Taxon	June 2002	June 2003
Pee bare-root	2.4	4.0
Pee container	2.9	4.5
BkX bare-root	2.5	4.2
BkX container	3.0	4.7
F2 bare-root	2.5	4.2
F1 container	3.8	5.8
Significance	***	***
5% LSD	0.12	0.14

Table 4. DBH (cm) by site preparation treatment.

Site preparation treatment	June 2002	June 2003
Nil	3.9	7.4
Strip (TP3)	3.6	7.2
Large (MB6)	5.4	9.1
Medium (MB4)	4.9	8.6
Spot	4.5	8.1
Significance	**	**
5% LSD	0.45	0.54

Table 5. DBH (cm) by taxon.

Taxon	June 2002	June 2003
Pee bare-root	3.6	7.0
Pee container	4.5	7.8
BkX bare-root	3.9	7.6
BkX container	5.1	8.9
F2 bare-root	3.8	7.5
F1 container	5.9	9.8
Significance	***	***
5% LSD	0.24	0.30

During the monitoring period rainfall reflected a below-average period with totals around 75 % of local long-term averages. Despite this, soils have had prolonged periods of waterlogging with the perched groundwater levels frequently within 0.4 m depth below surface. Further to this, throughout the majority of the monitoring period, soil moisture content in the 0 to 10 cm profile of the mounded treatments was regularly at or approaching wilting point inferring a degree of 'droughting' was prevalent in the upper soil profile. This droughting, even in a period when significant waterlogging occurred, may be an important consideration when prescribing site preparation procedures on sites subject to substantial year to year variation in rainfall.

Acknowledgements

The hydrological component of the study was partly funded through a Strategic Initiative Fund grant from the Cooperative Research Centre for Sustainable Production Forestry, Hobart, Australia.

ON THE GENETIC DIVERSITY OF NURSERY STOCK AS INFLUENCED BY CULLING PRACTICES: THE CASE OF *PINUS CEMBRA* L.

Raphael Th. Klumpp

Institute of Silviculture
University of Natural Resources and Applied Life Sciences, Peter-Jordan-Str. 70,
Vienna, Austria A-1190, Tel: +43 1 47654 4063
Email: raphael.klumpp@boku.ac.at

Introduction

Preserving the biodiversity of the European forests is one of the most challenging issues in our days. And we have to confess that the knowledge on the forest ecosystems is anything but conmplete. The dynamics of the gene pool, as for instance, is assumed to exhibit excess of homozygotes in the young generation of forest trees, which will disappear during the live cycle (e.g. Yazdani et al. 1985, Konnert 1991). Vice versa, an excess of heterozygotes is logically reported to be found in mature forest stands (Mitton 1995). Furthermore a superiority of the heterozygotes regarding vitality and growing yield is generally accepted (e.g. Bush & Smouse 1992, Mitton 1995), in spite of the fact that some publications revealed contradictory findings.

Afforestation has a special influence on one component of biodiversity: the genetic diversity. Research proved the fact, that the quality of the planting material is decisive for the success of afforestation. Later criteria for quality management were developed and grading became a standard procedure in nursery management (see Rikola 1989, McKay & Mason 1998). Early studies on the effects of nursery management on the genetic sustainability in *Pinus sylvestris* L. (Muona et al. 1987) as well as in *Pseudotsuga menziesii* [Mirb] Franco (Adams et al. 1998) found it to be according to the natural dynamics. Not so did the investigations in *Picea abies* L. and in *Abies alba* Mill. (Konnert and Schmidt 1996). Thus the question arose, whether grading in nursery results in genetic erosion. Moreover the additional question emerged, how the economic success can be simultaneously guarantied together with genetic sustainability.

Methodology

Two different types of nursery stock were used for this study: bareroot seedlings (age 2/0) of the provenance "Hallein" and container plants (age 2+1) of the provenance "Obdach". A sample of 60 plants was taken from a "sorted" (size graded) as well as from an "unsorted" (non graded) lot of the container stock. Metric traits were measured from fresh plants (shoot length, root collar, root length, shoot weight, root weight) and from dry weight (weight of root and shoot after 24 hours drying at 105^{o}C). Average values and extreme values were taken for the comparison of the samples.

Samples of 120 plants per variant were used for genetic analysis. Isozyme analysis was carried out on 13 enzyme systems of dormant bud tissue following the laboratory protocol of Hertel (Hertel 1997). The genetic variation was measured by means of the number of alleles per locus (A/L), the intrapopulation differentiation (Delta T, Gregorius 1987), the actual (observed) heterozygosity (Ha), the genic diversity (V, Gregorius 1987) and the hypothetical gametic multilocus diversity (Vgam, Gregorius 1978). Differences between frequencies of genetic types were tested statistically by employing the G-test of homogeneity in contingency tables. We used the GSED software (Gillet 1998) for scoring the data.

Results and Discussion

The material of this study does not allow comparisons among all samples as the material differs not only from provenances but also slightly from age. In spite of that, the material demonstrates that the well known differences between graded and ungraded material are due to lower shoot length of the non graded material. The dispersion of the shoot length is surprisingly higher in the container material than in the bareroot stock. Root collar and root weight exhibit differences between the quality types only for the bareroot stock. Hence the container plant is obviously performing different shoot length in spite of optimised root development in the container, where there is no competition with the neighbours. Finally, the sturdiness, which is the combination of shoot length and root collar, reveals the explanation for the better success of the graded material (figure 1): strong plants show wide root collar combined with suitable shoot length. Hence they have better storage capacity for nutrients and water in root and shoot (see Schmidt-Vogt 1985).

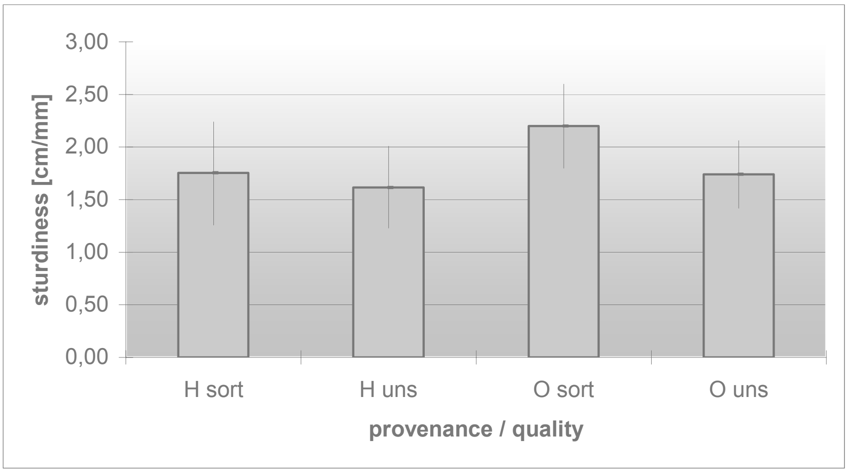


Figure 1: Average sturdiness and extreme values for bareroot seedlings (left: provenance "Hallein "H") and container plants (right: provenance Obdach "O") respectively.

Pinus cembra is well known to possess lowest genetic variability amongst forest tree species (Politov and Krutovskii 1994). In spite of that, isozyme gene markers reveal slight differences in the genetic variation between graded and non graded container stock (Table 1). Having the same number of alleles per locus, the gene pool of the graded planting stock is slightly more diverse compared to the ungraded one (Table 1: V) and it is better differentiated (Table 1: Delta T). Both features result in a higher, theoretical potential of the graded planting stock, to built up diverse gametes for future generations (Table 1: Vgam). So far, our results match those of the studies in Scots pine (Muona et al. 1987) and Douglas-fir (Adams et al. 1998), but are contrarily to the findings in Norway spruce and Silver fir (Konnert and Schmidt 1996). Further studies are needed to find out, whether the dynamic of the gene pool and its reaction to nursery management may differ according to the genus of the plants.

The question, whether grading in nursery results in genetic erosion should be taken serious, in particular for the genus *Picea* and *Abies*. At the other hand there is no doubt, that the weak plants have less chances for surviving the afforestation. Therefore the numbers of plants per afforestation needs to be increased, in case that non graded material is planned to be used.

Table 1: Comparison of different parameters of the genetic variation for two different quality types of container stock. For explanations see text.

	quality	**genetic parameter**				
provenance		**A/L**	**V**	**Ha**	**Delta T**	**V gam**
Obdach	size graded	2,18	1,157	0,114	0,136	23,25
	ungraded	2,18	1,146	0,113	0,128	19,56

References

Adams, WT, Shimizu, JY and Tappeiner, JC. 1998. For. Science 44: 390-396.

Bush, RM and Smouse, PE. 1992. Pp 179-196 *in* Adams, W.T., S.H. Strauss, D.L. Copes and A.R. Griffin (eds.): Population genetics of forest trees. Kluwer Academic Publishers Dordrecht.

Gillet, E. 1998. GSED, Genetic structures from electrophoresis data. Abteilung Forstgenetik und Forstpflanzenzüchtung, Universitaet Goettingen, 49 pp.

Gregorius, H.-R. 1978. Math. Bioscience 41: 253-271.

Gregorius, H.-R. 1987. Theoret. Appl.Genetics 74: 397-401.

Hertel, H. 1997. Mitt. d. BFA f. Forst- und Holzwirtschaft No. 186, Wiedebusch / Hamburg, 59 pp.

Konnert, M. 1991. Silvae Genetica 40(2): 60-65.

Konnert, M and Schmidt, S. 1996. Pp 22-37 *in* Müller-Starck, G. (ed.): Biodiversität und nachhaltige Forstwirtschaft. Ecomed Verlagsgesellschaft Landsberg a.L.

McKay, HM and Mason EG. 2001. New Forests 22: 111-131.

Mitton, J.B.1995. Pp 1-38 *in* Smith, W.K. and Hinckley Th.M.: Ecophysiology of coniferous forests. Academic Press, New York / Boston.

Muona, O., Yazdani, R. and Rudin, D. 1987: Silvae Genetica 36(1): 39-42.

Politov, V.D. and Krutovskii, K.V. 1994. Pp 36-42 *in* Schmidt, W.C. and Holtmeier, F.-K., (eds.): Proceedings - International workshop on subalpine Stone pines and their environment: the status of our knowledge. General Technical Rep. USDA Forest Service Intermountain Research Station INT-GTR-309, Ogden.

Rikola, R. 1989. Forestry Supplement 62: 29-37.

Schmidt-Vogt, H. 1985. Der Forst- und Holzwirt 37: 264-268.

Yazdani, R., Muona, O., Rudin, D. and Szmidt, A.E. 1985. Forest Sci. 31(2): 430-436.

Acknowledgements

This study was funded by the European Union as part of the project on "biodiversity of alpine forest ecosystems" (EU CT96-1949).

ASSESSING EFFECTS OF FOREST MANAGEMENT ON SELECTED PUBLIC FOREST GOODS AND SERVICES: A CASE STUDY

Daniel A Köchli[1] and Peter Brang[2]

Swiss Federal Research Institute WSL, Zürcherstr. 111, CH-8903 Birmensdorf, Switzerland
[1] daniel.koechli@wsl.ch; [2] peter.brang@wsl.ch

Introduction

Forest characteristics such as stand structure, tree species composition and developmental stage influence the quality and amount of public goods and services that forests provide, such as groundwater quality, species richness, recreational suitability or air quality.

For each good and service, specific characteristics are decisive, while others are less relevant. To a certain extent, these characteristics can be influenced by management activities (Burschel 1994, Blum et al. 1996). Estimating effects of different silvicultural strategies on goods and services provided would help in designing appropriate strategies.

While public demand is fairly well known (e.g. Franzen et al. 1999) and the value of forest goods and services can be estimated (e.g. using contingent valuation, Mitchell & Carson 1993), simple models to understand how forest characteristics are related to public forest goods and services are missing. Such models would enable the simulation of different management strategies, and thus the estimation of how they affect diverse target variables over a longer time period.

In this paper, we use a forest growth simulator and a GIS to assess the effects of three strategies on selected goods and services in a peri-urban catchment in Switzerland during 50 years. In this catchment, recreation is the most important service, ecological services (e.g. purification of water and air, biodiversity, etc.) are important, and wood production is of secondary importance (Köchli unpublished).

Methodology

We used the Greifensee catchment near Zurich as a case study. The catchment stretches over 165 km^2, including 30 km^2 of forests (19%) and covers an elevational range of 400 to 1100 m a.s.l. The forests are mostly on productive sites (growing stock: 518.5 m^3 ha^{-1}±100.5, mean ± standard error; annual increment 15.9±3.3 m^3 ha^{-1} y^{-1}, inventory data). Stand maps were fed into a GIS to get the initial state of the forests in the area. The 5238 stands delineated on the maps were grouped into 29 stand types, based on developmental stage, proportion of conifers and stand density.

For each of the three services recreational suitability, ground water and air purification, an index was developed which captures the suitability of a stand to provide the service. The indices should be simple, clearly related to the target service, and use information readily available on stand maps. The index for recreational suitability was based on accessibility, stand structure and patch diversity (Brändli & Ulmer 1999). The index for ground water, in particular its nitrate content, was linearly related to the capacity of a stand to bind nitrogen, (i.e. the volume increment), and to nitrogen removal by timber harvesting. The index for air purification was linearly related to the yearly average leaf area of a stand.

The growth simulator SILVA 2.2 (Pretzsch 2001) was used to project forest development during 50 years. The STRUGEN module of SILVA 2.2 was used to generate the initial stand structure for each stand type. The development of each of the 29 stand types was simulated under three silvicultural strategies using SILVA 2.2. These strategies were: B business as usual, N no intervention, and M mass production. In the B strategy, stands were thinned every 10 years, and regenerated at an age of 100 years (stands dominated by *Picea abies* (L.) Karst.) or 120 years (stands dominated by *Fagus sylvatica* L.). Before the final cut, the growing stock was linearly reduced during 20-30 years, and naturally regenerated using the tree species already in place. In the N strategy, no thinning occurred, and stands were continuously naturally regenerated. In the M strategy, stands were strongly thinned every 10 years from h_{dom}=16 m to h_{dom}=24 m, clearcut when h_{dom}=34 m was reached, and planted to pure *Picea abies* stands (2.800 SPH). In all three strategies, road maintenance continued. The outputs of SILVA 2.2 were transferred into the GIS, indices for the three services calculated, and aggregated over the study area.

Results and discussion

Recreational suitability

In both the B and N strategies, the index of recreational suitability moderately fluctuated around the initial level (Fig. 1). Highs and lows were very similar in these two strategies. In the simulation of the M strategy, the index of recreational suitability visibly declined after some 15 years due to advanced conversion of stands to *Picea abies* plantations.

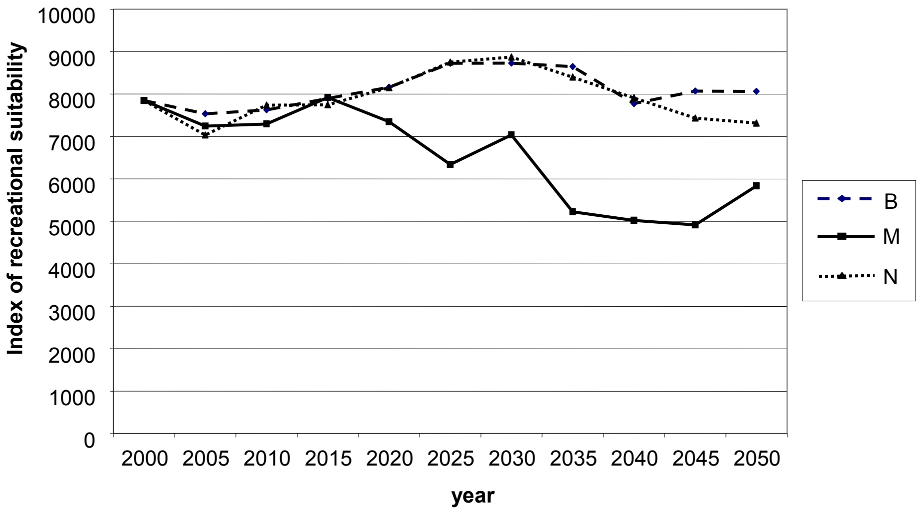


Fig. 1. Simulation of the overall course of the index of recreational suitability (dimensionless) in the Greifensee catchment with three management strategies: B=Business as usual, M=Mass production, N=No intervention. The strategies are described in the text.

Ground water

The ability of the forests to provide ground water with low nitrate concentrations slightly fluctuated around the initial level in the B strategy. In the N strategy, the index steadily decreased due to increased nitrogen-saturation as a result of high atmospheric inputs. The opposite was the case in the M strategy: In addition to increased N exports due to timber harvesting, tree growth in young plantations resulted in increased N storage. It has to be noted, however, that we did not take logging-induced short-term nitrate leaching into account.

Air purification

In the B strategy, the index of air purification first moderately fluctuated around the initial level, but later decreased due to increased regeneration activities in today's middle-aged and older stands. In the N strategy, the index continuously increased due to continuous growth of old and large trees. In the M strategy, it rapidly decreased at the beginning and reached a minimum after some 30 years. Thereafter, the index steeply increased as soon as the *Picea abies* plantations reached pole stage.

It does not seem useful to combine these indices into a single index. Apart from scaling and weighing problems, the goal of forest management in a peri-urban area such as the Greifensee catchment is to provide a mix of goods and services, with a minimum level for each good or service, and not to maximize the total. The N and M strategies presented are clearly extreme strategies which could not realistically be applied to the whole catchment due to the highly split ownership and current forest legislation. However, the results of our study can be used to show to what degree management activities affect goods and services. We propose to use such tools more often in forest planning processes to support the development of land use visions and policies on a regional scale.

References

Blum, A., Brandl, H., et al. (1996). AFZ/Der Wald (20): 22-26.

Brändli, U.-B. & Ulmer, U. (1999). In: *Schweizerisches Landesforstinventar - Methoden und Modelle der Zweitaufnahme.* Brassel, P. & Lischke, H. (Eds.). Birmensdorf: Eidg. Forschungsanstalt WSL.

Burschel, P. (1994). AFZ/Der Wald (12): 622-631.

Franzen, A., Hungerbühler, A., et al. (1999). Schriftenreihe Umwelt 309. Bern: Bundesamt für Umwelt, Wald und Landschaft (BUWAL). 152 S.

Mitchell, R. C. & Carson, R. T. (1993). Third Printing. Washington D.C.: Resources for the future. 463 S.

Pretzsch, H. (2001). *Modellierung des Waldwachstums.* Berlin: Parey Buchverlag. 342 S.

Acknowledgements

This study was funded by the Swiss Forest Agency and the WSL Research Programme “Land resources management in peri-urban environments”.

TRADITIONAL RESOURCE MANAGEMENT IN THE TANIMBAR (SOUTH EASTERN MOLUCAS)

Yves Laumonier, Yohanes Purwanto, Bayuni Shantiko and Yan Persulessy

Tanimbar Land Use Planning Project
European Union – CIRAD Forêt – BirdLife Indonesia
PO Box 7612, JKP 10270 Jakarta Indonesia
Cirad_tanimbar@cbn.net.id

Introduction

Tanimbar archipelago (dominated by the 3,333 km2 island of Yamdena), together with Wetar, Babar and others in Southern Moluccas, is one of the poorest island groups in Indonesia. The islands are geographically, politically and economically isolated, with most livelihoods heavily dependent on subsistence agriculture and wild products (from the sea and forest). The population was too small, and too remote to support industrial developments or significant government investment in the past. Infrastructure is still very poorly developed and access to education, health and markets is difficult and expensive.

Together with the fact that nature is still quite pristine, the distinctiveness of the region is that communities retain strong traditional resource management systems and have a history of local action against outside exploitation of resources. In 1992 the inhabitants began a campaign to stop logging on the largest island, Yamdena. They gained international support including a resolution from the European Parliament to the Indonesian Government.

The newly created Tanimbar Regency government, now the major decision-making body on the archipelago, is aware of the poverty and environmental issues, and keen to revise its land use planning and implementation to reflect the particular needs of the islands and their inhabitants.

The present study aims to facilitate mutual understanding between local government and population regarding planning and management of their natural resources, in order to avoid anarchic development in fragile environment, at the same time addressing poverty through sustainable management of resources.

Methodology

Biophysical inventory, socio-economic and anthropological surveys have been conducted through close work with local government and forest-edge communities, working at the level of planning and policy for the whole Regency, but also at village level to demonstrate the importance and effectiveness of local involvement in the process. Special emphasize has been given to studies on population's knowledge, attitude and behaviour towards nature conservation, forest conditions and management. The study is based on participatory research, emphasises capacity building for all stakeholders, and transparency and accountability as the key to successful integration of government and local systems of management.

Results and discussion

Forest cover on Yamdena still represents 70% of the land, a quite unique situation in Indonesia nowadays. Rain forest and moist deciduous forest types are equally represented, together with quite substantial mangrove areas and some more marginal vegetation types (forest on raised coral, some swamp forest, Melaleuca woodland, etc.). Biological diversity, although less varied than in western Indonesia, is still high with a distinctive mixture of Asiatic, New Guinean or even Australian influence.

Results show that the environment of these islands is very fragile. The human population is entirely confined to the coast, but depends on the forested water catchments inland for fresh water during dry season. The islands are predominantly calcareous, and as a result rain drains quickly and soils are often thin, easily eroded, especially in the southern part of Yamdena. The dry season places stress on these ecological systems, and there are frequent food and water shortages during the dry months.

Livelihoods of Tanimbarese, mainly subsistence agriculture and traditional fishery, could be threatened by unsustainable exploitation of resources and poorly planned development. At landscape level, the village land ("Petuanan") is managed by a grouping of families of the same lineage ("Soa" comprising several "Marga"), traditionally from the high caste of the society. The head of the "Soa" control is the resource, decides who has access to it and how the profits will be redistributed to the community. This is especially true for big agricultural project or large scale timber extraction. At lower level, the whole process of opening land for agriculture is made by customary leader and village government representative. This comprises when and where to open new land, which person will be in charge of the division of work, what custom rituals should be performed prior to action, etc.

Traditionally, Tanimbarese practice shifting cultivation, opening forest area, cultivating new field for 3 years (dry paddy, maize, and tubers), leaving the place as fallow land and then reopening it after another 10 years. Old fields are always finally planted with coconut trees for copra, the main traditional source of income for the region. In theory, this means that farmers will always need to open new forest plots. Nowadays however, many older farmers consider that the forest is already too far and prefer to reopen old regrowth forest plots for food crops instead of mature forest. It has benefits for the short term pressure on the forest, but in the long run means that the agriculture cycle will be shorten and will not change the fact that ultimately the field becomes coconut plantation, forcing farmer to look for new land for paddy.

Tanimbarese collect non-timber forest products for subsistence or commercial purpose, NTFPs generate actually substantial income to households through wild water buffalo and wild pig meat, roof leaves, rattan, birds (cockatoos and lories). It involves more people compared to timber harvesting. Communities extract timber for local needs but also for sale to local Chinese traders. These traders dominate local economy, buying commodities such as copra, marine products and timber from local farmers, and supplying goods from outside Tanimbar in return. Marine fisheries provide larger income compared with agriculture.

The traditional resource management system, locally known as 'Sasi', is a set of rules and taboos which limit the harvesting of a specific resource. The system is effective because each rule or taboo is made under the authority of the church (Sasi gereja) or traditional authority (Sasi adat) and is backed by a system of fines as well as social pressure to conform. Every family in every rural community in Tanimbar participates in exploitation of natural resources through the Sasi system, although the extent to which it is still effective varies. The traditional system of resource use has been weakened by conflict with the official system and has not been able to adapt new pressures. The Sasi system experiences difficulties to adapt to the changing economic and political environment in which it operates, for example, to stop fishing boats from outside Tanimbar from depleting fish stocks.

Further research is needed on how to support integration of the Sasi system into official resource use system, to give it authority and legitimacy when dealing with problems originating outside the community. Our findings also suggest that sustainable development on small tropical islands can only be achieved through community based land use planning, together with inhabitant priority access to resources in customary territory including coastal waters. In parallel with research on silviculture specific to the local forest types (rain forest and moist deciduous forest), Participatory Land Use Planning should be carried out in areas where there is foreseeable land use conflict and community assisted in managing timbers and NWFPs.

EFFECTS OF TOPOGRAPHY ON REGENERATION PATTERN OF SUB-ALPINE FORESTS IN WESTERN SICHUAN OF CHINA

Shirong Liu, Yuandong Zhang, Changming Zhao, Zuomin Shi and Xingliang Liu

Research Institute of Forest Ecology, Enviornment and Protection, Chinese Academy of Forestry, Beijing, 100091. P. R. China
Tel:+86-10-62889311, E-mail: liusr@forestry.ac.cn

Introduction

Western Sichuan sub-alpine is an extension of Qinghai-Tibet Plateau to Southeastern China and largely distributes in the upper valleys of Minjiang River, Yalongjiang River and Jingshajiang River, at the upper reaches of Yangtze River. The major component of western Sichuan alpine forest is dark coniferous forest, which accounts for 67% of the total volume of Sichuan provincial timber production and is mainly consisted of spruces and firs, such as *Abies faxoniana* Rehd. et Wils., *Picea purpurea* Mast. and *Picea asperata* Mast.(Chengbiao Li *etc*,1990). Situated in steep mountains, deep valleys, and source-head of Yangtze River, western Sichuan sub-alpine coniferous forest is identified and managed as water conservation forest. As a result of long-term over-logging on a large scale, however, it has been greatly reduced and degraded. Species composition and community structure of the existing forests have been modified with the varying stages. Therefore, forest restoration and regeneration are being highlighted in the sub-alpine region. Miyaluo(31º4'-31º55'N, 102º35'-103º4'E, elevation 2400-5500m) is located at upper reaches of Zagunao, which is a main branch of Minjiang River. The forest distribution and the management in Miyaluo, along with the topography characteristic, is the epitome of sub-alpine forest of the whole west Sichuan (Youxu Jiang,1963a; Yan Wu *etc*, 2001). The current forest distribution occurs in a mosaic landscape pattern composed of pure plantation, natural regenerated forest, mixed man-made and natural regenerated forest, and remaining old growth forest, with different ages, density and species composition.

Methodology

The ETM satellite image in autumn 1999 was used for vegetation mapping of Miyaluo. By the supervised classification in Erdas 8.5, nine vegetation types are classified with 105 ground sites. Between the valley in 2400m and tree line in 4200m, there are four types of forest vegetation, they are old coniferous forest (OC), young & middle age coniferous forest (YMC), deciduous broadleaf forest (DB), and mixed forest with coniferous and deciduous (MCD). The regeneration characteristic of four types was analyzed with ground survey. The regeneration pattern along the gradients of elevation, slope aspect and grade was studied through overlay analysis of the vegetation map with DEM data.

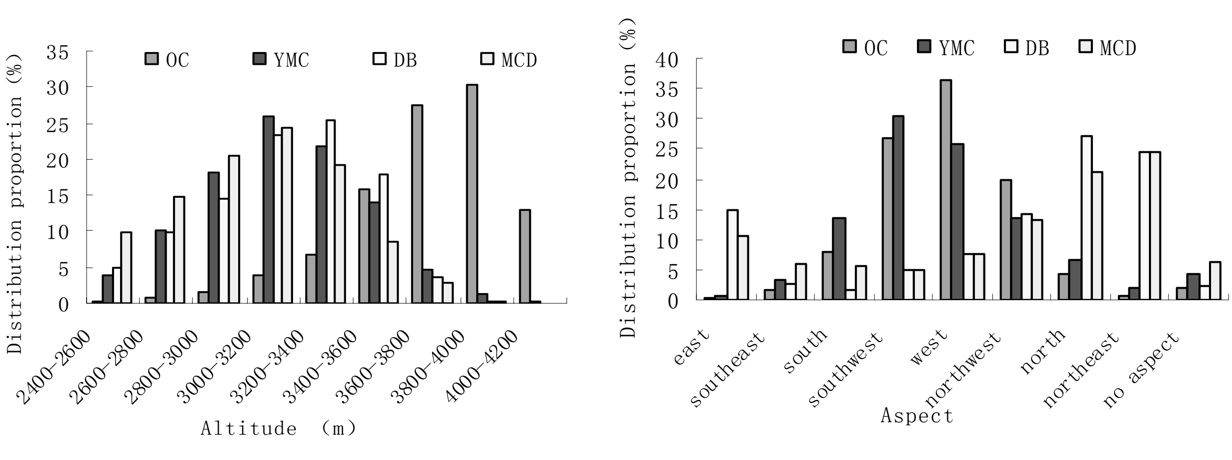
Results and discussion

The community and regeneration characteristic of four forest vegetation types is in Table 1.

Table 1. The community and regeneration characteristic of four types

Forest type	Community and characteristic	Cutting and regeneration history	Regeneration characteristic
OC	*A. faxoniana* forest, mixed forest with *Picea purpurea* and *A. faxoniana*, mail storey 20-40 meter high, older than 150 years	No cutting, primary forest with natural regeneration	Dominant with *A. faxoniana* in different ages and diameter breast height, but the seeding lower than 1m is less.
YMC	*P. asperata* forest, main storey 5-25 meter high, 15-50 years old	Clear cutting, artificial regeneration with *P. asperata* in different time between 1955 and 1990	The stands are from plantation, with same ages and with individual differentiation. No seeding of the coniferous
DB	*Betula albo-sinensis* forest, *Populus davidiana* forest, *Betula platyphylla* forest, main storey 15-25 meter high, 15-50 years old	Clear cutting, artificial regeneration with *P. asperata* in early time, usually between 1955 and 1970	Natural regeneration has replaced the plantation, the seeding of the coniferous is less.
MCD	Mixed forest between *B. albo-sinensis* and *A. faxoniana*, *Picea spp*., or *Tsuga chinensis*, the deciduous 15-25 meter high in main storey, the coniferous in secondary or under storey.	Clear cutting, artificial regeneration with *P. asperata* between 1955 and 1990	The deciduous from natural regeneration grow fast and become the main storey. The coniferous in some community are from natural regeneration of remaining mother tree and have different ages and diameter breast height, but those in others are from plantation degenerating gradually.

Figure 1. The distribution proportion of four types in altitude and aspect



Elevation and slope aspect are most important factors influencing forest landscape distribution and natural regeneration pattern (Fig.1). Young and middle age spruce forest through artificial regeneration was successfully established in southwest and west aspect at the elevation between 2800 and 3600m, but it failed in north aspect at the elevation between 2400 and 3600m, instead, natural secondary regenerated forest composed of deciduous broadleaf tree species and mixed conifer/deciduous broadleaf forests occurred on clear cutting sites after 30 or 40 years succession. It was found that the remaining old-growth spruce/fir forest mostly distributed adjacent to tree line at the high elevation.

The above analyses showed that spruce was appropriate to be planed in southwest/west aspect at the elevation between 2800 and 3600m, but it was not suitable to north aspect. Before clear cutting, fir and hemlock occupied the north aspect (Youxu Jiang, 1963b). Now days, they have regenerated naturally in the sites with remaining mother tree and become the mixed conifer/deciduous broadleaf forests. Fir and hemlock may be appropriate species to grow in north aspect. According to their distribution characteristic in elevation, fir is appropriate to grow at the elevation between 2800 and 3800m, and hemlock between 2200 and 3000m (Yupo Yang and Chenbiao Li, 1992). Natural regeneration was encouraged when possible, while artificial regeneration can only be applied as complementary measure when natural regeneration was inadequate.

References

Chengbiao Li, 1990, Ecological Research on Sichuan Forest,3-44,Chengdu: Sichuan Sci.& Tec. Press
Youxu. Jiang, 1963a, Scientia Silvae Sinicae 8:321-335
Youxu. Jiang, 1963b, Acta phytoecologica et Geobotanica Sinica, 1:42-50
Yupo Yang and Chengbiao Li,1992, Forest in Sichuan, 196,386, Beijing: Chi. For. Press
Yan Wu, Qing Liu *etc*, 2001, Acta Phytoecologica Sinica, 25:648-655

Acknowledgements

Supported by NKBRSF□PR China, No. 2002CB111504, the Outstanding Young Scientist Program of National Natural Science Foundation of China (No.:30125036) and China National Scientific and Technical Key Project (No.:2001BA510B06).

SILVICULTURAL SYSTEMS FOR NON-TRADITIONAL AND MULTIPLE OBJECTIVES: EXPLORING ALTERNATIVES

James N. Long[1] and Scott D. Roberts[2]

[1]College of Natural Resources, Utah State University, Logan, UT, 84322-5230, USA
Tel: +1-435-797-2574 E-mail: fakpb@cc.usu.edu
[2]Department of Forestry, Mississippi State University
Mississippi State, MS, USA

Introduction

Increasingly, forest managers are being called upon to achieve stand-level objectives outside the realm of existing silvicultural experience. Objectives can be ambiguous and are sometimes mutually. The systematic development and analysis of silvicultural alternatives can be an effective way to identify challenges and inconsistencies, and to ultimately refine and focus management objectives. While our thesis is intuitive, this approach is not often formally followed to facilitate effective development and comparison of alternatives.

Methodology

Design of a silvicultural system should begin with careful characterization of the goals-objectives-evaluation criteria hierarchy. Goals relate to general management direction and may apply at scales ranging from a single stand to a complete landscape or ownership. Objectives represent more precise characterizations of general goals. They have a stronger tie to the stand level and are more specific with respect to desired outcomes. Evaluation criteria, which are often quantitative, are even more focused and specific with respect to desired outcomes. For example, depending on the objective, evaluation criteria may specify, using appropriate metrics, desired future stand structure, species composition, or an ecological process such as fire behavior. Carefully chosen evaluation criteria will highlight important differences between silvicultural alternatives. Difficulty in specifying appropriate evaluation criteria may serve to focus attention on ambiguous or otherwise poorly characterized objectives.

Comparison of alternatives must, of course, be done over an appropriate planning horizon (e.g., decades). It is therefore necessary to project stand structure and composition into the future. The projection does not have to be perfect, but it does have to be reasonable with respect to the basic elements of the analysis represented by the evaluation criteria. The Forest Vegetation Simulator (FVS) is a distance-independent individual tree growth and yield model that is extensively used in the United States. Local growth information is used to customize modeled growth relationships, and variants exist for nearly all of the United States. FVS can project stand structure and composition for a variety of forest types and stand structures, including multi-cohort and multi-species stands. A key use of FVS is predicting how alternative management practices might affect future stand structure and composition and, indirectly, how these changes might influence resource values of interest, e.g., wildlife habitat, or susceptibility to catastrophic fire or insect outbreak.

Results and discussion

We illustrate our approach with three examples each of which illustrates potential conflicts among stand management goals. The first example involves production management of loblolly pine (*Pinus taeda* L.) forests of the southeastern United States. This is a simple and straightforward illustration of our approach with the goal to maximize some measure of economic yield. While economic yield can be a complicated factor to assess, in its simplest sense it is a function of volume of wood produced, the value per unit volume, and the time it takes to produce that volume. Of course, production costs are also an important consideration. A primary role of the silviculturist, therefore, is often to develop prescriptions that provide the best combination of total yield and product value within a reasonable rotation length.

We have specified two objectives common to many commercial forestry operations. The first is to capture most, if not all, of the site's production capacity, thus assuring high yield. The second objective is to produce large, high-value sawlogs. Sawtimber value is, in large part, a function of tree size, and therefore an objective is to produce a large average tree size to capitalize on high value per unit volume.

Management of stand density is strongly influenced by growth-growing stock relations. The relationships between tree and stand growth and relative density are fundamental to understanding responses to silvicultural practices, particularly those involving thinning and density of regeneration. At relative densities lower than the threshold of competition, tree growth is maximized for a given combination of species, age, and site quality; at these low relative density, however, stand growth will be substantially below its potential. In contrast, at high relative density stand growth approaches its potential but is associated with slow individual tree growth. At very high relative density net stand growth declines with the onset of self-thinning.

We specify four criteria with which to compare alternative silvicultural alternatives designed to achieve the objectives: 1) total yield (m^3 ha^{-1} yr^{-1}); 2) mean annual increment (m^3 ha^{-1} yr^{-1}); 3) quadratic mean stem diameter (cm) at end-of-rotation; and 4) rotation length (yr). We use mean stem diameter as a surrogate for value per unit volume at the end of the rotation; although another approach to evaluating this objective would be to examine the distribution of yield within the various size/product classes.

We compare two alternatives, developed in the context of growth-growing stock relations, with SDI used to characterize relative density and guide density management. The prescriptions were simulated using FVS, and the results of the simulations evaluated by the criteria. One alternative is intended to capture a high proportion of the site=s potential growth. This involves planting sufficient trees to set up an early commercial thinning and using a series of thinnings to maintaining SDI between the lower limit of full site occupancy and the onset of self-thinning. The second alternative favors rapid individual tree growth by planting fewer trees and maintaining lower relative densities throughout the rotation.

Comparison of the evaluation criteria makes clear that the two objectives, while not necessarily mutually exclusive, do represent substantial tradeoffs. The system intended to produce large, high-valued trees in a relative short rotation will do so at the cost of lower yield and reduced MAI. As illustrated in this fairly simply example, specifying criteria with which to evaluate each objective, and modeling alternative systems through time provided a clear view of the tradeoffs between individual tree and total stand growth.

Our next example is for a young, naturally regenerated lodgepole pine (*Pinus contorta* var. *latifolia* Dougl. ex. Loud.) stand in northern Utah. General goals are to provide future nesting habitat for northern goshawk (*Accipiter gentilis* L.) and minimize stand susceptibility to mountain pine beetle (*Dendroctonus ponderosae* Hopkins). For nest stands, northern goshawks are undemanding with respect to tree species; however, they have fairly exacting requirements for relative density. The goal to provide future stand structure consistent with northern goshawk nest stand requirements is, therefore, specified with objectives relating to overstory and understory density. Susceptibility to attack of lodgepole pine stands by MPB is also influenced by relative density.

A challenge in developing a silvicultural system that simultaneously accomplishes both general goals is that when trees are big enough to support a goshawk nest (i.e., 25 cm), they are also large enough to be susceptible to MPB attack. A more serious challenge results from the fact that the range of relative densities appropriate for goshawk nest stands and the range of relative densities associated with increased susceptibility to attack by MPB to a large degree overlap. Fortunately, the overlap is not complete.

FVS facilitates an assessment of a series of thinnings intended to accomplish both goals. Our analysis suggests that producing future northern goshawk nest stands which are not overly susceptible to catastrophic loss to MPB is at least technically feasible. Accomplishing these objectives, however, will require great care in implementing the silvicultural system. Timely thinning will be required to maintain the overstory within the desired range of relative density and timely retreatment of the understory will be required to maintain an open understory.

Our final example is a mixed-conifer stand located in the Sierra Nevada Mountains of northern California. One goal for this stand is to restore to stand structure and composition historically maintained by frequent, low-intensity wildfires. The second goal is to minimize risk of catastrophic wildfire. The restoration goal is reflected in an objective involving the maintenance of a stand dominated by relatively few, large, early seral trees with evaluation criteria specifying the range of relative densities and the size, number, and species of trees in the overstory. The fire behavior goal is specified with objectives and evaluation criteria relating to potential flame lengths and crown fire behavior.

We use the Fuels and Fire Extension (FFE) to FVS to compare several alternatives involving various combinations of thinning and prescribed burning. A constraint on the thinning prescriptions, however, is a prohibition on harvesting of trees larger than 75 cm dbh. An important result of the analysis is the absolute necessity to periodically retreat the understory in order to prevent natural regeneration from rapidly rebuilding ladder fuels that can result in unacceptable fire behavior. A second important result is the impossibility of reducing relative density to even the upper end of the desired range as a consequence of the restrictions on harvesting large tree.

The examples illustrate how systematic development and careful evaluation of silvicultural alternatives can be an effective way to identify potentially conflicting goals and objectives, and to ultimately refine and refocus management objectives. Realistic projections also allow assessment of how constraints, such as a prohibition on removal of large trees or restrictions on use of prescribed fire, might impact accomplishment of objectives.

IMPACT OF SELECTIVE LOGGING ON MATING SYSTEM AND GENE FLOW OF A TROPICAL RAIN FOREST SPECIES.

Mathieu Lourmas* and Marie-Hélène Chevallier

[1] CIRAD Forestry Department, UMR Cefe-Cnrs, 1919 route de Mende,
34293 Montpellier cedex 5, Tel: +33 4 67 61 32 62; *E-mail: lourmas@cefe.cnrs-mop.fr

Introduction

Conservation of genetic variability of tropical trees is an important aspect in sustainable management of forest. In tropical rain forests, most silvicultural pratices are based upon selective logging which alters genetic and demographic processes such as loss of genetic variability for adaptative evolution, random fixation of deleterious mutations or alleles by genetic drift, and inbreeding depression (Alvarez-Buylla *et al*. 1996; Barrett and Kohn 1991). Selective logging consists of removing mature trees leading to changes in the density and the spatial distribution of the reproductive trees, and the mating system. Consequently, the composition of the male and female pools, self-crossing rates and gene flow could be perturbed (Konuma *et al*., 2000; White *et al*., 2002). We assume that pollination occurs mainly between proximal trees. Our hypotheses are that logging, by reducing the density of effective reproductive trees, may modify the selfing rate as well as the average pollination distance and the genetic drift. We tested those hypotheses in the African mahogany, Sapelli (*Entandrophragma cylindricum* (Sprague) Sprague, Meliaceae) using four microsatellite nuclear markers.

Methodology

We analysed two samples of seeds from the same stand located in a Cameroonian rain forest that were collected before (2002) and after (2003) logging activities (see table 1 for details). For each sample, an average of 15-20 mother trees and 10-25 seeds per mother were collected. We characterized the mating system and gene flow before and after logging by reconstructing parental links with paternity tests using the software FaMoz (Gerber *et al*., 2003), assumed that all the trees (potential fathers) inside the stand were mapped and genotyped with four discriminate microsatellites.

Results and Discussion

Characterisation of mating system and mean pollination distances inside the stand are recorded in Table 1. We divided the total gene flow into two different components: gene flow from inside the stand when it was possible to identify the father tree inside the stand and gene flow from outside the stand in the other cases. On average, the level of gene flow received from inside the stand amounted to 31% in 2002 and to 23% in 2003. 78 trees participated as pollen donors in 2002 and 87 in 2003.

Table 1 : Characterisation of the mating system and gene flow

	No. of mother trees / total no. of trees	No. of analysed seeds	Gene flow inside the stand / No. identified fathers	average diameter of father trees inside the stand	self - fertilisation rate	Mean pollination distance inside the stand
Before logging	15/152	255	31%/78	88 cm dbh	3.1%	326 m
After logging	20/113	373	23%/87	80 cm dbh	1.6%	287 m

The rate of self-fertilisation was low even after logging and the average distance of pollination inside the stand decreased. The number of identified male parents increased in the distance class from >0 to 50m (Figure 1).

Figure 1: Distributions of identified male parents in function of distance classes inside the stand.

The geographic distribution of pollen donors are presented for 15 maternal trees before logging and for 20 maternal trees after logging (Figure 2).

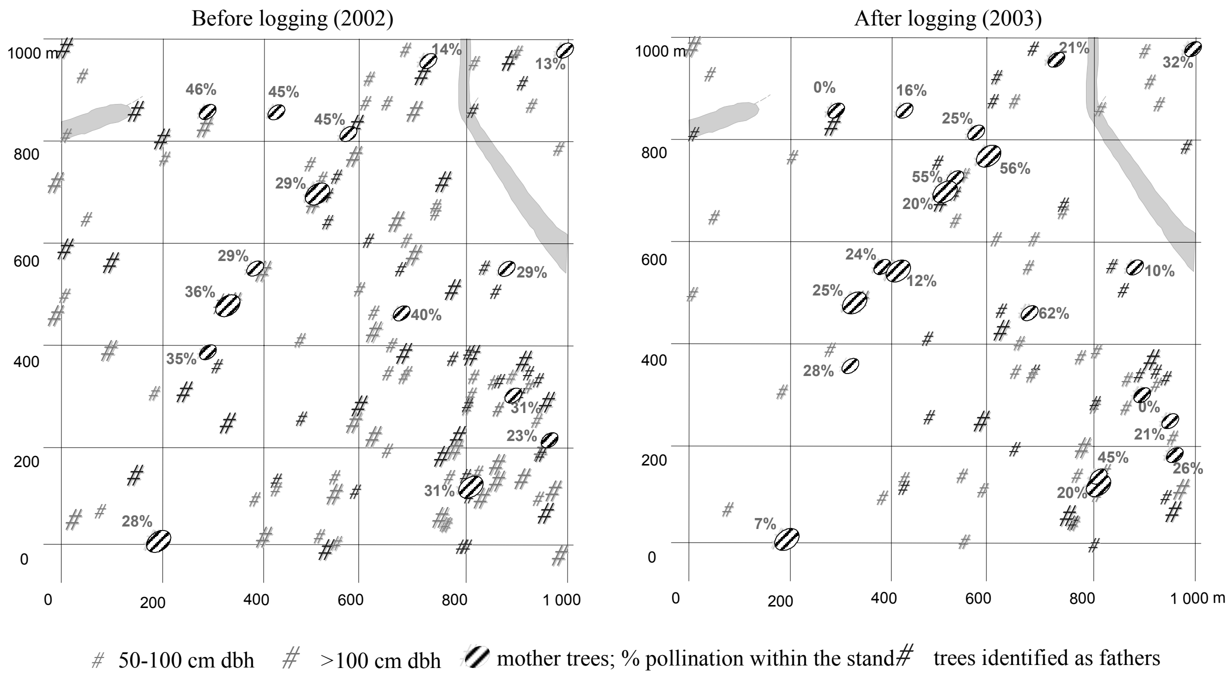


Figure 2: Map of the study stand before (2002) and after logging (2003). The locations of the trees sampled for paternity analysis and trees identified as fathers are given.

We found that gene flow coming from outside the stand varied from 54% to 87% before logging and from 38% to 100% after logging. This result is depending on the mother but it seems to be independent of the geographical location of the mother tree in the stand

Microsatellite markers appeared to be powerful tools for tracing pollen flow in a Cameroonian forest stand before and after selective logging for Sapelli, and thus to define recommendations for *in situ* conservation of the species. According to Kitamura et al. (1994) and Wickneswari et al. (2000) results show that overall outcrossing rate was high and that logging has no clear impact on the amount of selfing. We found also that selective logging increases gene flow from outside the stand indicating that pollen can move over long distances, maybe due to a an adaptative behavior of the pollinator (White et al., 2002). We need further studies on the reproduction biology of Sapelli and especially on its pollinators in order to better understand the impact of logging on gene flow. In conclusion, our results show that a single logging event in a Cameroonian forest did not cause severe changes in the genetic diversity (Lourmas et al., submitted) and in the mating system of Sapelli. Thus, selective logging seems to be a suitable strategy to ensure the sustainable use of Sapelli.

References

Alvarez-Buylla ER, Garcia-Barrios R, Lara-Moreno C, and Martinez-Ramos M.1996. *Annu Rev Ecol Sys* 27**:**387-421.

Barrett SCH and Kohn JR. 1991. *In* 'Genetics and conservation of rare plants'. (Eds DA Falk and KF Holsinger):3-30.

Gerber S, Chabrier P and Kremer A. 2003. *Mol Ecol Notes* 3**:**479-481.

Kitamura K, Mohamad Y, Ochiai O and Yoshimura H. 1994. *Pl Sp Biol*.9: 37-41.

Konuma A, Tsumura Y, Lee CT, Lee SL and Okuda T. 2000. *Mol Ecol* 9:1843-1852.

Lourmas M, Garcia F, Joly HI, and Chevallier MH. *Mol Ecol (submitted)*

White GM, Boshier DH and Powell W. 2002. *P Natl Acad Sc USA* 99**:**2038-2042.

Wickneswari R, Lee CT, Norwati M, and Boyle TJB. *In* Forest genetics and sustainability (Mathyas C ed): 171-181.

MODELLING AS A FOREST MANAGEMENT DECISION TOOL IN RESPONSE TO CLIMATE CHANGE – REGIONAL IMPACTS OF CLIMATE CHANGE ON WOOD PRODUCTION AND CARBON STORAGE IN TEMPERATE FORESTS

Denis Loustau, Alexandre Bosc, Antoine Colin, Jérôme Ogée, (1)
Michel Déqué, Emmanuel Cloppet, (2)
Dominique Arrouays, Christine Le Bas, Nicolas Saby, (3)
Gérôme Pignard, Nabila Hamza, (4)
Christophe François, Eric Dufrêne, Hendrik Davi, Kamel Soudani, (5)
Nicolas Viovy, Philippe Ciais, (6)
André Granier, Nathalie Breda, Vincent Badeau, Jean-Luc Dupouey, (7)
Marie-Laure Desprez-Loustau, Benoit Marçais, Cécile Robin, (8)
Richard Joffre & Serge Rambal (9).

(1) INRA-Ephyse 69 route d'Arcachon, 33612 Gazinet cédex, France. Tel. +33 5 57 12 28 51
loustau@pierroton.inra.fr
(2) CNRM - Météo France, Toulouse, France.
(3) INRA Infosol, Orléans, France.
(4) IFN, Evaluation de la Ressource, Montpellier, France.
(5) Ecologie Végétale, Université D'Orsay-Paris XI, Orsay, France.
(6) CEA- LSCE, Saclay, France.
(7) INRA-Ecologie, Nancy, France.
(8) INRA-Pathologie Forestière, Bordeaux and Nancy, France.
(9) CEFE, CNRS Montpellier, France.

Introduction

Global change affects the local forest environment through rapid changes in carbon and water resources availability, temperature and air humidity and indirect effects on nitrogen and nutrient cycles. interaction between climate and local site characteristics are most probable but, until recently, large scale climate scenarios had a too coarse spatial resolution for allowing these interactions to be analysed. Today, the scientific understanding of the effects of the accumulation of greenhouse gases in the atmosphere on climate together with the recent progress in climate modelling makes it possible to obtain plausible scenarios of climate at the subregional level. Combined with models which summarise our knowledge of the sensitivity to climate and greenhouse gases of the main plant species composing temperate forest canopies, this enables us to analyse the potential impacts of climate scenarios on forest growth, hydrology and production as well as the geographical distribution and tree-pathogens interactions. This communication presents the results obtained in the case of the French forests in plains, the northern broadleaved forests (*Fagus* and *Quercus*) and atlantic southern pine forest (*Pinus pinaster* ait.) and discussed the potential of forest management to adapt forests to the climate scenario.

Methodology

We have modelled the regional impacts of climate change and forest management scenarios on wood production, forest carbon balance and hydrology as well as tree species distribution and some fungi pathogens in French forests in the plains as follows. We combined three data sources: a climate scenario, a forest inventory and a soil network survey. These data were aggregated over a 50x50 km grid, i.e. the spatial resolution of the climate data, and were implemented in process-based models of forest carbon balance and growth to predict the impact of climate change at the sub-regional scale on forest hydrology, carbon balance and wood production (fig. 1). In addition, three options of forest management were analysed, a *business as usual* scenario, a *short rotation* scenario and a *long rotation* scenario. Forest growth, carbon balance and hydrology were then simulated using process based models previously evaluated using observed data.

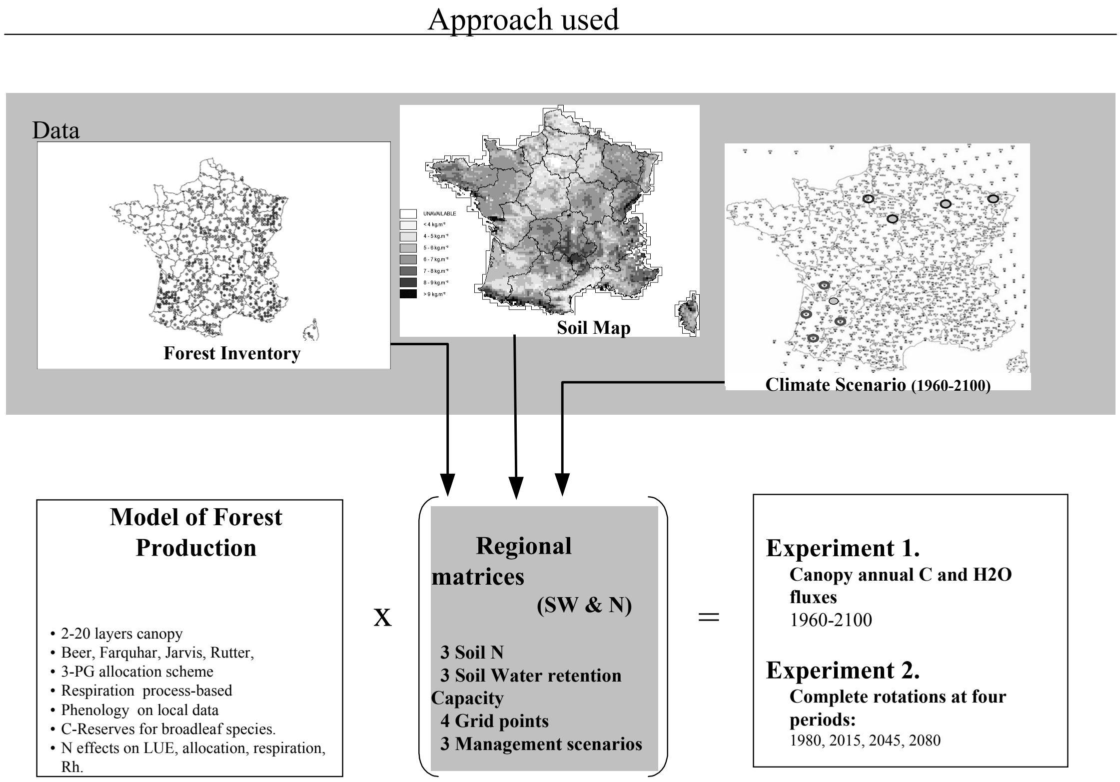


Figure 1. Modelling approach used.

Results and discussion

In order to disentangle the age, management and site effects from the climate effects, two simulation experiments were achieved.

First, we predicted and analysed the climate impact on the long-term trend in the potential production of a mature forest over the period 1960-2100. All models used predicted a slight increase until 2030-2050 followed by a plateau or a declining phase 2050-2100 with strong geographical variations. In northern broadleaved forests, the primary productivity and wood production were less positively affected in the western Atlantic side than in the eastern continental part due to soil water and air water vapour saturation deficits (Fig. 2). This longitudinal gradient was reversed in the Southern forests where the increase in atmospheric and soil water deficits in the continental zone overcompensated the CO_2 fertilising effect and depleted the net primary production.

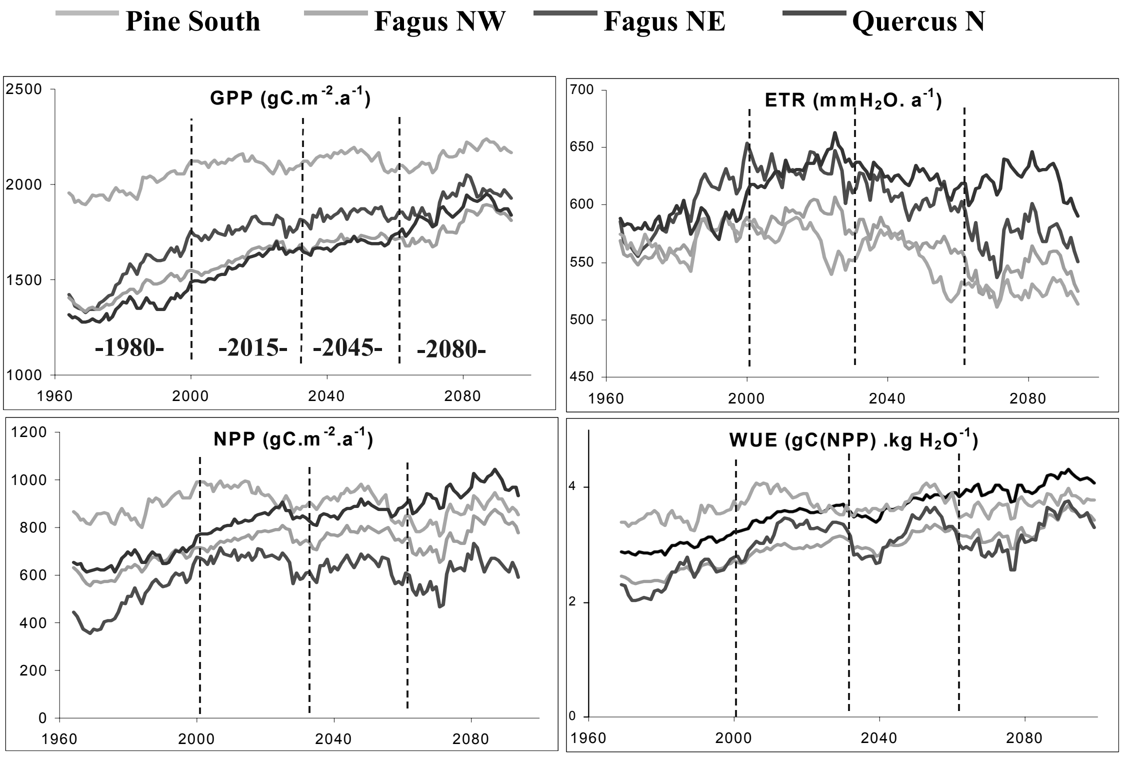


Figure 2. Annual gross primary production (GPP) , evapotranspiration (ETR), net primary production (NPP) and water use efficiency (WUE) from1960 to 2100 (10yr moving averages) showing the geographical and species interactions with the climate scenario.

Second, we estimated the water and carbon balances of the entire forest rotation for the 3 forest management options considered under four climate periods, i.e. 1980, 2015, 2045 and 2080. Predictions were made using multidimensional matrices covering the range of local soil and climate conditions allowing the results to be included in GIS and projected on regional and national maps. The results show significant interaction with site fertility and soil water holding capacity: the most fertile sites were more affected by the opposite impacts of increasing [CO_2] and water deficits than the less fertile (fig. 3). Management scenarios were differentially affected by the climate scenarios: the short rotation scenario was generally more responsive to climate effects than the longer ones. These interactions were particularly important in the southern pine forests as compared with the northern broadleaved forests.

Several conclusions are drawn from this exercise.

- the respective site, age and management effects can be made explicit when simulating effects of a given change in environment on forest functioning.
- operational recommendations for adapting forests to the change in climate need rare events such as extreme temperatures, windstorm and drought to be more accurately described at the sub-regional level.

- for regions exposed to a predicted increase in soil and atmospheric water deficit, the management strategy of water resources at the landscape and watershed levels must consider the water requirements of forests.
- a quantitative enhancement of the availability of belowground resources per individu is a key issue for adapting forest stands to climate change in sites prone to water or nutrient deficits, e.g. soil preparation techniques allowing a larger and deeper soil volume to be exploited by individual tree root system must be considered.
- species substitution by southern vicariants must be planned in relationship with climate monitoring.

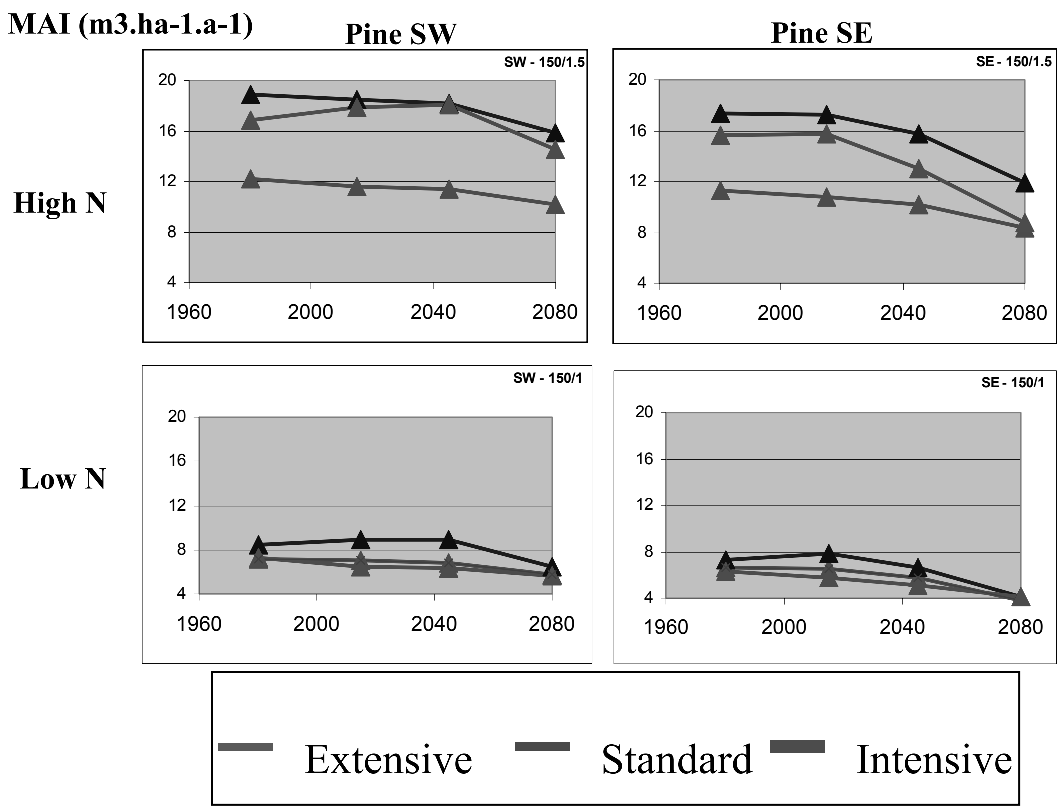


Figure 3. Example of rotation predictions. Mean annual increment (MAI) of entire rotations accordingto soil fertility (High N and Low N) for maritime pine in southwestern France.

Acknowledgements.

The CARBOFOR project was co-funded by the GICC (MEDD) and GIP Ecofor (MAP) and involves 14 laboratories from INRA, CIRAD, CNRS, IFN, CEA, Universities of Paris XI and Orléans and Météo-France.

BEECH SILVICULTURE WORLDWIDE – PRESENT AIMS AND FUTURE CHALLENGES

Palle Madsen[1], Khosro Sagheb-Talebi[2] and Kazuhiko Terazawa[3], Robert Rogers[4] and Katrine Hahn[5]

[1] Danish Centre for Forest, Landscape and Planning, KVL, Kvak Møllevej 31, DK-7100 Vejle, Denmark. Tel: +45 75 88 22 11; E-mail: pam@kvl.dk
[2] Forest Research Division, Research Institute of Forests & Rangelands, Iran
[3] Division of Forest Environment, Hokkaido Forestry Research Institute, Japan
[4] Robert Rogers, College of Natural Resources, University of Wisconsin, USA
[5] Danish Centre for Forest, Landscape and Planning, KVL, Denmark

Introduction

In this paper we focus on the present aims and future challenges of beech silviculture worldwide. We analyse the present situation of beech silviculture, and try giving 'guestimates' of how and in which directions future beech silviculture may evolve. The paper is based on case studies from four important beech forest regions; *Fagus sylvatica* (L.) in Europe, *Fagus grandifolia* (Ehrh.) in north-east America, *Fagus orientalis* (Lipsky) in west-Asia, and *Fagus crenata* (Bl.) in Japan.

The RG 1.10.00, Improvement and Silviculture of Beech, recently organized the 7[th] International Beech Symposium in Tehran, Iran. In conclusion the RG decided to use the group network to accumulate knowledge and develop a framework to support the overview of present and future beech silviculture. Consequently, this paper only present our first steps in a process that strives to create such overview, and we will highly appreciate input and co-operation with other IUFRO RG's and WP's.

The present state and distribution of beech woodland is a product of both natural processes (glaciation, climate changes, migration etc.) and human induced activities (woodland utilization and clearing, domestic stock, game management etc.) leading to changes in forest cover and species composition (e.g. Björse and Bradshaw, 2000; Farrell et al., 2000; Hahn and Fanta, 2001; Hannon et al., 2000; Peters, 1997; Sagheb-Talebi and Schütz, 2002; Stanturf and Madsen, 2002). Beech forests in all four regions have been subject to human use for very long times, by both indigenous people and later settlements. In Europe and west-Asia, beech forests have been used by local people for very long times, whereas in the human impact in northeast America and Japan is characterised by a long history of low-intensity use by indigenous people, but a short history of recent and intensive use. For each region we aim to give an overview of past and present distribution of beech forests, migration history, hybridisation, ecological ranges, site characteristics, climate, co-dominant species, main beech forest types, human impact, and naturalness at local and regional scale.

Well known examples of past utilisation, which has significantly influenced the extent, structure, and species composition of beech forests, include slash-and-burn culture, wood pastures, mast pigs, coppice and pollarding, charcoal production and small dimension wood. At present, timber prises, policy instruments and subsidies influence beech silviculture dramatically in some regions, whereas the need for wood products and forest cover are major issues in other regions. These main types of beech silviculture (local/regional/worldwide) have had a strong impact on species composition and stand structure (diameter distribution, dead wood, stem density, site index, etc.).

Methodology

The development over time will be described by use of the three main historical periods; pre-industrial period (= exploitation), industrial period (= wood production), and modern time (= multi-purpose forestry).

Two of the presently hottest and inter-related topics in beech silviculture and research are 'gap-regeneration' and 'natural disturbance regimes'. These topics will be given special attention in the analyses, including regional disturbance patterns, gap size distribution, species response to gap formation, and interactions between forest structure and ground vegetation.

The future challenges of beech silviculture can be summarised as multiple aims combined with constantly changing priorities. Therefore we need to go one step further and ask questions as:

- Does beech silviculture and forestry meet the present management objectives?
- What are the changes in objectives, policies and regulations?
- What are and what will be the main challenges for beech silviculture?
- What do we need to know to meet these challenges?
- How can research contribute to solve the new challenges?

This means that future beech silviculture and research needs to meet the different requirements from four different stakeholders:

1. Government (legislation and certification)
2. Forest owners and managers
3. NGO's
4. Public demands.

Results and discussion

We will outline the challenges of multiple and opposite demands, various principles for solutions, benefits of close interaction between researchers and managers, and identification of topics where current knowledge is insufficient and should be addressed through future research. The case will made for studies of red heart formation in beech wood which, from a wood production perspective, is primarily solved through shortening the rotation period, while biodiversity requirements in beech forests would demand a lengthening of the rotation age.

In conclusion, beech silviculture research may seem from a classical scientific point of view to be a well-defined scientific field. However, exploring the complex challenges of beech silviculture reveals needs for close co-operation with other scientific disciplines as well as end-users and other stakeholders in order to meet the real-world challenges and support proper implementation of useful new knowledge gained through research.

References

Björse, G., and Bradshaw, R.1998. 2000 years of forest dynamics in southern Sweden: suggestions for forest management, Forest Ecology and Management, 104, 15-.

Farrell, E.P., Führer, E., Ryan, D., Andersson, F., Hüttl, R. and Piussi, P. 2000. European forest ecosystems: building the future on the legacy of the past. Forest Ecology and Management 132, 5-20.

Hahn, K. and Fanta, J. (eds.) 2001. Contemporary beech forest management in Europe. Deliverable 4 of the NatMan project. Available at www.flec.kvl.dk/natman, 175 pp.

Hannon, G. Bradshaw, R. and Emborg, J. 2000. 6000 years of forest dynamics in Suserup Skov, a seminatural Danish woodland, Global Ecology & Biogeography, 9, 101-.

Peters, R. 1997. Beech forests. Kluwer Academic Publishers. 169 pp.

Sagheb-Talebi, K. and Schütz, J.-P. 2002. The structure of natural oriental beech (*Fagus orientalis*) forests in the Caspian region of Iran and potential for the application of the group selection system. Forestry 75, 4, 465-472.

Stanturf, J., and Madsen, P., 2002. Restoration concepts for temperate and boreal forests of North America and Western Europe, Plant Biosystems, 136, 2, 143.

LANDSCAPE BASED FOREST MANAGEMENT - A REAL WORLD CASE

Martin Mendoza[1], J.J. Fajardo[2], and J. Zepeta[2]

[1]Colegio de Postgraduados
Apartado Postal 421, 91700 Veracruz Ver., Mexico
Tel & fax +52 2299 349100; E-mail: mmendoza@colpos.mx
[2]Consultoría Ambiental S.A.

Introduction

In the last two decades landscape ecology has established itself as a dominant explanation of the ecology of the forest. After the major scientific issues have been settled, it is now possible to develop management techniques that use landscape ecology as support in the decision making involving forest resources.

Landscape management is pertinent to the current situation of Mexican natural forests because of the recent concern that public opinion ought to be considered in land management decisions, even tough all forest land is privately owned. Conceptual elements and practical considerations in landscape ecology permit an efficient consideration of public concerns expressed directly by stake holders, or present as issues embedded in the forest planner considerations.

El Llanito, a mixed pine forest in western Mexico, covers3357 ha. In 2003 this forest was selected to be the testing ground for a new silvicultural and managerial approach that followed the theoretical guidelines of landscape ecology.

Methodology

An opinion survey, focused on western Mexico's general public, sought to disclose current opinion about forestry and environment in this region which happens to have a longstanding tradition of private forestry. Opinion trends were compared against attitudes of forest owners and other stakeholder groups, and the outcome was used as evidence of possible interest in new land management directions such as landscape forest management.

The choice of El Llanito as study case was influenced by its relative good natural conditions after half a century of continuous, systematic timber management. Remoteness allowed the forest in El Llanito to remain in near pristine condition up to middle 20th Century. Timber has been harvested from El Llanito in three previous entries, dating back to 1941. The first two entries followed the Mexican management method. This method prescribes selective removals of 35 % up to 50 % of merchantable volume, taken from trees over a minimum diameter of 35 cm. Marking is directed to harvest the largest, oldest, least growing, high risk, damaged, or poorly formed trees. Harvest proceeds sequentially over the length of the forest to complete a cutting cycle of 26 years. The regulation algorithm adjusts harvest intensity to reach a constant annual allowable cut during the cycle. This policy, after two entries, has liquidated most late successional structures, which were considered at that time as worthless surplus standing inventory that eats up space needed for high yield structures. Maintaining a continuous forest cover was an important aim of management policy under the Mexican method.

During the last entry, from 1993 up to 2002, El Llanito forest was managed for conversion to evenaged structures, and its age distribution was driven by regulation policies to eventually achieve a normal forest distribution. This latter policy exacerbated fragmentation, which was already in progress as a result of severe pest and fire incidents. The large structural diversity in stands coming from the Mexican method treatments severely limited the conversion to one story structures during this third entry.

Since 2003, forest planning has been following a new silvicultural regime, one designed to transform current stand structures back to structures like the ones before forest management. A forest plan following the theoretical principles of landscape ecology has been drafted for El Llanito. Theoretical definition of stand structures follow Oliver and Larson (1990), as well as FAO descriptions of stand structure changes through natural succession. Silvicultural treatments were designed to induce artificial successional changes in favor of the least frequent conditions. Protection silviculture from previous management policy was adapted to allow fire and pests to occur unchecked if they appear in the expected successional stage, but controlled otherwise. Harvest regulation follows a mathematical algorithm that uses financial criteria to select treatments that are economically efficient, and comply with occupancy targets for each type of stand structure, while improving fragmentation conditions toward a contiguous forest cover, separated from large permanent openings. Currently, most stands contain young dense, simple structures, in a heavily fragmented geographic pattern. Hence, landscape management intends to reduce fragmentation and edge effects, while increasing frequency and complexity of late successional structures at a rate that makes a measurable change in ecological functions. Sequential silvicultural treatments constitute biopath regimes that seek a prompt development of functional structures similar to late successional natural structures.

Results and Discusion

Public opinion shows a growing concern for land stewardship. Both, rural and urban citizens support rational timber harvesting, but they would like to see greater attention to environment, and other noncommercial forest values. Timber owners and industry perceive that the extra cost and complications in a more socially responsive land management might be acceptable to them if they were viewed as a sign of their commitment for land stewardship, and therefore, a deterrent of additional mandatory regulations.

The landscape management plan for El Llanito has already completed two annual harvest areas, out of ten that makes the cutting cycle prescribed. Most merchantable stands in the study area received light thinning treatments where marking critera attempted to correct the effect of the conversion to evenaged structures. Since today's condition in the forest is full of juvenile exclusion stage, one story stands, most of the two and three story stands were directed to accelerate diversification to eventually perform late successional functions. Enriching species composition was helped by the fact that a number of legally protected species are present (*Podocarpus* sp*., Abies guatemalensis*), and they behave in a rather agresive way competing successfully with the best commercial species (*Pinus douglasiana, P. pseudostrobus,* and *P. montezumae*). Presence of large individuals of many broadleaved species also facilitated diversification.

Areas impacted last decade by fire and pests constitute a sizable reserve of temporary openings that satisfy the need for initiation structures and open areas. Therefore, final harvesting and regeneration treatments have been limited to only one stand of 6 ha. Some of the oldest damaged stands now contain enough regeneration that they helped to increase the total closed forest area beyond the target in the management plan, thus improving fragmentation statistics for the whole forest. This has been especially notable in the nonmerchantable timber stands, which are dominated by oaks and poorly formed pine species such as *P oocarpa* and *P devoniana*.

Some 25 ha have been salvaged. To a great extent, salvage cuts were used in lieu of true regeneration treatments. Their specs were modified so as to secure a sufficient amount of very small clearings inside the canopy closed areas, just like it was also prescribed by the regular final cut treatment. These small openings, or chablis, are expected to eventually fill with incoming regeneration, and they will need to be replaced by removing mature tree groups in other parts of the stand. Should clearings inside the stand be larger than 0.5 ha, and if there were no advance regeneration, then planting completed the cover target; however, natural, spontaneous regeneration has been abundant all around. The actual treatment in final harvest and salvage cuts resembles a rather dense seed tree cut, or a severe shelterwood cut.

Best management practices complemented biopath silvicultural regimes. Best management involves improving road specs regarding drainage, and slope stability. In addition, some roads were closed whenever technically possible, given the improved capability of the logging equipment of today. Sawnlog material is cable logged with a highlead system, while pulpwood is handled manually. Slash disposal and other site prep maneuvers are directed to attain a target fuel loading where fine fuels are disposed off, while coarse materials are kept to regain a level of at least 100 ton/ha.

Specific treatments to riparian zones are also part of best management. Increasing late successional conditions is also a driving force in riparian silviculture. This is done by harvesting competing trees and vegetation around trees with the largest crowns. Harvesting mandates a careful uphill removal of logs, an doing all that is possible to reduce sediment runoff to the channel. Cattle management changed to prevent animals reaching the riparian zones, and slash disposal in and around riparian areas is used to create obstacles that retain sediments, foster dense brush understory, and discourage animals from crossing these areas. A similar regime was designed for ridge conditions to promote wind firm trees.

Early results from the 2003 and 2004 harvests in El Llanito are presented showing some progress towards the target forest, and a reasonable financial and operational performance. Current plan has been able to allocate an annual harvest rate of 5450 m3, similar to the historic rate of the previous cycle, despite considerable losses to pests and fire in the last decade, and without compromising fragmentation improvement goals, nor slowing down recovery of late successional functionality. Landowner is cautiously optimistic, while early responses from the public, forest authorities, and some environmental groups have been favorable.

References

Oliver, Chadwick D., and Bruce C. Larson. 1990. Forest stand dynamics. McGraw-Hill, New York 467 p.

CHARACTERISATION OF FOREST STRUCTURE OF SCOTS PINE STANDS ACROSS A 120-YEAR ROTATION

Fernando Montes* and Isabel Cañellas

Centre for Forest Research. INIA. Ctra. A Coruña km 7,5 28040 Madrid, Spain
*E-mail: fmontes@inia.es

Introduction

Forest structure is a key component of forest ecosystems that has been found related to many fundamental aspects, like stability, production, soil protection or landscape beauty, and it determines the presence of the microclimate conditions of life and the habitat availability of many plants and animals (MacArthur and Mac Arthur 1961; Degraaf 1998; Ferris-Kaan, et al. 1998). Many authors have suggested that forest structure may be used as a surrogate for the capability of forest ecosystems to support biodiversity (Kuuluvainen, et al. 1996, Hunter 1990).

This study is focused to the assessment of structural changes across rotation in managed even aged Scots pine stands. To achieve this objective a chronosequence trial has been established in *Pinar de Valsaín*, a Scots pine (*Pinus sylvestris* L.) forest of the Central mountain range of Spain. Although in *Valsaín* the management system has changed several times, the uniform shelterwood system has been used in a similar way (opening gradually the stand in a more than 20 years period and allowing the regeneration to take place naturally) since the management plan of 1889 (Montes, et al. 2003). Thinning is carried out when the stand has reached the stem exclusion stage, approximately at the age of 40 years. Rotation in *Valsaín* is 120 years, which has not changed since 1889.

Methodology

A plot of 0.5 ha was established for each developmental stage (0-20 years after the regeneration fellings, 20-40, 40-60, 60-80, 80-100 and 100-120). All trees higher than 10 cm of diameter were mapped and those smaller than 10 cm were located in a 2×2 m grid, and their diameter and height was measured. The forest survey samples were used to asses the structure at broader scales. The samples are circular with 9.8 m radio and are located in a 200×200 m grid. Within each sample the diameter of all trees higher than 10 cm was measured and the trees smaller than 10 cm were counted in a 5 m radio subsample.

Height, crown length and diameter differentiation was analysed in each plot using Gadow's differentiation index (Gadow 1993) taking into consideration the three nearest neighbours in the calculations. The spatial pattern of the different height classes and the pair wise distribution of their combinations was analysed using the Ripley's function $K(d)$ (Ripley 1977, Dale 1999) multiplied by n_i / A, being n_i the number of trees of class i and A the surface of the plot and the $L(d)$ function (Besag, 1977, in the discussion of the Ripley's paper). To assess the global structure the semivariograms of the local densities classifying the trees in diameter classes and the spatial correlation between the different classes were analysed.

Results and discussion

In our chronosequence, differentiation at microstructure level decreases with the time, peaking at the shelter phase but dropping noticeably after the first thinning, i. e. in the 40-60 years old plot. The similar values of Gadow differentiation index obtained in other studies for Scots pine (Kint 2003) could indicate that microstructure is mainly linked to intraspecific competition, which would act in a similar way for the same species everywhere.

The analysis of the Ripley's function $K(d)$ gives a cluster spatial arrangement of stems more than 10 cm of diameter in the first stages of the stand that smoothes along the chronosequence although remains at least till 120 years after establishment of the stand. The regular pattern commonly found in short distances in managed forests (Kuuluvainen 1996) hasn't been found in Valsaín.

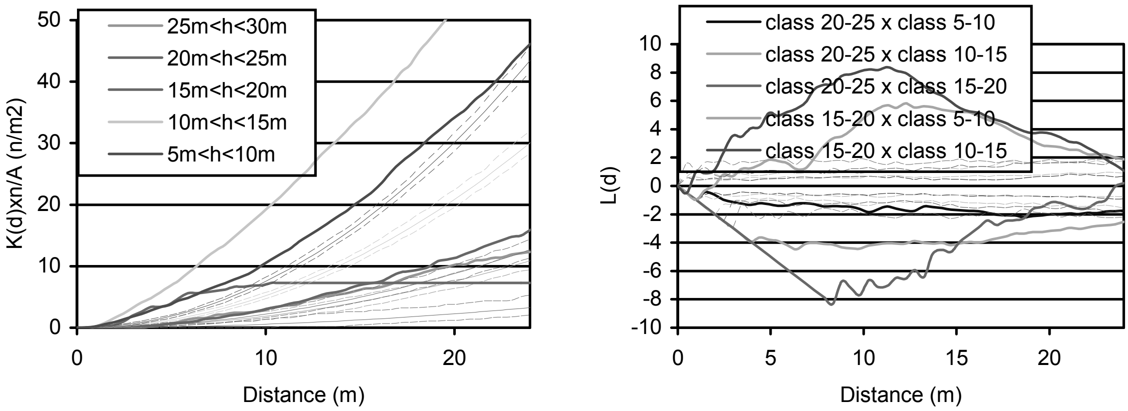


Figure 1. Analysis of the function *K(d)* for the different height classes and the function *L(d)* for the interclasses distributions in the plot 1 (the shelter phase just finishing)

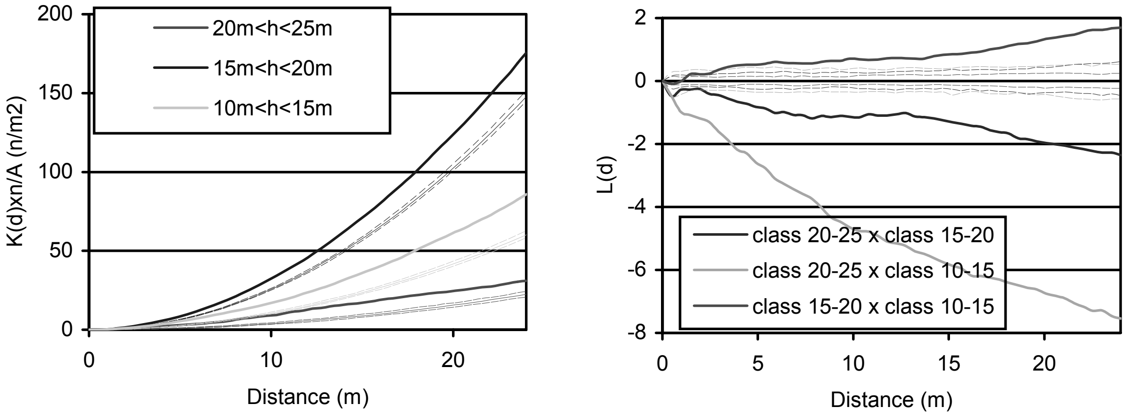


Figure 2. Analysis of the function K(d) for the different height classes and the function L(d) for the interclasses distribution in the plot 3 (40-60 years old)

The spatial pattern of the different height classes within the stand for the plots 1 (just at the finish of the shelter phase) and 3 (stand 40-60 years old) is analysed in the figures 1 and 2 respectively. The function $K(d)\cdot(n_i/A)$ for each height class is plotted in the left graph. For each curve there is represented in dotted lines the upper and the lower 95% confidence boundaries of the random distribution. When the curve falls above the upper boundary the distribution is cluster. All the classes show cluster pattern at the analysed scale (up to 25 m), although the range of the cluster seems to be approximately this distance for the higher class and the regeneration between 5 and 10 m height in the plot 1. These graphs show the differences in number of trees per area unit among the different diameter classes. The function *L(d)* for the pair wise distribution of the different height classes is plotted in the right. When the function *L(d)* falls above the upper boundary of the confidence interval the two classes are aggregated in the space. In plot 1 the lower height classes tend to occupy the space where there isn't trees of the higher class up to approximately the maximum distance of the analysis. Moeur (Moeur 1993) reports similar results for Western hemlock dominated old growth forest in

Idaho, US. The spatial exclusion of trees of different sizes is much more noticeable in the plot 3 (figure 2), 4 and 5, giving arise very regular looking stand.

The use of semivariograms doesn't requires mapped plots, instead the local densities are only required, so seem to be more suitable to asses the spatial structure of very dense strata or to include shrub or herb layer in the analysis. Classifying the trees by diameter the range of the spatial correlation of the density of trees of each diameter class within the stand is higher for the 20-30 cm, 30-40 cm and 40-50 cm (figure 4, left) diameter classes (up to 2000 m) whereas the spatial autocorrelation is very weal for the lower diameter classes (figure 3 right). The analysis of the cross-variograms for the different combinations of diameter classes show a negative spatial correlation between the smaller and the larger classes at distances lower than 800-600 m being positive the autocorrelation between adjacent classes. This results indicates that the regeneration show a great variability throughout the whole forest, although the development of the stand leads to a regularisation at landscape level.

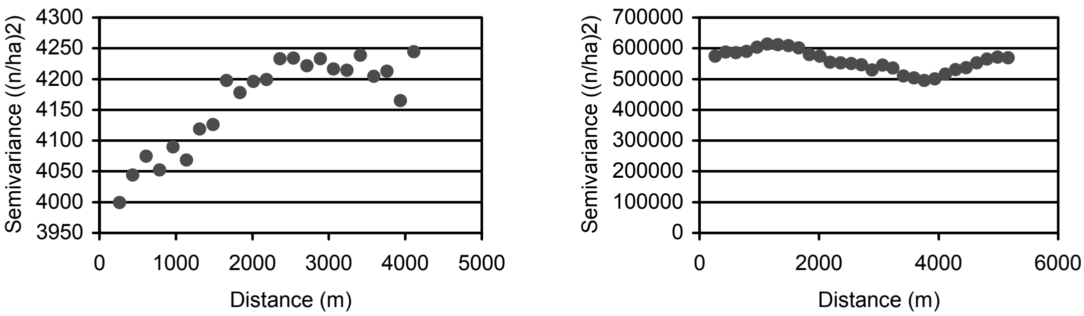


Figure 3. Variograms of the 40-50 cm diameter class (in the left) and the 0-10 cm diameter class.

References

MacArthur, RM and Mac Arthur, JW. 1961. Ecology, 42: 594-598.
Degraaf, RM, Hestbeck, JB, Yamasaki, M. 1998. For. Ecol. Manage., 103: 217-233.
Kuuluvainen, T, Penttinen, A, Leinonen, L and Nygren, M.1996. Silva Fennica, 30: 315-328.
Kint, V. 2003. Thesis of the Faculteit Landbouwkundige en toegepaste biologische wetenschappen. Melle-Gontrode, Belgium.
Montes, F, Sánchez, M, del Río, M and Cañellas, I. 2003. Eds. Lexer, MJ, Vacik H, Rauscher MH, Reynolds KM, Brooks RT. Proccedings of the Decision support for multiple purpose forestry conference. University of Natural Resources and Applied Life Sciences, Vienna, Austria.
Ripley, BD. 1977. J. Royal Statistical Society, 2: 172-212.
Gadow, KV. 1993. Forst und Holz, 21: 601-606.

Acknowledgments

This study was supported by project AGL2000-1545.

RATIONALE FOR DEVELOPING TEAK CLONAL PLANTATIONS

Olivier Monteuuis[1], Doreen K. S. Goh[2] and Henri-Félix Maître[1]

[1] CIRAD-Forêt, TA 10/C, Baillarguet, 34398 Montpellier, Cedex 5, France
Tel: +33-(0)4 6759 3787/36 Fax: 33-(0)4 6759 3733, E-mail: monteuuis@cirad.fr, maitre@cirad.fr
[2] Innoprise Corporation Sdn Bhd., P. O. Box 60793, 91017 Tawau, Sabah, Malaysia.
Tel: +60-89-775-328, Fax: +60-89-762-314, E-mail: dorngoh@pc.jaring.my

Introduction

Despite being the most prized timber species, teak wood supplies represent currently only 1% of the total volume of high value timber used worldwide (Behaghel 1999). Stronger international demands for good quality teak have resulted in an ever-increasing depletion of natural resources which are more and more protected by strict conservation policies aiming at preserving *in situ* biodiversity. This situation has been responsible lately for a basic change in the teak plantation concept. Traditional teak plantations, managed mostly by state organizations and harvested after 60 or 80 years, are no longer adapted to the current context. There is now an increasing demographic pressure on land tenure accounting for an overall intensification of crop productivity (Ball et al. 2000, Nair 2000). The emerging trend is therefore characterized by a stronger involvement of private investors looking for the best returns on investment in the shortest delays. Suitably selected and wisely deployed teak clones appear to be the best options to meet this goal (Behaghel and Monteuuis 1999).

Methodology

Techniques for mass producing teak clones from Plus trees of any age were developed in Sabah in the early 1990's within the framework of a collaboration between Cirad-Forêt and Innoprise Corporation Sdn Bhd, "ICSB" for short (Goh and Monteuuis 1997). Efficient and economically-viable nursery (Monteuuis 1995) or tissue culture (Monteuuis et al. 1998) procedures can be used, depending on the situation. The respective advantages and limitations of the nursery versus in vitro systems have been highlighted elsewhere (Monteuuis 2000).

Trees clonally or bulk-produced from cuttings and microcuttings have been established and assessed since 1994 on ICSB's research areas and various locations within Malaysia as well as countries such as Australia, and in Africa and South America. Concomitantly, rich base populations comprising of various natural provenances and seed-sources have been set up under ICSB for an enhanced selection of superior trees (Goh et al. 2003). These provenance and progeny trials were designed in such a way that the plots can be easily converted to seed production areas for supplying genetically improved quality seeds without inbreeding risks, while at the same time can be considered as *ex situ* biodiversity conservation sites encompassing a very diverse collection of teak origins from around the world

Results and discussion

Clonal mass propagation techniques

In Sabah, where there is no distinct dry season, 450 to 500 rooted cuttings per square meter of properly managed and container-grown stock plants can be produced annually in adapted nursery conditions. Average rooting rates range from 70 to 80% once the rejuvenation process has been achieved for mature selected genotypes – 60 year-old or more (Monteuuis et al. 1995). Applying this procedure, 250,000 cuttings have been produced since 1992 for various uses such as: establishment of demonstration plots, clonal tests, commercial plantations and sale to local clients, demonstrating the efficiency of the developed technique as being totally adapted to the mass production of superior quality teak clones.

Nevertheless, comparative economical analyses had clearly shown that for the production of more than 100,000 cuttings per year, the tissue culture procedures are more efficient. This is particularly true for exporting clones to various oversea clients in absence of any phytosanitation restrictions, contrary to rooted cuttings. About 300,000 vitroplants have so far been produced by the Plant Biotechnology

Laboratory – "PBL" for short - on a pilote scale and shipped to different countries all around the world – Australia, South and Central America, Africa and in South East Asia.

Field behavior of the cuttings and microcuttings-derived plants

Contrary to many forest trees species, teak plants issued from cuttings and microcuttings developed true-to-type in absence of any phenotypic abnormalities – the so-called "C effects" -. Growth rate is impressive in the first years with 3 to 4 meters in height, then the trees increase more in diameter with average annual increment of 2.5 to 3cm. Some of these cutting-issued trees have attained 28-30m in height and 40 cm in diameter 10 years after planting, while measurements of 29m in height and 36cm in diameter were recorded 8 years after planting for microcuttings-derived teak trees.

Investigations underway

Advanced wood characteristic analyses will be used for refining the initial selection based mainly on phenotypic criteria. Possible genotype X site effects on these criteria will be similarly assessed. The networking established among the various buyer countries and on different continents in which the same clones have been introduced appears to be highly enlightening and useful in this respect

Resorting to molecular biology for DNA profiling will allow a better identification of the genotypes and of their genetic relatedness for wiser clonal deployment and seed orchard establishment, thus preventing risks of inbreeding. Another application will be the genotypic characterization through DNA fingerprinting of the clones available for sale, in particular where property rights are concerned.

Prospects

The advantages of developing clonal plantations for teak were advocated since a few years ago (Monteuuis and Goh 1999). Recent promising field results from cuttings or microcuttings- produced teak plants and the noticeable change of mentality as far as timber plantations and land uses are concerned have greatly reinforced this point of view. The possibility to establish fast growing, high wood quality and uniform teak plantations to enhance the yield and the commercial value of this highly prized timber species in the shortest delays should be determining factors for any investors or even land owners. These plantations can be wisely developed as monoculture or agroforestry systems applying proper silvicultural practices. Plant material with narrow crowns will be preferably adapted to agroforestry, with the possibility to get early cash flow from the associated crops, which, especially when legumes, can benefit the teak trees. In view of all these arguments, and aware of the serious limitations of seed-issued planting stock (Monteuuis 2000, Goh and Monteuuis 2001), the clonal option appears to be the best if not the only way to maximize the investments with regard to the establishment of teak plantations, and from a more general standpoint, to land use.

References

Ball J.B., Pandey D., Hirai S. 2000. FORSPA Publication N°24/2000, Teaknet Publication N°3: 11-33.

Behaghel I. 1999. Bois et Forêts des Tropiques. 262: 5-18.

Behaghel I., Monteuuis O. 1999. Bois et Forêts des Tropiques. 261: 70-79.

Goh D., Monteuuis O. 1997. ITTO Tropical Forest Update, 7 (2): 13.

Goh D., Monteuuis O. 2001. Proc. of the Third Regional Seminar on Teak,. 31/7- 4/8/2000, Yogyakarta, Indonésia: 237-247

Goh D., Alloyisus D., Gidiman J., Chan H., Mallet B., Monteuuis O. 2003. Proc.on "Quality timber products of teak from sustainable forest management", Peechi, India, 2-5 Dec., 2003: 281-289.

Monteuuis O. 1995. Proc. of BIO-REFOR, Kangar, Malaisie, 28 Nov. -1er Dec.,1994 : 117-121.

Monteuuis O. 2000. FORSPA Publication N°24/2000, Teaknet Publication N°3: 209-222.

Monteuuis O., Vallauri D., Poupard C., Hazard L., Yusof Y., Wahap Latip A., Garcia C., Chauvière M., 1995. Bois et Forêts des Tropiques, 243 : 25-39.

Monteuuis O., Bon M.-C., Goh D. 1998. Bois et Forêts des Tropiques, 256: 43-53.

Monteuuis O., Goh D. 1999. Bois et Forêts des Tropiques, 261: 28-38.

Nair C.T.S. 2000. FORSPA Publication N°24/2000, Teaknet Publication N°3: 1-10.

SILVICULTURAL LESSONS ABOUT STAND DYNAMICS AND FOREST HEALTH FROM A STUDY OF OAK DECLINE IN SOUTHERN MISSOURI

W. Keith Moser[1], Kathy Kromroy[2], Mark Hansen[1], Chris Woodall[1], Linda Haugen[3] and Manfred Mielke[3]

[1] USDA Forest Service, North Central Research Station, Forest Inventory and Analysis Program, 1992 Folwell Avenue, St. Paul, MN 55108 USA.
Tel: +1 651 649-5155; fax: +001 651 649-5140; email: wkmoser@fs.fed.us;
[2] USDA Forest Service, North Central Research Station, Forest Diseases Research Unit
[3] USDA Forest Service, Northeastern Region State and Private Forestry

Introduction

Ecological stability is generally defined as whether an ecosystem can return to pre-disturbance states of composition and productivity and how quickly it returns to that state (Ricklefs and Miller 1999). Threats to ecological stability include anthropogenic influences, such as harvesting trees or set-fires, and "natural" events such as wind- and ice-storms, wildfires, insect and disease attacks. Often, the likelihood of attack and severe damage from these natural events are exacerbated by man's activities.

Silvicultural treatments, regardless of the intent or the intensity, can increase the risk of "bad" events happening. For example, "no management" of a stand or forest on a lower slope may result in a change of composition from one dominated by oaks to one predominantly composed of silver maple, thus increasing the susceptibility to ice damage. Examples of "over-management," such as pruning eastern redcedar or heavily fertilizing slash pine, can result in increased likelihood of heart rot or fusiform rust, respectively. Vigorous, healthy trees are often more resistant to insect or disease attacks, or can recover more quickly than trees with reduced vigor (Manion 1981). It follows that management actions that fail to increase individual tree vigor ("under-management") increase the susceptibility of the stand to attack, decline and mortality.

The Central Hardwood forest ranges from eastern Oklahoma northeast to southern New England (Hicks 1998). Oak – hickory forests constitute the vast majority of acreage in the eastern United States (Powell 1993) and in the Central Hardwood forest region. In the State of Missouri, oak–hickory forests constituted almost three-fourths of the total forest land area and oaks constituted 66% of all removals of growing stock on timberland between 1999 and 2002 (Moser et al. 2004). Forest health problems that affect oak growth and survival could have a significant impact on Missouri's forest ecosystem and economy.

Oak decline is considered a "complex:" a suite of pathogens and insects that together contribute to reduced growth, quality defects and mortality trees species in the red oak (*Erythrobalanus*) group. Consisting of the two-lined chestnut borer, the red oak borer, *Armillaria* fungus and *Hypoxylon* canker, with additional impacts caused by 4 other insects (Starkey *et al.*1989), this forest health condition is native to the Central Hardwoods region and has long been endemic to oak forests. Although evidence of oak decline has been observed since the 19th century, the complex has had an increasing impact on the forests of the Ozark Plateau of Missouri and Arkansas with evidence of crown dieback, growth reduction and mortality in oak forests since the 1980's, far exceeding historic levels. The severe drought of the late 1990's, combined with the advancing age of the Ozark forests, has intensified the spread and severity of the effects (Lawrence *et al.* 2002).

Previous work developed interim management guidelines for forests susceptible to oak decline (Moser and Melick, 2002). Underlying the recommendations, based on personal observations and inputs from many field managers as well as other researchers, were assumptions about the impact of five stand and site factors present in all susceptible forests. These "Five Factors" are: site, age, density, the proportion of susceptible species, and stand diversity (Moser and Melick, 2002; Starkey et al., 1989; Nebeker et al., 1992; Millers et al., 1989). Moser and Melick postulated that the site factors influenced the likelihood of attack by oak decline in the following ways:

- *Site* (ridgetops and south-west aspects are frequently poor in terms of nutrient and/or water availability)
- *Age* (stands over 70 years old)
- *Species* (scarlet and black oaks being the most prone to oak decline, particularly on poor sites)
- *Density* (trees in stands with higher densities are more stressed than those in lower-density stands) and
- *Lack of diversity* (stands with high proportions of susceptible oaks are more prone to oak decline)

These characteristics, no doubt similar to attributes influencing forest health in many parts of the world, can all be largely influenced by silvicultural choices. Based on user requests for information on the health of forests in the Mark Twain NF, the North Central Research Station and State and Private Forestry have been preparing a report that documents patterns of growth and mortality in response to hypotheses about these five factors and occurrences of oak decline.

Given the widespread nature of oak decline on the Ozark Plateau, there are not enough foresters, loggers or markets to deal with all of the areas potentially requiring management action. As an intermediate measure, Moser and Melick (2002) proposed management guidelines that focused on manipulating these predisposing factors to avoid or reduce the opportunity for oak decline or, at least, to mitigate its effects. The guidelines spoke to increasing diversity, both in species and tree size (age), before oak decline is present. Species should be matched to sites where they are most appropriate: pines on south and west-facing slopes and ridgetops, white oaks on midslopes, northeast slopes for northern red oaks and dryer (north and east aspect) sites for scarlet and black oaks. Species that are especially susceptible, such as scarlet and black oaks, would be aggressively thinned to increase vigor and harvested by the time they are 70 to 80 years old.

Methodology

The Forest Inventory and Analysis program in the North Central Research Station focuses on understanding the forested ecosystems in the North Central and Northern Great Plains States through annual inventories and analyses of the results. Concurrent with these activities is research into improved techniques of data collection and analysis. With Phase 2 and Phase 3 (FHM) plots, the FIA process measures the above-ground vegetation and the site (soils) factors.
We used 1989 and 2002 data collected on FIA plots in the 3 FIA survey units situated in the Missouri Ozarks. In this case, the independent variables were 1989 FIA variables, except for the 1990 – 1999 average annual rainfall, while the dependent variables were the growth and mortality values for 1999-2002, the remeasurement period. We calculated the average annual growth and mortality values per unit area, based on the change in inventory values between 1989 and 1999-2002.

Results and Discussion

Results validate our hypotheses about species mix and density influencing mortality and growth. They appear to support the proposition that over-mature stands are more prone to forest health problems, at least as defined by mortality. Yet, there are subtleties to site and species selection that are partially a function of the unique geology of the Ozark Plateau and partially a residual "memory" of past management on the landscape. Managers are faced with the conundrum that the species most prone to oak decline are also those that provide the greatest growth and, historically, valuable timber. This paper will present the results of consecutive measurements on FIA plots in southern Missouri, the characterization of growth and mortality trends as functions of the predisposing factors and the pattern of response as a function of the land use history. We will present recommended silvicultural treatments that look to a) minimize risk and/or b) increase output. Manager's choices will be presented in the context of the individual's risk aversion.

References:

Lawrence R, Moltzan B, Moser WK. 2002. Oak decline and the future of Missouri's Forests. Missouri Conservationist. 63(7): 11 – 18.

Manion PD. 1981. Tree disease concepts. Englewood Cliffs, NJ: Prentice-Hall. 399 p.

Miller I, Shriner DS, Rizzo, D. 1989. History of hardwood decline in the eastern United States. USDA, Forest Service Northeastern Forest Experiment Station General Technical Report NE-126. 75 p.

Moser WK, Brand GJ, Treiman T, Moltzan B, Lawrence R. 2004. Missouri's forest resources in 2002. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. Resour. Bull. NC-233. 42 p.

Moser WK, Melick R. 2002. Management Recommendations for Oak Decline. Unpublished memo to the Missouri Department of Conservation and the Mark Twain National Forest. 3 p.

Nebeker TE, Ammon VD, Boyle CR, McCracken FI, Solomon JD. 1992. Oak Decline: A comparison of study results from different areas of the South. Mississippi State, MS: Mississippi Agricultural and Forestry Experiment Station Technical Bulletin 183. 19 p.

Ricklefs RE, Miller G. 1999. Ecology (fourth edition). W. H. Freeman, New York.

Starkey DA, Oak SW, Ryan GW, Tainter FH, Redmond C, Brown HD. 1989. Evaluation of Oak Decline Areas in the South. USDA Forest Service Southern Region. p. 36.

LES UNITÉS PILOTES D'AMÉNAGEMENT, DE REBOISEMENT ET D'AGROFORESTERIE (UPARA): NOUVELLE APPROCHE DE GESTION DURABLE DES FORÊTS CONGOLAISES

Antoine MOUNTANDA[1], Pierre TATY[1], et Jean Albert Placide KAYA[2]

[1] Service National de Reboisement (SNR), B..P. 839 Pointe-Noire (Congo-Brazzaville),
Tél. +242 – 94 02 79 ; +242 – 20 77 80; + 242 - 57 35 13; Fax : +242 - 94 09 05;
site web : www.snr-congo.com; e-mail : snrcongo@free.fr
[2] Centre de Recherche Forestière du Littoral (CRFL), B.P. 764 Pointe-Noire (Congo-Brazzaville)

La République du Congo-Brazzaville développe depuis un peu plus de six ans un programme de création d'Unités Pilotes d'Aménagement, de Reboisement et d'Agroforesterie (UPARA) dans les principaux massifs forestiers du pays. Les travaux sont menés par le Service Public chargé du reboisement en collaboration avec les sociétés forestières. Ce programme est axé sur les travaux de reboisement, d'agroforesterie et de foresterie communautaire dans trois permis industriels couvrant une superficie de 810.000 hectares de forêt. Les activités réalisées portent essentiellement sur l'enrichissement avec les essences autochtones des zones plus ou moins dégradées par l'exploitation forestière, la sélection d'un certain nombre de géniteurs (épargnés des coupes au moment de l'exploitation pour les besoins de récolte de graines), la création et la conduite des pépinières et le suivi de la régénération naturelle dans les concessions forestières concernées. Le bilan des six premières années d'activités donne des résultats encourageants et permet d'identifier un certain nombre de contraintes et montrent l'impérieuse nécessité d'intégrer l'outil ''plantation forestière'' dans la gestion des Unités Forestières d'Aménagement (UFA) au Congo.

I – HISTORIQUE DE LA GESTION FORESTIERE AU CONGO

La volonté de gérer rationnellement les forêts congolaises remonte au début des années 60 avec la promulgation de la Loi n° 34-61 du Juin 1961, fixant le régime forestier. Elle s'est véritablement précisée à partir de 1974 avec la promulgation de la loi n° 004/74 du 4 janvier 1974, portant Code Forestier qui, suivant les évolutions des contextes national et international, a été successivement modifié en 1982 (loi n° 32/82 du 7 juillet 1982, portant code forestier), puis en 2000 (loi n° 16-2000 du 20 novembre 2000, portant code forestier). La toile de fond de ces différentes épisodes de la politique et la législation forestières congolaises est restée caractérisée par: aa gestion et l'utilisation durable des forêts; la pérennité de la production forestière; la valorisation optimale des produits de la forêt; et la conservation et la protection des écosystèmes forestiers et de la biodiversité. Cette volonté de gestion durable s'est toujours traduite dans les faits par la prise d'un certain nombre de mesures réglementaires, dont les principales sont:

le découpage de la forêt en unités forestières d'aménagement (UFA), qui sont des unités de base pour l'exécution des tâches d'aménagement, de gestion, de conservation, de reconstitution et de production (Art. 54 de la loi n° 16-2000 du 20 novembre 2000). Les UFA, autrefois de taille relativement réduite, sont, conformément au contexte actuel, entrain d'être remembrés en de grands ensembles susceptibles d'asseoir de façon conséquente la méthode d'aménagement polycyclique (à coupes multiples) adoptée. De ce fait, on passerait des rotations de l'ordre de 25-30 ans à celles de 40-50 ans;

la fixation pour chaque UFA d'un volume maximum annuel (VMA), qui correspond à la possibilité annuelle de la forêt, à prélever chaque année par l'exploitant sur une superficie bien définie appelée coupe annuelle, conformément aux stipulations du plan d'aménagement de l'UFA;

la fixation d'un diamètre minimum d'exploitabilité (DME) pour chaque essence exploitable (Art. 91 du Décret d'application de la loi 16-2000).

II – CREATION DES UPARA

2.1 - CONTEXTE ET JUSTIFICATION

La forêt congolaise couvre environ 20 millions d'hectares, soit près de 60 % du territoire national, et 12,3 % des forêts d'Afrique Centrale. Elle renferme une biodiversité relativement importante parmi laquelle se comptent de nombreuses essences de bois d'œuvre dont les sujets sont très dispersés (1 à 3 pieds/ha), notamment en ce qui concerne la dizaine d'espèces couramment exploitées. Ces forêts font depuis plusieurs décennies l'objet d'exploitation, essentiellement pour leur bois d'œuvre. Le caractère sélectif de cette exploitation, couplé à la pratique courante des cultures sur brûlis dans les défriches forestières, a entraîné l'appauvrissement et/ou la dégradation de certaines de ces forêts, au risque de compromettre la durabilité de leurs diverses fonctions, surtout en ce qui concerne la production de bois.

A titre d'illustration, une étude globale visant l'aménagement durable des forêts du sud Congo, menée conjointement par la FAO et une équipe du Ministère de l'Economie Forestière, dans une concession forestière de 15 000 ha basée dans le massif du chaillu, appartenant à Socobois (Scharpenberg et al, 1998), a permis de constater un déséquilibre entre les prélèvements et la reconstitution des ressources dans les zones de coupe. Dans le contexte mondial actuel, caractérisé par une prise de conscience universelle sur la nécessité de gérer durablement l'environnement, ces pratiques traditionnelles de valorisation des ressources forestières, entraînant la dégradation des écosystèmes forestiers, constituent un facteur notoire d'appauvrissement de notre environnement socio-économique. Consciente du déséquilibre avéré entre prélèvements et reconstitution, et soucieuse d'éradiquer cette entropie et parvenir au développement de l'arrière pays sur la base de l'exploitation durable des ressources forestières et fauniques, afin d'assurer une contribution plus grande du secteur au P. I .B., la République du Congo a opté pour la gestion durable de ses forêts, dont les points forts sont entre autres :

- l'octroi des permis de grande surface;
- la poursuite des inventaires;
- la définition et l'application des plans d'aménagement dans toutes les concessions forestières;
- le remembrement des superficies forestières morcelées qui ne permettent pas l'exploitation rationnelle de la ressource;
- la conduite des travaux de reconstitution et d'accroissement de la ressource forestière ligneuse dans le cadre de la mise en œuvre des plans d'aménagement des UFA.

Ainsi, face au nouveau contexte mondial et face au danger que représentent la destruction de la forêt et la disparition éventuelle de certaines espèces floristiques et fauniques fortement écrémées, en l'absence des plans d'aménagement pouvant garantir le renouvellement de la forêt et la gestion durable des ressources, le Département de l'Economie Forestière du Congo a mis en place en 1996, des structures devant pencher sur la question. Il s'agit des Unités Pilotes d'Aménagement, de Reboisement et d'Agroforesterie (U.P.A.R.A) installées auprès de quelques entreprises forestières plus structurées des secteurs Nord et sud. Ces sociétés produisent chacune en moyenne 150.000m^3 de grumes par an. La gestion des UPARA est confiée au Service National de Reboisement (S.N.R). Pour la mise en œuvre de cette politique d'aménagement, les U.P.A.R.A ont procédé dans un premier temps à la réalisation d'un programme de régénération forestière. Ce programme est axé notamment sur:

- L'enrichissement pour la restauration des trouées d'exploitation ;
- L'installation de quelques dispositifs sommaires d'amélioration des peuplements naturels, notamment le programme de phénologie des arbres ;
- La mise en place de quelques parcelles agroforestières.

2.2 - OBJECTIFS

L'objectif principal poursuivi par les U.P.A.R.A est la détermination des itinéraires techniques pouvant permettre d'intégrer l'outil « plantation forestière » dans la mise en œuvre des plans d'aménagement des UFA, notamment :

- l'identification au sein de l'U.F.A de ou des espaces propices à la régénération artificielle ;
- la mise au point d'une technique adéquate de préparation de terrain, pour résoudre les problèmes d'exigences en lumière des différentes espèces plantées ;
- la sélection d'un matériel végétal de bonne qualité, pouvant servir aux programmes de plantation, et le cas échéant aux schémas d'amélioration.

2.3 - SITES D'IMPLANTATION

La phase pilote des U.P.A.R.A a été conduite dans les chantiers respectifs de quatre sociétés forestières reparties de la manière suivante:

- U.P.A.R.A SOCOBOIS et BOPLAC dans le massif du chaillu (3,5 millions d'ha) localisé dans les forêts du sud Congo à prédominance d'okoumé ;
- U.P.A.R.A CIB et ITBL dans les forêts du nord Congo (15 millions d'ha environ) dominées par les Méliaceae, notamment le sapelli et le sipo.

2.4 - ORGANISATION ET FONCTIONNEMENT

D'une manière générale les U.P.A.R.A sont gérées par une équipe légère composée d'un Ingénieur forestier secondé par un agent technique principal des eaux et forêts, tous deux recrutés par le Service national de reboisement (SNR). Le suivi technique de ces unités est confié au Service National de Reboisement (SNR), notamment pour la mise en œuvre des techniques sylvicoles et l'application des normes de travail. Un comité de suivi présidé par l'administration forestière, et comprenant les représentants de la recherche scientifique, des sociétés partenaires et du Service National de Reboisement siège chaque année, pour adopter les budgets et les programmes d'activités annuels.
Jusqu'à l'entrée en vigueur du fonds forestier en 2002, les budgets des U.P.A.R.A étaient entièrement financés par le fonds d'aménagement des ressources naturelles (FARN) sous forme de préfinancement consenti par les sociétés forestières partenaires abritant ces unités.
Dès l'année 2003, et en attendant la définition de nouvelles modalités de financement de ces structures, le Ministère en charge de l'Economie Forestière et les sociétés forestières ont opté pour un cofinancement destiné aux travaux d'entretien et de maintien des acquis.

III – RESULTATS OBTENUS

3.1 – Superficies plantées

Les rapports du Service National des Reboisement (SNR) révèlent 446,9 ha de superficies reboisées jusqu'au 31 décembre 2002 et repartie de la manière suivante: 320,2 ha au nord et 126,7 ha au sud du pays (tableau 1).

Tableau 1 : Répartition des superficies plantées (ha) par UPARA

ANNEE	UPARA CIB	UPARA ITBL	UPARA SOCOBOIS	UPARA BOPLAC	TOTAUX
1996	-	-	12	-	12
1997	52,37	-	-	39,55	91,92
1998	50,44	-	50,15	25	125,59
1999	10	20	-	-	30
2000	26,84	77	-	-	1O3,84
2001	20,32	17,13	-	-	37,45
2002	28	18,10	-	-	46,1
TOTAL	187,97	132,23	62,15	64,55	**446,9**

Le suivi régulier de ces plantations, notamment à l'U.P.A.R.A-C.I.B et U.P.A.R.A-ITBL, à travers des séries d'entretien et de mensurations a permis de constater que la croissance initiale des sujets était relativement meilleure sur les points de planting découverts par le haut, tant pour les espèces réputées d'ombre (sapelli, sipo, etc.) que pour les espèces de lumière (limba, okoumé, etc.).

A titre indicatif, les mensurations faites sur le sipo à l'U.P.A.R.A CIB ont permis de constater qu'à deux ans, les sujets éclairés par le haut mesuraient en moyenne 2,37 m de hauteur, tandis que leurs congénères ombragés par le haut n'avaient en moyenne que 1,46m.

3.2 - Espèces plantées

Le choix des espèces à planter a été guidé par la structure des VMA (volume maximum annuel) respectifs de chaque société. Cependant dans d'autres UPARA, on s'est intéressé aussi à l'introduction de certaines espèces en dehors de leurs aires de répartition. C'est le cas de l'Okoumé, qui n'existe pas naturellement dans les forêts du Nord Congo, mais qui a été introduit à l'UPARA CIB. Sa croissance moyenne est d'ailleurs très spectaculaire (1 à 2m/an en hauteur). Les semences utilisées pour la production de ces plants étaient soit produites par des arbres semenciers opportuns ou préalablement sélectionnés, soit reçu de la Direction du SNR à titre d'essai d'introduction.

Le regarnissage des zones dégradées dans les UPARA SOCOBOIS et BOPLAC s'est fait avec les essences suivantes :

- okoumé et limba (plantés en layon dans les trouées d'exploitation forestière à écartement de 7 m x 7m pour l'okoumé, 10 m x 10 m pour le limba) ;
- douka, padouk, doussié (bipendensis), moabi (plantés dans les layons sous couvert à écartement de 10 m x 10 m).

Dans les U.P.A.R.A CIB et ITBL, les activités ont porté sur les espèces telles que: sipo, sapelli, acajou, limbali, wengue, afrormosia, ayous plantées dans les layons à 10 m x 20 m ou à 10 m x 10 m, et dans les jachères forestières à 10 m x 15 m ou à 10 m x 10 m. Les espèces de bois d'œuvre ont constitué l'essentiel des espèces plantées; ceci pour soutenir à terme la production de bois. Cependant dans les pépinières, on a produit aussi des espèces d'arbres diverses comme le safoutier, le manguier, l'avocatier, le figuier, l'irvingia, destinées aux essais agroforestiers et à la création des vergers pour les besoins des populations, notamment dans les U.P.A.R.A. CIB et ITBL. En ce qui concerne le suivi de la régénération naturelle, quelques parcelles y relatives ont été créées au niveau de l'U.P.A.R.A, et portent sur l'observation de quelques sujets de sipo, sapelli, tiama, … au stade gaulis.

3.3 – Techniques utilisées

La technique sylvicole utilisée est celle des layons. Ceux-ci sont ouverts dans le sens est-ouest avec deux mètres de large, tant dans les jachères que dans les zones de forêt déjà exploitée. Les plants sont produits par semis effectués dans des pépinières semi-modernes et éduqués jusqu'à atteindre la taille requise pour le planting. Les graines sont récoltées au pied des arbres semenciers opportuns ou préalablement sélectionnés. Des essais de semis direct ont également été réalisés en plantation. L'entretien des plantations se fait manuellement : il consiste à désherber autour du plant et le long du layon pour faciliter la circulation. Toutes les opérations de pépinière, de préparation du terrain et de planting sont effectuées par la main d'œuvre journalière locale encadrée par les agents du SNR, et travaillant sur la base des normes en vigueur au SNR.

IV – FAIBLESSES ET ATOUTS

Nonobstant ces réalisations relativement intéressantes, il y a lieu de relever les quelques faiblesses qui ont caractérisé cette phase pilote :

- l'absence des textes juridiques d'appui organisant le fonctionnement (règlement intérieur des upara et des comités de suivi, code de déontologie) ;
- l'absence d'un plan d'action et des objectifs quantifiés;

- l'absence d'un protocole d'exécution des différentes opérations, notamment en ce qui concerne le suivi de la régénération naturelle ;
- l'absence notoire de la recherche forestière dans la phase d'élaboration des programmes et le suivi des dispositifs mis en place ;
- les tergiversations de certaines sociétés forestières pour pré financer les opérations de terrain ;
- les principes et les mécanismes de financement non définis ;
- le non fonctionnement des comités de suivi.

Cependant, quelques atouts méritent d'être mentionnés, tels que :

- l'adhésion des sociétés forestières dans la mise en œuvre de cette initiative ;
- l'engagement des cadres du SNR à réaliser tant bien que mal les activités programmées ;
- les réalisations elles-mêmes, qui dorénavant pourront servir de base à plusieurs travaux de recherche ou de développement.

V – PERSPECTIVES

Depuis sa création, le programme des U.P.A.R.A a mis en place plus de 400 ha de forêt que nous nous attelons à caractériser pour en évaluer le comportement pendant les cinq premières années d'implantation. C'est dans ce cadre que le SNR a mis en stage un Ingénieur au sein du CIRAD-FORET pour réaliser à l'UPARA-CIB (Pokola) un travail qui nous permettra de répondre aux principales questions suivantes:

- Les premiers essais de reboisement en forêt dense équatoriale du Congo sont-il une réussite sur les plans technique, socio-économique et environnemental ?
- A partir de ces dispositifs installés sans protocole de recherche, peut-on déduire les accroissements et la productivité des peuplements de quelques essences de cette forêt, notamment les Entandrophragma ?
- Ces accroissements, et l'importance des dispositifs (superficie) peuvent-ils garantir un recrutement efficient en volume et qualité dans les classes de diamètres exploitables ? - (arbres d'avenir). Comparaison des résultats avec ceux des autres pays d'Afrique Tropicale (Côte-d'Ivoire, Cameroun, Gabon, Centrafrique, Ghana). Les différentes classes de diamètre exploitées par CIB, et celles qui manquent le plus
- Quel est le coût moyen à l'hectare de ces enrichissements ?
- La régénération naturelle, est-elle suffisante pour assurer la restauration des couverts forestiers ?
- Les résultats obtenus peuvent-ils permettre d'esquisser un plan d'aménagement de la forêt étudiée, pour assurer le renouvellement durable de la ressource ?
- Dans tous les cas, les premiers résultats obtenus par les U.P.A.R.A à cette étape de la phase pilote constituent une opportunité :
- Pour la recherche forestière qui dispose désormais d'une plate forme substantielle pour la conduite des essais sur l'observation de la régénération naturelle, de la régénération artificielle, de l'agroforesterie, etc.… ;
- Pour le Gouvernement qui peut déjà dans une certaine mesure étendre progressivement les U.P.A.R.A à d'autres sociétés forestières ; ce qui donnerait de la matière au SNR qui dans cette approche fait figure d'incontournable grâce à l'expérience acquise en la matière.

BIBLIOGRAPHIE

1° - Etude FAO : 1997 – Contrat d'exploitation forestière sur domaine public. 205 p
2°- Ministère des Eaux et Forêt, 1996 : Accord relatif à la mise en place des Unités d'Aménagement, de Reboisement et d'Agroforesterie ; 2p
3°- Robert SCHARPENBERG et al, 1998 – Exploitation forestière dans les forêts naturelles de la République du Congo. Etude FAO ; 63p
4°- Code Forestier Congolais, 2000 – 32p
5°- Décret n° 2002-437 du 31 Décembre 2002 fixant les conditions de gestion et d'utilisation des forêts.

PLANTATION TECHNOLOGY AND FIELD PERFORMANCE OF SELECTED TREE SPECIES OF MULTIPLE END-USES, INDIGENOUS TO INDIAN PENINSULA

K.K.N. Nair, C. Mohanan and George Mathew
Kerala Forest Research Institute, Peechi-680653, Kerala, India
E-mail: kknnair@kfri.org

Introduction

The monsoon forests of Indian Peninsula are very rich in indigenous tree species of varied end-uses. However, this rich biological resource is at present getting scarce due to several reasons including habitat destruction and over-exploitation. Therefore, it is much desired to artificially regenerate such species in order to ensure the continued availability of their products and ecological functions. As pointed out by Evans (1982), the practical difficulty in the large scale growth of indigenous species is the lack of proven technologies. To fill this lacunae, the plantation technology of five such species, namely *Calophyllum polyanthum* Wall., *Dysoxylum malabaricum* Bedd., *Garcinia gummi-gutta* (L.) Robson, *Melia dubia* Cav. and *Vateria indica* L. were standardised. All the tree species yield timber of various end-uses, apart from products like Camboge (*G. gummi-gutta*), medicinal oil (*D. malabaricum*), illuminant seed-oil (*C. polyanthum*), White Dammar and seed-fat called Piney-tallow (*V. indica*) and linolic and oleic acids and butter-oil (*M. dubia*). In literature, Troup (1921) and its revised editions (FRI, 1975-85) and Luna (1996) gave scanty information on the artificial regeneration of selected Indian trees, wherein the species dealt with here are either not included or not studied in detail. Similarly, Dent (1948) had given partial data on storage of seeds and Sengupta (1937) standardised seed weights and germination rates of quite a few indigenous species of India, where there is not much data available with regard to the species tried. Earlier, Nair *et al.* (1991) investigated the plantation aspects of six indigenous tree species of India, not covering the species included here. A detailed treatise on the plantation technology of the species tried here is available in Nair *et al*. (2002).

Methodology

Data on seed characteristics, their collection and processing methods and nursery techniques for the production of propagules by seed and vegetative methods, and details on field-planting and survival and growth rates of the field-planted seedlings were generated through laboratory, nursery and plantation experiments. Also, data on potential pests and diseases affecting the fruits, seeds and seedlings in the nursery and field-planted propagules were generated and control measures standardized.

Results

Seed collection, processing and storage

The seeds of *C. polyanthum* and *D. malabaricum* are available in the natural stands of the species in the evergreen forests of Indian peninsula, during June to August and May to July, respectively. In the case of *G. gummi-gutta, M. dubia* and *V. indica*, the seeding season is from May to September, November to February and May to August. The seeds of *C. polyanthum* are often eaten away by monkeys and other wild animals and that of *D. malabaricum* are severely affected by a *Daccus* pest, even when they develop on the mother trees. In the case of *V. indica,* weevils damage the fruits. Therefore, in such cases, damage-free seeds have to be collected for germination. The details on the characteristics of fruits and seeds, pests and diseases affecting them and storage period before sowing are given in Table 1.

Table 1. Seed characteristics, pest and diseases and storage period

Species	Fruits		Seeds					
	Type	Shape	Average size(cm)	Shape	No. per 1 kg	Pest/ protection	Disease/ protection	Storage period
C. polyanthum	Drupe	Ovoid	2.2 x 1.5	Elliptic	800-850	Shot-hole borers/ screening in field	Spermaplane fungi/ Dressing with Capstan	Less than six months
D. malabaricum	Capsule	Pyriform	3.5 x 2.4	Sub-globose	390-410	*Daccus* pest/ Screening in field.	Spermaplane fungi/ Dressing with Capstan	No storage period
G. gummi-gutta	Berry	Globose	3.3 x 1.5	Ovoid	590-600	Nil	Nil	Nil
M. dubia	Drupe	Ovoid	2.5 x 1.1	Ovoid	800-850	Nil	Spermaplane fungi/ Dressing with Capstan	More than one year
V. indica	Capsule	Ovoid-ellipsoid	4.6 x 3.3	Ovoid	42-44	Weevil	Spermaplane fungi/ Dressing with Capstan	Less than one year

Nursery techniques

The results of germination trials conducted in standard nursery beds of 12 m x 1.2 m size and in root-trainers of 10 x 5 cm cell space, filled with mixed weed and coir pith compost are given in Table 2. Also, the best results of vegetative propagation trial using shoot-cuttings treated with Indole Butyric Acid (IBA) at 3000, 4000 and 5000 ppm concentrations are given in Table 2. In the case of *M. dubia,* where seed germination percentage is very poor, vegetative propagation method is more promising. Also, removal of seed coat can substantially enhance the germination rate of *G. gummi-gutta.* In the case of *D. malabaricum,* pest-free, fallen fruits with green cotyledons germinate by 20 per cent, or more.

Table 2. Data on seed pre-treatments and other nursery experiments

Species	Seed pre-treatment	Sowing in seed beds		Root trainers/polypots		Vegetative propagation	
		Seeds / bed	Germin-ation %	Seed / capsule	Germin-ation %	IBA (ppm)	Rooting %
C. polyanthum	Dry for 5-10 days in shade	1 kg	47	Two	45.5	4000	75
D. malabaricum	Dry for 5-10 days in shade	35 kg	20	One	17.3	3000	12.45
G. gummi-gutta	Removal of seed coat	1.83 kg	82.5	One	71	4000	54
M. dubia	Seeds soaked in farmyard manure for 7 days	1.33 kg	14	One	3	5000	50
V. indica	Dry in shade for 3-5 days	11.4 kg	5	One	81	4000	6

Plantation technology and growth of seedlings

The survival and growth of seedlings, field-planted during June-July, *i.e.* by the onset of South-West monsoon, in pits of 30 x 30 cm size, at a spacing due to draught are essential for all the species, and in the case of *Garcinia gummi-gutta,* grazing by wild animals has to be controlled for better survival and growth of the seedlings. Based on the technology developed, establishment of plantations of the five indigenous tree species of multiple end-uses is a viable method to augment the growing stock, dwindling supply of various products and also conservation of them. In general, being environment friendly, plantations of indigenous trees can be established in their natural habitats, *i.e.* in countries and vegetation types, where they grow as part of the natural ecosystem.

Table 3. Plantation technology and survival and growth of seedlings.

Species	Habitat for planting	Survival after 3 months	Growth after 12 months	Pests/control	Diseases/ control	Tenting operations for two years
C. polyanthum	Evergreen forests	89.62%	20 cm	Leaf-feeding caterpillars; mild but may attain pest status	Leaf-spot (not potential)	Mulching, shade and watering during summer
D. malabaricum	Evergreen forests	97%	34.3 cm	Nil	Shot-hole and Sooty-mould (not potential)	Mulching, shade and watering during summer
G. gummi-gutta	Moist deciduous forests	65%	23 cm	Nil	Nil	Prevent grazing; mulching and watering during summer
M. dubia	Moist deciduous forests	62.5%	27 cm	Nil	Die-back due to draught	Mulching, shade and watering during summer
V. indica	Moist deciduous forests	90.5%	85 cm	Nil	Nil	Mulching, shade and watering during summer

References

Dent, T. V. 1948. Seed storage with particular reference to the seeds of Indian forest plants. *Indian For. Rec.*(NS) *Silviculture* 7(1): 1-124.
Evans, J. 1982. *Plantation Forestry in the Tropics*. Clarendon Press, Oxford.
FRI, 1975-85. *Troup's Silviculture of Indian Trees.* 6 vols. Controller of Publications, Delhi.
Luna, R. K. 1996. *Plantation Trees.* International Book Distributors, Dehra Dun.
Nair, K.K.N., K.C. Chacko, A.R.R. Menon, K.V. Bhat, George Mathew, M.I. Mohammed Ali and R.C. Pandalai 1991. Studies on Selected Indigenous Species for Future Plantation Programmes in Kerala, India. *KFRI Research Report.* Peechi.
Nair, K. K. N., C. Mohanan and George Mathew 2002. Plantation Technology for Nine Indigenous Tree Species of Kerala State. *KFRI Research Report* No. 231. Peechi.
Sengupta, J. N. 1937. Seed weight, plant percents, etc. for forest plants of India. *Indian For. Rec.* (NS) *Silviculture* 2(5): 1-221.
Troup, R. S. 1921. *The Silviculture of Indian Trees.* 3 vols. Clarendon Press, Oxford.

QUANTIFIER LES OBJECTIFS DE LA SYLVICULTURE À L'AIDE DU CONCEPT DE PEUPLEMENT CIBLE

Philippe Nolet[1], Frédérik Doyon[1] et Éric Forget[1]

[1]Institut Québécois d'Aménagement de la Forêt Feuillue, 58 Principale,
Ripon, Québec, Canada
J0V 1V0 Tél: +1-819-983-2006, Courriel : pnolet@iqaff.qc.ca

Introduction

Diverses raisons historiques, administratives et opérationnelles ont mené le Québec et bien d'autres provinces canadiennes à encadrer la sylviculture dans un système normatif strict. Cette situation a) limite l'intégration des nouvelles connaissances dans les pratiques quotidiennes de la sylviculture; b) fait en sorte que l'on peut appliquer à des peuplements des traitements qui ne leur conviennent pas (Smith et al. 1996); c) a pour effet que les forestiers cessent de penser aux problèmes sylvicoles (Smith et al. 1996).

Les définitions du terme sylviculture sont d'une grande variété dans la littérature. On parle parfois d'un art, d'une pratique ou d'une science (Métro 1975, Smith et al. 1996, Helms 1998); certains auteurs intègrent les objectifs du propriétaire de la forêt dans leur définition (Helms 1998) alors que d'autres n'en font pas mention (Métro 1975; Smith et al. 1996). Tout un chacun s'accorde toutefois sur la nécessité de bien établir les objectifs avant de réaliser un traitement sylvicole. Pourtant, la littérature – livres de références et articles scientifiques – est plutôt silencieuse sur la façon d'identifier, de caractériser et de quantifier les objectifs sylvicoles.

Afin a) d'offrir une alternative à la sylviculture normative, b) d'optimiser l'intégration des nouvelles connaissances dans la pratique de la sylviculture, c) de s'assurer que les traitements sylvicoles soient adaptés à la réalité du terrain tout en respectant les objectifs établis à l'échelle de l'aménagement, nous avons développé l'approche de la sylviculture par objectifs (Doyon et al. 2003). Un des concepts clé de cette nouvelle approche est la caractérisation du peuplement cible. En sylviculture par objectifs, le sylviculteur doit, entre autres, faire l'effort de quantifier l'ensemble des objectifs reliés au peuplement cible. Les objectifs de cette présentation sont de présenter de façon explicite le concept de peuplement cible et de démontrer ses nombreuses utilités.

Méthodologie

Dans le cadre d'un projet par lequel quatre (4) peuplements forestiers de régions différentes sont traités selon l'approche de la sylviculture par objectifs, nous avons réuni une quinzaine de forestiers, tant de l'industrie que du ministère responsable de la gestion des forêts publiques, afin d'établir des peuplements cibles pour les quatre peuplements. Les quatre peuplements sont dominés par l'érable à sucre (*Acer saccharum* Marsh). Nous avons a) défini le peuplement comme étant un peuplement idéal atteignable pour une station forestière donnée; b) fourni un exemple concret de description de peuplement cible; c) avons répondu à toutes les questions posées afin de clarifier le concept; d) fourni un cadre de travail précis afin de bien décrire le peuplement cible. Ensuite, considérant leurs connaissances des érablières et des sites sur lesquels on retrouve ce type de peuplement, nous avons demandé aux participants de se diviser en quatre sous-groupes afin qu'ils puissent définir le peuplement cible de leur région.

Résultats et discussion

Dans les peuplements feuillus du Québec, la loi sur les forêts exige que la coupe de jardinage soit le traitement privilégié lorsque les caractéristiques dendrométriques et stationnelles permettent son application. Ainsi d'entrée de jeu, le peuplement cible aurait une structure qui permet ce traitement socialement acceptable (tableau 1). La grande majorité des buts identifiées sont par contre à vocation économique. Certains des buts décrivent un état du peuplement cible (1,2,3,4,5 et 9) alors que d'autres décrivent ses fonctions de production (6,7,8).

Tableau 1 : Description des buts et objectifs définissant un peuplement cible

But	Vocation	Objectifs
1. Avoir une structure qui s'applique à la coupe de jardinage	Sociale	▪ Avoir une structure qui ressemble à la courbe de Liocourt
2. Avoir la possibilité d'effectuer une récolte rentable	Économique	▪ Ratio Bénéfices/coûts >1.2 pour l'industriel ▪ Redevances de 40 $/ha/an pour l'état
3. Avoir la possibilité d'effectuer une récolte rentable (2)[1]	Économique	▪ Récolter au moins 50 m3/ha lors des coupes partielles
4. Avoir une grande proportion des tiges feuillues de qualité bois d'œuvre (2) [1]	Économique	▪ 25 m^3/ha en bois d'œuvre d'essences feuillues désirées lors des coupes partielles
5. Avoir une composition fortement dominée par des essences désirées (4) [1]	Économique	▪ Composition à 80 % en essences désirées et moins de 10 % en essences indésirables
6. Avoir un accroissement net qui permet de reconstituer le volume récolté avant la prochaine rotation	Économique	▪ Produire 2.5m^3/ha/an
7. Avoir des tiges vigoureuses et de qualité dans les stade perchis et basse futaie (6)[1]	Économique	▪ Produire 1,25 m^3/ha/an en bois d'œuvre en essence feuillue désirée
8. Avoir une composition des stades gaulis, perchis et basse futaie dominée par des essences désirées (7) [1]	Économique	▪ Les stades gaulis, perchis et basse futaie sont composés à 75 % en essences désirées
9. Avoir une grande diversité en essences	Écologique	▪ Avoir 8 essences par peuplement ▪ Avoir une essence marginale

[1] Signifie que le but No 3 est un moyen d'atteindre le but No 2. Idem pour les autres nombres entre parenthèses.

L'exercice effectué a permis aux intervenants d'une région donnée de visualiser le même peuplement cible. Une fois celui-ci défini, l' étape suivante consiste à comparer chacun des objectifs quantifiés du peuplement cible à la description du peuplement réel. À titre d'exemple, des inventaires dans le peuplement réel démontrent que la composition forestière en termes d'essences désirées, neutres et indésirables est respectivement de 54%, 8% et 38%, ce qui est très différent de l'objectif établi (tableau 1). Cela démontre clairement aux parties en présence (représentants de l'industrie et de l'état) que des efforts majeurs dans la prescription du traitement sylvicole devront être consacrés à l'objectif de composition en essence. Dans le cadre normatif québécois actuel, aucun effort n'aurait été effectué pour tenter de faire évoluer la composition forestière vers une composition plus désirable. Cette exercice de confrontation entre le peuplement cible et le peuplement réel doit être fait pour l'ensemble des objectifs établis au tableau 1.

Une des principales difficultés rencontrées par les forestiers a été de quantifier les objectifs qu'ils se sont donnés. Deux principales raisons ont été invoquées pour expliquer ces difficultés. D'abord, certains forestiers présents ont avoué, que dans le cadre normatif actuel, il ne se posaient plus de questions précises par rapport à l'avenir du peuplement. Ainsi, l'exercice d'identification du peuplement cible amène le forestier à réfléchir activement aux problématiques sylvicoles. L'autre raison invoquée pour expliquer la difficulté à quantifier les objectifs est le manque de connaissances, qu'elles existent dans la littérature ou qu'elles requièrent une recherche scientifique. Ainsi, par la sylviculture par objectifs et le peuplement cible, la sylviculture-pratique et la sylviculture-science trouvent une voie de communication.

Dans le contexte forestier québécois où de très grandes superficies forestières sont sous aménagement, les rôles de l'aménagiste et du sylviculteur doivent être explicites. Aussi, faut-il s'assurer qu'il existe une communication efficace entre eux. Le peuplement cible constitue une interface de premier choix comme moyen de communication entre les échelles de l'aménagement et de la sylviculture. Le peuplement cible n'a pas à être défini pour l'ensemble des peuplements du territoire sous aménagement, car l'exercice serait beaucoup trop fastidieux. Nous proposons de décrire un peuplement cible par station forestière. Ainsi, pour chaque station, le sylviculteur et l'aménagiste, le premier avec ses connaissances du terrain et le second avec ses contraintes et objectifs d'aménagement, décrivent ensemble le peuplement cible. Bien évidemment, le peuplement cible pourra être influencé par le zonage de la forêt. Le concept de peuplement cible défini par station forestière trouve à cet égard une certaine ressemblance avec les concepts de peuplement idéal et de série tel que décrits par l'ONF (1989).

Enfin, mentionnons que le peuplement cible, en considérant d'entrée de jeu à la fois les valeurs sociales, économique et écologiques, constitue un outil privilégié pour la gestion intégrée des ressources.

Références

Doyon, F., P. Nolet et P. Sabbagh. 2003. Pour un retour du sylviculteur: la sylviculture par objectifs. Aubelle 143: 12-15.

Helms, J.A., ed. 1998. The Dictionary of Forestry. Soc. Amer. Fors. Bethesda. MD. 210 p.

Métro, A. 1975. Terminologie forestière. Sciences forestières, technologies, pratiques et produits forestiers. Association française des Eaux et Forêts. Collection de terminologie forestière no 2, 433 p.

ONF. 1989. Manuel d'aménagement (3e édition). Ministère de l'Agriculture et de la Forêt, République Française. 151 p.

Smith, D.M., Larson, B.C., Kelty, M.J. et P.M.S. Ashton. 1996. The Practice of Silviculture: Applied Forest Ecology. 9th edition. John Wiley & Sons, New York, 537 p.

PRODUCTIVITY RELATIONSHIPS IN MANAGED FOREST STANDS

Kevin L. O'Hara

Department of Environmental Science, Policy and Management, 151 Hilgard Hall, MC 3110, University of California, Berkeley, CA 94720-3110, USA
Tel: +1-510-642-2127, E-mail: ohara@nature.berkeley.edu

The productivity of forest stands is an important concern for timber production as well as other ecosystem values. The productivity of a stand is dependent on site quality, but also on other factors that are generally more affected by human activities and forest management. Forest managers can greatly influence stand growth and productivity through a variety of management treatments including those that affect initial tree growth rates and those that influence the amount and distribution of volume or biomass over the life of a stand. Treatments that influence initial tree growth might include planting of different stock types, planting density, fertilization, vegetation control, tree improvement, or limiting herbivory. Those that affect the amount and distribution of volume or biomass during stand development also include initial density and fertilization as well as subsequent control of density, species composition, stand structure (representing the sizes and distribution of trees and their crowns), and age structure. This review focuses on the latter group of variables to reexamine several classical relationships in silviculture. Concepts related to the efficiency of converting growing space to stem volume increment of trees and stands will be the basis for revisiting the relationship between stand increment and density, the temporal dynamics of tree and stand respiration, and the relative productivity of forest stands with different structures.

Understanding stand growth and productivity requires understanding tree growth. A tree growing from seed without competition will quickly acquire growing space: expanding its crown as it increases in height, diameter and stem volume. All of these dimensions would follow a sigmoid growth form expanding quickly at first and then gradually slowing. A tree with growing space constrained by competition will experience a lower increase in growing space occupancy, height, volume or diameter once competition begins. Eventually, competition may limit the growing space occupancy of some trees leading to their death. One measure of occupied growing space is the leaf area of an individual tree. Leaf area is responsive to the light, moisture and nutrient resources available to a tree and is constrained at the stand level by the sum of these resources. Trees vary in their efficiency of use of leaf area because of crown position, age, species, and other factors. A measure of tree efficiency is the ratio of volume or basal area increment to leaf area. This measure of efficiency is indicative of the carbon balance of the tree: trees with greater carbon to allocate to stem growth will be more efficient since allocation to stem increment is a relatively low priority for carbon allocation.

Individual tree patterns of efficiency within stands are complex. It might be expected that trees with larger crowns would be more efficient because of their greater photosynthetic production and thereby have greater allocation to stem growth. However, the greater respiring tissues required to support increasing crown sizes reduce the net increment allocated to stem increment. Additionally, lower photosynthetic rates in older trees or hydraulic limits to tree height may also limit efficiency. The result is that within an individual stand, trees with moderate crown sizes may be most efficient: larger trees appear to have an excess of supporting tissues and inefficient foliage whereas smaller trees are limited by resource availability. The important implication of this is that trees can be combined in different structures while holding LAI and growing space occupancy constant, but having significant effects on volume increment.

Silviculturists may affect the efficiency through adjustments in stand density or structure. Whereas these treatments might alter the crown environment, they do not affect the crown directly. Artificial pruning reduces crown length thereby affecting crown size and crown efficiency. Lower limbs on many trees are less productive than younger, shorter limbs in better light environments so the result is an improvement in efficiency.

Forest stands exist under a different set of constraints than individual trees because of site limitations on total available growing space. Möller et al. (1954) were among the early researchers to document the pattern of foliage biomass and respiration during even-aged forest stand development. Foliage biomass or leaf area index (LAI) increases until reaching a maximum related to site resources and then levels off or declines. Respiration steadily increases during stand development usurping a greater proportion of gross photosynthesis. This fundamental process of stand development and productivity indicates that the most productive and efficient stands are those that support maximum LAI but minimize the respiring support structures. These are generally young stands near the point of crown closure.

The relationship between volume increment and stand density has been another fundamental concept in silviculture. The "Langsaeter hypothesis" (Langsaeter 1941) suggested that periodic volume increment was maximized over a relatively wide range in stand density. This plateau in increment has dominated work in this area to the extent that the focus of some studies was to find the edges of the plateau (Curtis et al. 1997). Given the differences in growth and efficiency of trees of the same age but different crown size, there is great latitude for variation in periodic increment for stands of the same density. Most recent work indicates increasing increment with increasing density. In any case, the concept of an increment - density relationship is flawed unless it also considers the important source of variation represented by stand structure.

Similar concepts underlie the productivity of mixed-species even-aged stands. Stand LAI would be a function of included species. In a simple two species system, LAI would be intermediate between the LAI of the two species when grown singly. A complicating factor would be the interactions between species and their effects on tree increment. For example, a shade tolerant tree of the same height and directly adjacent to an intolerant would have a longer crown and would likely have more effect on the intolerant than the opposite effect. Species replacement studies have generally not shown consistent productivity advantages of mixed-species stands, but these studies are limited because of the logistical constraints in their design and maintenance.

Uneven-aged stands have traditionally been assumed to be less productive than comparable even-aged stands (Assmann 1970). In contrast to even-aged stands where canopy heterogeneity is the result of differential growth rates, the heterogeneous canopy of the managed uneven-aged stand is the result of the intentional retention of trees of different ages. The uneven-aged trees have highly variable growth efficiencies related to their canopy position and can therefore be arranged in structures that affect stand growth (O'Hara 1996). The potential to affect uneven-aged stand growth while holding LAI or occupied growing space constant is therefore at least as great as for even-aged stands because there is a greater range of stand structural variability. An implication of this potential is that a difference in how uneven-aged stands are structured probably has a greater contribution to stand increment than any inherent difference between even- and uneven-aged stands.

Literature Cited

Assmann, E. 1970. Principles of Forest Yield Study. Pergamon Press. Oxford, UK.
Curtis, R.O., D.D. Marshall, and J.F. Bell. 1997. Journal of Forestry 95(7): 19-25.
Langsaeter, A. 1941. Meddel. F. d. Norske Skogforsøldbrdrm 8:131-216.
Moller, C.M., D. Muller, and J. Nielson. 1954. Forst. Forsogsvaesen i Danmark 21: 327-335.
O'Hara, K.L. 1996. Forest. Science 42: Monograph 33. 34 p.

A NEW SILVICULTURE: LOOSENING THE GRIP

K. J. Puettmann[1], K. D. Coates[3], and C. Messier[2]

[1]Department of Forest Science, Oregon State University, Corvallis, OR 97331,
[2]British Columbia Forest Service, Canada
[3]GREFi, Dép. de biologie, UQAM, Canada

Historical context

The development of forestry and silviculture can only be fully understood in their historical contexts defined by the interplay of social or political conditions (mainly human needs or desires), ecological conditions, and our scientific understanding of forest ecosystems. A review of the history of these linkages shows that a shift in any of these factors is commonly reflected in the development of new or modified silvicultural approaches and practices. For example, it is no coincidence that the development of silviculture as an orderly discipline occurred at a time when economical principles started to become influential in forest management in central Europe. At that time, an emphasis on the need for a sustainable wood supply lead to the development of the "Normalwald"- a concept that became the dominant tool for planning and forest management in 19th century Europe. The assumptions underlying the "Normalwald" (homogenous species mixtures or monocultures, homogenous site conditions, equal distribution of age classes, homogenous stand densities and wood quality) are still reflected in the silvicultural approaches used today (Mathew 1989).

The accelerated changes in human needs and desires, ecological conditions, and scientific understandings in the last few decades provide special challenges for silviculturists. The increasing population in many parts of the world is not only paying more attention to environmental issues, it is also demanding a steady supply of cheap wood, and increasingly views the forest as a place for recreational enjoyment and to provide ecological services. At the same time global species diversity is declining at an unprecedented rate, introduced species are spreading everywhere, and changing global climate is expected to increase the stress for our natural and managed ecosystems. Following, we argue that the current silvicultural approach was developed for a different set of challenges and is therefore too limited to address current and future concerns.

Command and control

Over the past two centuries, forestry practices have brought us great benefit in terms of a steady and predictable flow of timber and wealth. Silviculture has typically focused on the production of timber in uniformly managed stands using a suite of traditional silvicultural systems that describe a cycle of activities in which a stand is harvested, regenerated and tended over time (Matthews 1989). In the last 50 years, silviculture became even more narrowly focused as a post-logging activity, usually after clear felling, with reforestation the focus of interest. The research arm of silviculture has used agricultural experimental methods to study tree- or tree-related issues such as site preparation, vegetation control, planting methods, provenance testing and growth and yield prediction. The agricultural research model emphasizes experiments designed to find the best treatment among a set of restricted possible treatments, a reasonable approach with a clear objective such as optimizing timber yield. The search for a 'best treatment' resulted in foresters striving for simple stand structures, in many areas with an emphasis on even-aged, single species stands. Government agencies and forest companies implemented policies and regulations aimed to achieve best practices. Foresters strove to tame variability and complexity. The practice of silviculture became 'command and control' management, where the emphasis was on reducing natural bounds of variation in stand-level responses to make them more predictable. Silviculture fell into the pathology of natural resource management as described by Hollings and Meffe (1996). Command and control silviculture was successful as long as we believed "what is good for timber production is good for forest ecosystems", or accepted that the price to pay for predictable high yields is the loss of some species and/or ecological integrity in parts of our forests. The latter was a commonly accepted assumption when large tracts of natural forests could still be found in "wild" places, such as Canada, Russia or Brazil. We now recognize the limitations of our last natural forests. We believe silviculture must evolve to meet new challenges; that it must embrace variability and complexity, that it must find research approaches that identify trade-offs in different resource values, rather than strive for a best treatment that optimizes a single value.

Acknowledging complexity

As our ecological understanding of forests increased in the last 80 years, starting with Braun-Blanquet, Clements, and Gleason, then Whittaker, Odum, and Harper and more recently Tilman, Grime, and Franklin, we have come to realize that a large part of what make a forest a forest is its complexity. These and numerous other ecologists have brought home the notion that forests are complex entities and that this complexity is an integral part of a forest ecosystem. Ecologists have struggled to understand these concepts, and even today they describe them with difficult to define terms, such as biodiversity, resiliency, ecological health or integrity, or fully functioning forest ecosystems. Ecologists have been unable to relate the notion of ecosystem complexity to management implications (Bazzaz et al. 1998). For example, the Jabowa type models developed by Botkin and coworkers (Botkin et al. 1972) were a seminal step in viewing forest stands as a heterogeneous composite of gaps. This concept has been applied quite widely in ecological research and model development and has provided interesting insights into forest ecosystem dynamics (e.g., Garman et al. 2003). The gap models were developed for ecological studies, rarely included a management component, and had different input variables and validation procedures than generally accepted in forest management. Thus, these ecological models have not been applied widely by silviculturists (Vanclay 2003). Silviculturists, however, are asked to consider complexity and biodiversity in their management since these concepts have become important socially and economically.

Recent discussions in the ecological community have made it clear that our best protection against environmental threats and the best way to produce the many goods and services desired of forests is the maintenance of diverse and complex forests. Modern foresters must develop silvicultural approaches that can answer to the new needs and challenges of the 21st century. These approaches do not need to "throw away" all that silviculture has accomplished in the past, but silviculture has to acknowledge that complexity does not need to be fought or tamed, instead it needs to be accepted and encouraged and "let loose".

Loosening the grip

We believe that the emphasis on stand averages and management practices that stress homogeneity of stand conditions is the major reason why silviculture is currently struggling to provide the goods and services society is requesting. Similarly, ecology has provided us with useful understanding of the importance of stand complexity, heterogeneity, and stochasticity in forests, but ecologists have not been successful at developing management practices that can deliver good and services within that context. We propose that silviculturists need to borrow heavily from ecology to develop a new approach to forestry that embraces complexity, ecological knowledge and uncertainty principles and at the same time can provide us with the desired good and services through active management. Philosophically, silviculturists have to acknowledge the limitation of the traditional focus on the tree and fiber, stand average, the idea of a "best" treatment, and the command and control approach. Instead, we have to explicitly consider managing the dynamic complexity of conditions and living things that inhabits the forest. A logical consequence of this altered thinking is that on the research end, the quest for the best treatments needs to be replaced with studies that view any treatment as part of a continuum. Rather than ranking treatments, we need new types of studies that provide information about the magnitude of tradeoffs when moving along a treatment continuum. The new silviculture requires studies that bridge various scales and focuses on understanding of ecosystem processes, rather than describing stand average responses to silvicultural treatments. To understand and predict the response to silvicultural treatments in dynamically complex forest systems will require that we use powerful computer simulation tools that organize the new knowledge into a user friendly fashion and provide managers with practical tools. We also firmly believe that only when these new philosophical and research approaches have penetrated educational activities can we expect practicing silviculturist to wholeheartedly embrace the new silvicultural approaches.

A lot of work still has to be done until practical application of this new approach can become standard operations and we don't claim to know what exactly all these "new" applications will look like. But as silviculturists acknowledge that responses to silvicultural treatment always are often uncertain, non-linear, and occur at much smaller and larger scales than stand level averages, they will have to become comfortable basing management on predictions that include stochastic elements, such as probabilities of achieving a desired regeneration density at least 5 out of 6 years or density distributions within a stand. We are optimistic that these changes will help silviculturist to better provide humankind with all desired goods and services while protecting the integrity and health of forested ecosystems.

References

Bazzaz, F. et al. 1998. Science 30; 282: 879.

Botkin, D.B., J.F. Janak and J.R. Wallis. 1970, IBM Research Report 3140, Yorktown Heights, NY. 21 pp.

Garman, S., Cissel, and J., Mayo, J. 2003. USDA For. Serv. PNW-GTR-557.

Hollings, C.S. and Meffe, G.K. 1996. Cons. Biol. 10(2): 328-337.

Mathews, J. D. 1989. Silvicultural systems. Oxford University Press.

Vanclay, J. K. 2003. Can. J. For. Res. 33:536-541.

WATER MANAGEMENT IN "LA ANTIGUA" (VERACRUZ): A MULTIPRODUCT MODEL APPROACH IN MEXICAN FORESTRY

Ana-Rita Román-Jiménez[1], Martín Mendoza[2], Mario Martínez[3]; Alejandro Velázquez[4]; Juan-Manuel Torres[5]; and Hugo Ramírez[6]

Colegio de Postgraduados. Programa Forestal, Campus Veracruz; Km. 26.5 Carretera Federal Xalapa-Veracruz, 91700 México.; E-mail: aritacolpos@yahoo.com
[2] Colegio de Postgraduados, Campus Veracruz; Km. 26.5 Carretera Federal Xalapa-Veracruz, 91700 México. Tel: (229)934-8822 ext. 3012; Fax: (229)934-9100; E-mail: mmendoza@colpos.mx
[3] SISACOP. Colegio de Postgraduados. E-mail: mmario@colpos.mx
[4] IRENAT. Colegio de Postgraduados. Montecillo, 56230 México; E-mail: alejvela@colpos.mx
[5] CIDE. Santa Fe, DF.; E-mail: juanmanuel.torres@amadeus.cide.edu
[6] INIFAP. Coyoacán, DF. Mexico. Tel: +52(55)5658-0193

Introduction

Recently Mexican government has qualified water as a matter of National Security (Aguilar, 2001). To date, despite all efforts, 40% of water-flow derived through facilities to users is lost because of broken ducts (Aldana, 2001). There is an obvious contradiction between what it is said (i.e. water is valuable) and whatever it is done (i.e. reckless use, squandering, waste and inappropriate regulation). Problem is evident: water is a non-market good; it is produced and it is required but, because of lack of well-defined property rights, costs and prices are not clear and can not be efficiently and fairly assigned. Due to all above, a conceptual water value model is presented here, and it is illustrated with a case study: La Antigua watershed (232, 643 hectares located in central part of Veracruz) where water availability is not an issue yet, but water quality is. Public concern is set on land clearing, and as a result forestry is now confined to small areas. Xalapa, the state capital of Veracruz, with a population of 690,000 is located near by; this city uses 32’287,258 m^3 of water per year, most of which is caught at La Antigua (CMAS-Xalapa, 2000), and there is not local regulation available regarding forestry water management. On the other hand, lowlands near the Gulf of Mexico are often exposed to seasonal droughts and eventual floods, which adversely affects both agriculture and towns. A detailed review of key issues and operational conditions of water use and management is urgent in Mexico. This review would show that it is possible and feasible to plan forest management to get water as principal product. And, because of the multifaceted nature of water resources, this is another case of natural resource management with multiple objectives, choices and functions.

Methodology

A characterization of water uses, preferences, interests and competitive pressures over management possibilities in different localities of La Antigua watershed, was developed after design, application and analysis of site-specific question-response techniques (Ajzen and Peterson, 1988). Ecological condition of plant communities (Oliver and Larson, 1990) and public attitudes related to water uses were analyzed in stratified field located sites. A qualitative grading scale was developed to standardize both, condition and attitudes. In addition, Federal laws and actual regulations were reviewed and so were water instances, facilities and users, in order to associate mandatory versus actual common practices regarding water management along the well-defined distinct biotic and economic regions of La Antigua watershed.

Results and Discussion

Comparison between actual common practices in water management and mandatory cases described in Federal Laws and Regulations clearly showed there is a huge lack of information on water issues in Mexico, from hydrological (stream volumetric data, water quality, riparian zones) down to domestic matters (who, how and when water is used). Politicians and scientists see this limitation as a barrier that prevents rational, scientifically based forest management for water production. But water is being used any way, and its use is becoming chaotic. Spatial context is a reason for it, as occurs everywhere (Huff *et al*., 2000). Water use is related to land management at a local level in La Antigua, but to which extent or what consequences with are still unknown in quantitative terms.

Based on characterization we made, water is just one of many possible goods derived from land management that landowners may choose. But most important, water is a multiple good, in fact, a whole "basket" of products and services that are still elusive to people due to *water nature itself*. There is such a familiarity involved in all issues related to water, that public thinks water is a substance, a single good. A careful insight in our modern environment reveals water is as much a natural resource, as a human product. Moreover, we are the ones who need water, use it, dispose it, concern about, and take a stand on water issues. As a result, main choice criteria related to water seems to be neither economic nor volumetric, but subjective (a matter of preference), qualitative, temporal and spatially related, and density dependent, not only of plant communities in the land through which it flows, but also of human populations. Through their choices, behavior, and attitudes, people express what, how, and to which extent different water products and services are important. This research retrieved as much quantitative data as currently possible to build a model capable of depicting these varied facets of water in La Antigua watershed. Characterization we made brings out, at least, the following:

Water for energy. Hydroelectric generation industry; water transportation capacity; rivers or ponds navigation and meanwhile waterfalls' involved energy is a recreational service, sediment transportation is a derived risk.

Water for agriculture. Surface runoff is used in agriculture, though no volumetric data are available locally, and water for farming purposes, if derived manually, is for free.

Water for consumption and disposal. Homes, businesses, and industries use and dispose water. Facilities for water and sewage have been built for urban and rural populations, but waste disposal schemes are poorly thought, sewage mixes go downstream the currents to whole basin.

Water for drinking. This is a self-evident truth that deserves analysis in Mexico. Since tap water is not fit to drink, there has sprung a huge industry of purified drinking water.

Water as a hazard. Excesses are bad, water means danger when either there is too much or too less of it. Mexico has well documented cases of both.

Due to all reasons above, water in La Antigua watershed should be shown to public as a product of the land; a multiple resource, capriciously distributed, used by individuals, groups or enterprises, despite its benefits and consequences are both public and private. Water nature, which accounts for such a reality, leads us to another key issue: *Water property rights and duties.* Mexico's National Water Law 1992 states, “Water is a national property regulated to achieve an integrated sustainable development”. Its Regulation grants private water use rights; and water for free in some cases, when quantity or quality is not affected (CNA, 2000). Ambiguity, uncertainty and contradictions arise from a careful analysis of the law. Two of them are: First, it is impossible to take and later return water from streams without significant quality alterations, even with no artificial devices. The steady small changes brought about by each use, downgrade riparian zone and water quality; so, there is no credible reason for water to be free for anybody. Second, there is no connection between public welfare, and water use rights. That is, although the Law states that water is a national property, benefits and costs related to water uses are not accrued equitably by all citizens. Subsidies to users (direct cash outlays or tax exemptions) cause inequity. Public dominion is just a statement in the Law, but it is not exerted (it can not be) in current conditions. As a consequence, land management, forestry management, and water management are not guaranteed to be efficient.

Representing water management in "La Antigua" watershed in a private and commercial context provides insights explaining the poor support that society has for effective, intensive and rational measures to share water costs and benefits equitably between users, affected citizens and taxpayers. Building a model to represent this view of water management confirmed the notion that some volumetric parameters and financial values need empirical research. However, information available covers other commercial and controversial issues, and therefore, a sufficient picture emerges from the model. Public reluctance to pay for water and to get involved in controversial issues seems to convey that water services are satisfactory. Assigning quantitative estimates to important water common practices, such as derivation, storage, and urban or rural consumption, model shows that land management is responsible for current water services quality levels, due to activities that occur in the forested highlands.

Forestry in La Antigua is the only activity that actually adds to a fair water management strategy: careful planning may improve water quality, ecological conditions, and social welfare. Using the model just developed, riparian zones and highland roads have been identified as major sources of risk to water management, due to their fragility and lack of maintenance, as it occurs along the courses of streams and rivers. Model shows that some key-factor values are missed, overlapped or misunderstood; however it makes possible to infer that if numerical functions could be acquainted, they would render estimators of value for several forest and natural management activities in the watershed. And this may be useful in decision-making processes, because it may reinforce the municipalities' right to local regulation. General concerns might then be analyzed in an open-way, so public participation would be encouraged.

References

Aguilar Z., A. 2001. La Jornada. Domingo 22 de julio de 2001. pp: 10.

Aldana, A. 2001. La Jornada. Domingo 10 de junio de 2001. pp:14.

Ajzen, I.; and G.L. Peterson. 1988. In: Peterson, G.L.; B.L. Driver; and R. Gregory (Eds.). 1988. Amenity Resource Valuation. Venture Pub. Inc. pp: 65-76.

CMAS-Xalapa. 2000. Presupuestos para el uso y mantenimiento de la red de distribución de agua para la ciudad. Comisión Municipal de Agua y Saneamiento. Xalapa, Veracruz.

CNA. 2000. Ley de Aguas Nacionales (1992) y su Reglamento (1994). Comisión Nacional del Agua. México, DF. 169 p.

Huff, D.D.; B. Hargrove; M.L. Tharp; and R. Graham. 2000. Managing forests for water yield: the importance of scale. Journal of Forestry 98 (12): 15-19.

Milenio Semanal. 2001. Suplemento Milenio, No. 197. Lunes 25 de junio del 2001.

Oliver, C.D. and B.C. Larson. 1990. Forest Stand Dynamics. McGraw Hill, Inc. 467 p.

Acknowledgements

CONACYT and Colegio de Postgraduados, for providing scholarship and partial field work support. INIFAP and SEMARNAT-Veracruz, for digital images processing and field transportation.

A NEW APPROACH TO SILVICULTURAL RESEARCH IN THE BRAZILIAN AMAZON – DENDROGENE

Romy B. Sato, Ian S. Thompson[2], Jorge A. G. Yared[3], José do C. A. Lopes[3], Márcia Maués[3], Regina C.V.M Silva[3], Denis R. do Valle[4], Bernd Degen[5], Milton Kanashiro[3]

Dendrogene Project, Embrapa Amazônia Oriental/DFID, Pará, Brazil
Tel: +55 91 277-3514; E-mail: d_gene@cpatu.embrapa.br
[2] DFID, Dendrogene Project, Embrapa Amazônia Oriental/DFID
[3] Embrapa Amazônia Oriental, Dendrogene Project
[4] Imazon, Dendrogene Project, Embrapa Amazônia Oriental/DFID
[5] INRA, UMR Kourou, French Guiana

Introduction

The last 10 years has seen major changes in world economic, social and political structures associated with technological innovation especially in information and communication technologies. Tropical forests have been one of the most affected ecosystems. Within the "forestry world" the perceived failure of management for production has seen increasing emphasis on conservation, the private sector broadly continues predatory practices and certification has emphasized social and legal aspects of management. Within society the rise of concern over poverty has led to increased emphasis on and priority to social inclusion and governance issues and lower concern over forest management practices. Brazilian society expects that Amazonian research contributes to the region's social and economic development and so to poverty alleviation and research funding reflects these expectations.
Today's challenge is for the silviculturalist to make a case for continued efforts to improve tropical forest silviculture but placing this in the context of sustainable development initiatives. This requires that the silviculturalist participates within a multi-disciplinary research framework. It also means that the overall indicators of success will reflect the desired impacts on poverty.

Embrapa is a federal agricultural research corporation. Its Eastern Amazon centre, based in Belém, continues a tradition of twenty-five years in tropical forestry research. From 1993 to 1998 it implemented the Rainforest Silviculture Research Project aimed at improving forest management practice in the Brazilian Amazon. Technical, financial and infrastructure support was given to different research themes such as plant ecology and forest monitoring, which resulted in specific advances in each theme. However it became increasingly clear that the assumption that there was a strong client demand that would lead to uptake of results was not valid. A demonstration logging of two hundred hectares showed that forest management could not make use of many of the research findings, for example the identification of pollination syndrome (Maués 2001) despite the relevance of the information generated.

Methodology

These lessons led to the development of follow-up projects based on a new paradigm for the forestry group with poverty alleviation as their goal. One project was elaborated to create the conditions necessary for technological innovation at the municipal level by strengthening the participatory management of natural resources. The second project, Dendrogene, subject of this paper, set out to develop mechanisms to apply scientific knowledge in species composition, reproductive health and genetic diversity of tree populations to sustainable forest management.

Results and Discussion

In the planning phase three technical outputs were judged necessary for the project to have a successful impact on forest management policy and practice. These were:

i) To enhance local capacity for correct species identification
ii) Developing simulation models for analysing the impacts of logging on ecological and genetic structures and processes.
iii) Developing a decision support tool for forest planning that contains the latest scientific knowledge.

Due to the complexity and scale of these issues in the Amazon the project adopted a strategy emphasizing the participation of multiple institutions already involved in the themes. Given the emphasis on achieving impact through applying knowledge and tools a communication component was seen as critical. It also included the responsibility of achieving effective team working across the different disciplinary teams, across institutions and across very geographically separated locations.
As the project progressed it evolved in response to its experience in implementation, to the changing external environment and to formal external monitoring. A key factor here is the flexibility in project supervision and control to permit changes based on the lessons learned and the management competence to manage the change.

As the project involved multiple disciplines the common assumption of silviculture research that forests are valuable to traditional communities and improved management will help alleviate poverty was not taken for granted. The project included activities to examine this assumption. Two strategies were followed, one was to work with communities as users of the knowledge and technology and the other was to shift emphasis from timber management to multiple use of the forest. The former strategy meant establishing partnerships with development actors. In this case the project worked with a community in a region where the use of forest resources had been identified as a priority problem. Project members participated with the community to plan actions financed by the development project including such Dendrogene-led activities as training in botanical identification. Staff were assigned to accompany the community in their use of the training in inventories of timber and non-timber products and increasingly are involved in a range of activities which go beyond the management of forest resources to local development planning. A critical issue, which arises when working with communities, is the difficulty of securing continuity as achieving real impact on a community scale is frequently a long-term process. The shift from timber management to include more work on non-timber products sought to demonstrate the need for scientific knowledge and management tools (such as models and decision-support programmes) to community forest use in the context where few communities have the capacity to exploit timber. A good example is the study of the use of the oil of the tree piquiá (*Caryocar villosum* (Aubl.) Pers.) for medicinal purposes. These properties are being verified and the ecology and the effects of logging on the resource and community access to it are being investigated. The key principle is that the research should help local communities improve their situation within a broader local development framework

A second major change was provoked by the commitment made to interact with the target audiences of research in order to focus on achieving impact on broader goals rather than to narrower research outputs. In the reality of limited human and financial resources this inevitably led to the involvement of researchers in non-research activities and to the application of project funds to support this. A good example is the botanical component, which had to spend considerable energy on changing attitudes to botanical identification, leading discussions at policy level and fomenting actions to enable the products of research to be applied. For example the project team organized a regional workshop on the relevance of correct identification to the timber sector, which identified the lack of a recognized profession (botanical parataxonomist) as a key barrier to improving capacity. The team has continued to play a central role in developing proposals and seeking financing to implement an officially recognized course. Obviously this reduces the research output. The response has been to involve more

students but while this gives an immediate return, the high level of supervision required places further demands on the qualified specialists time.
As a result of the broadening remit of the project the demands on project administration, management and communication grew such that the project leader and facilitator have minimal availability for conducting technical work. Involvement in management also calls on a significant proportion of the communications leader's time. The project achievements to date have been encouraging; indeed it received a Ford Motor Company-Conservation International prize in the category of Science and Human Resource Development in 2003.

Species identification sheets have been developed for twenty priority species and a model can be seen on the internet (www.cpatu.embrapa.br/dendro/fichas.htm). Training material has been produced and validated with communities and technicians. A 500 hectare plot has been established enabling monitoring of ecological and genetic processes in response to logging. This unique resource will permit analysis of gene flow even amongst less abundant species. A dioecious species is one of seven chosen for intensive study reflecting different life traits. Twenty-five hectares of seedling plots make this the first large scale study of logging impact on recruitment processes. These data strengthen confidence in the Ecogene simulation model, which has been adapted in partnership with INRA, for application to the neotropical forests. This model is now being used to examine the impacts of different management scenarios to look for critical thresholds for species level impacts that can be used to guide management regulations. Another simulation model, SIMFLORA, has been adapted from an Asian model for use in Brazil. The decision support software TREMA has been developed to facilitate the planning of forest management with emphasis on forest logging. This now incorporates the official IBAMA tree species list and has many functions that make the selection of trees for logging transparent and efficient. Although still undergoing improvements it is being distributed through training courses and is under evaluation for incorporation within the government's control system. The communication programme has made Dendrogene a well-known brand name associated with the ecological sustainability of forest management. Certain products, such as the children's book Piquiá, bring this issue to a wider audience while others contribute to scientific and policy debates.

Our principal conclusions are that:

- Research management becomes critically important in the complex multi-disciplinary and multi-institutional context where research must go hand-in-hand with development. The capacity to effectively lead and manage teams, a team-based working culture and effective communication must be developed as a priority, preferably as a part of a wider institutional change strategy. Of special sensitivity is the management of effective partnerships.
- To achieve development goals projects need to have longer-term commitments and that frequently financial and human resources requirements are under-estimated.
- Silvicultural research should be conceived as part of a programme, centred on communication, linking research and development actors, and that the purpose of the programme ought to guarantee the impacts desired by society.

References

Maués, 2001. A silvicultura na Amazônia Oriental. Embrapa Amazônia Oriental. 85-116

Acknowledgments

Dendrogene is funded by DFID as part of the Brazil-UK bilateral cooperation programme.

EFFECTS OF FOREST MANAGEMENT ON BIODIVERSITY OF GROUND VEGETATION IN CANADIAN AND EUROPEAN CONIFER FORESTS

Andreas Schmiedinger[1], Jürgen Kreyling[1], S. Ellen Macdonald[2] and Carl Beierkuhnlein[1]

[1] University of Bayreuth, Chair of Biogeography, Universitätsstr. 30, 95440 Bayreuth, Germany
Tel: +49 921 552299, E-mail: andreas.schmiedinger@uni-bayreuth.de
[2] University of Alberta, Department of Renewable Resources, T6G 2E3 Edmonton, Canada

Introduction

Since the Earth Summit in Rio de Janeiro 1992 the influence of forest management on biodiversity has been extensively discussed (NORTON 1996, EHRLICH 1996, SPIECKER 2003) and suggestions for the conservation of biodiversity in managed forests have been made (HANSEN et al. 1991, MASON & QUINCE 1995, LUST et al. 1998, SPENCE 2001). Furthermore, standardized sampling methodologies are needed to quantify biodiversity of ground vegetation and to detect areas with high levels of plant species diversity. In our study we analysed patterns and drivers of understorey plant biodiversity in forests in the Monashee Mountains (British Columbia, Canada) and in the Fichtelgebirge (Bavaria, Germany). Forests in these two parts of the world are similar in terms of topography, lithology, and climate. Both regions are dominated by conifers. They differ, however, in the composition and the diversity of canopy tree species, in their disturbance history and regime as well as in recent management, and in the regional pool of understorey species. Our objectives are to understand the factors which affect the diversity of understorey forest vegetation, to assess the role of management and disturbance history, to develop standardized methods in order to detect areas with high biodiversity. We hypothesize that a) spatial patterns of beta-diversity of stands with similar stand structure are affected by different edaphic site factors, b) Structural differences among stands, as induced by forest management treatments, have a strong impact on patterns of biodiversity and c) the impact of site factors on species diversity shifts due to different regional species pools.

Methodology

Both investigation areas cover an area of 676 km² (26 km * 26 km). The Fichtelgebirge is located in Northern Bavaria, Germany; the Monashee Mountains are located in Southern Interior British Columbia, Canada. The investigation areas have been overlain by a 2 km by 2 km grid (Fig. 1). From these grid cells regularly distributed investigation units were chosen for sampling. In each investigation unit 3 random units (RU, 250 m * 250 m) with different stand structures types (ST) - a disturbed stand (DS), a mature (or old growth, MS), and an intermediate stand (IS) - have been randomly chosen. The disturbed stands sampled represent harvested areas or in some cases windthrows not older than 6 years. Sampling within each RU was conducted within a 10 m * 10 m plot. The plots had to fulfill special criteria like distance to forest edges, forest service roads and rivers, slope. Species composition of vegetation was recorded using the Londo-scale (LONDO 1975) including terrestrial ferns and mosses. Frequency of species was assessed using squares of 2 by 2 m regularly distributed over the 10 * 10 m plot. Within each plot soil samples were taken with two replicates of the O_h-and A-horizon for analysis nutrient availability. Stand structure was determined via the diameters at breast height (DBH), variable radius method (MÜLLER-DOMOIS & ELLENBERG 1974), and height of trees. Hemispherical photographs were taken at plot centre to characterize shading and plots were also photographed to characterize stand structure. Further, slope, relief, and if possible the age of stand were documented for each plot.

To scrutinize which site factors are influencing understorey composition, and as a result of this the pattern of beta diversity, multivariate ordination methods are being used. Further a matrix of site factors was correlated to a matrix of Euclidian Distances. In addition to these investigations natural regeneration on recent clear-cuts (5-8 years old) was analyzed in the Monashee Mountains. Species composition of plots sampled In the Fichtelgebirge in 2003 were compared to those first investigated with the same methods in 1997.

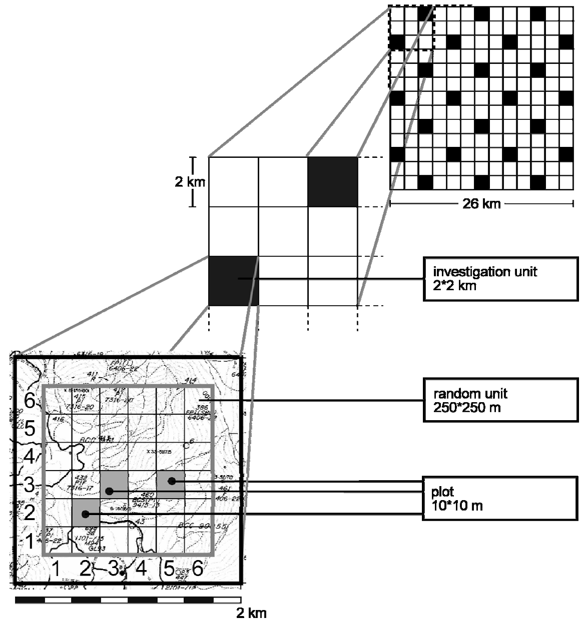


Fig. 1: Example of the sampling approach to explore biodiversity of ground vegetation one different structure types (ST). The figure illustrates the overall grid of 24 regularly-distributed investigation units (IUs, black squares) for the first iteration. Each IU has a 250 m buffer on all sides which should not be sampled. The rest of the IU was overlain with a 6 * 6 grid of 36 squares of 250 m * 250 m. Three squares (Random Units, RUs) with a disturbed, a mature and an intermediate stand each were selected randomly. Sampling within each RU was conducted within a 10m* 10 m plot (black dots). The plots had to fulfill special criteria like distance to forest edges, forest service roads and rivers, slope, etc.

Results

In the Fichtelgebirge 117 plots (DS n=37, MS n=41, IS n=39) have been sampled, the data in the Monashee Mountains result from 63 plots (DS n=22, MS n=35, IS n=6). In the Fichtelgebirge 155 species were found in the ground vegetation, and in the Monashees178 showing that both regional species pools are on a comparable level. Highest species richness was observed in disturbed stands (FI: 119 species, MO: 126 species) followed by mature stands (FI: 99 species, MO: 123 species). The fewest species were present in the intermediate stands (FI: 71; MO: 47). Thus, the total number of species is related to the occurrence of different structure types. The distribution of species between different structure types shows a high similarity between both investigation areas. 29 % of the species in the Monashee Mountains were restricted to the disturbed stands, 27% in the Fichtelgebirge. Different to species richness alpha-diversity, expressed by the Shannon-Wheaver-Index (Hs) increases from MS (Hs=1,70; s=0,42) and DS (Hs=1,66, s=0,53) to IS (Hs=1;64; s=0,60) in the Fichtelgebirge whereas in the Monashees the IS (Hs=2,79; s=0,22) and MS (Hs=2,76, s=0,33) are on the same level, highest diversity can be found on the DS (Hs=2,95;s=0,30).

The most apparent difference in species composition between conifer forests in both regions can be found in the mature stands. 22% of the species in the Monashee Mountains rely on mature stands. In the Fichtelgebirge only 14 % of the species could be found specifically on mature stands. Especially mosses and herbs depend on the micro climate of this structure type in the Monashee Mountains, where since 1960 about 25% of the investigation area has been harvested, app. one third of it in the 1990s. Thus, within the next 60 years the highest proportion of old growth stands might vanish. Consequently, beneath the conservation of old growth stands it is important to monitor regeneration of second growth forests. One factor expected to influence tree regeneration is distance to nearest forest edge, as it represents the minimal distance that must be overcome by seeds not originated from the seed bank. Success of natural tree regeneration is related to spatial variables. Numbers of tree seedlings decrease with increasing clear-cut size as well as increasing distance to the nearest forest edge. In excess of about 70 m from the forest edge, stocking targets (1600 seedlings per ha) are not reached in 50 % of the plots. All tree species that were present in the former stand show successful regeneration.

The chronological approach in the Fichtelgebirge showed a decline of ground species on 8 out of 9 tested plots. On 63% this plots more than 4 species vanished. This result might be due to the drought in summer 2003 and has to be monitored in the next years. Admittedly, a higher frequency of warmer and drier summer has been predicted for the future.

Discussion

The entire number of species (FI=155, MO=178) (gamma-diversity), the average number of species on the plots (FI=15, MO=21) (alpha-diversity) as well as the average values of the Euclidian Distance between the plots (FI=51, MO=59) (beta-diversity) are on a comparable level in both investigation areas. It seems reasonable to assume that the drivers which affect the reactions of ground vegetation on disturbances rely on similar mechanisms in both investigation areas.

Almost one quarter of all plant species in the Monashee Mountains rely on mature, i.e. natural stands. This demonstrates that old growth stands play an important role to preserve forest biodiversity. The results are consistent with the statement of ANDERSSON & ÖSTLUND (2004); the authors point out a dramatic decline of old trees in North-Sweden caused by forest management treatments. In North America and Scandinavia there are strong endeavors to attain sustainable forest management by imitating natural successions. To achieve this aim clear cutting is considered the favored forest management system. It can be concluded that clear-cutting can be a sustainable management tool in these forests, if spatial and temporal patterns of natural disturbances are respected as constraints, and quantities of harvesting plus natural disturbances stay in a historical range. In this context JALONEN & VANHA-MAJAMAA (2001) UND KUULUVAINEN (2002) emphasize that interactions between different forest management treatments are needed to achieve nature-orientated forest management.

The presented first results show that the methodology can be a useful tool to analyze and monitor biodiversity of ground vegetation in conifer forests in space and time. .

References

ANDERSON & ÖSTLUND (2004): Biological Conservation 118: 443-453
EHRLICH, PR. (1996): For. Ecol. Manage. 85: 9-19.
HANSEN, A.J., T.A. SPIES, F.J. SWANSON & J.L. OHMANN (1991): BioScience 6: 382-392.
JALONEN, J., VANHA-MAJAMAA, I. (2001): For. Ecol. Manage 146 (1-3): 25-34
KUULUVAINEN T. (2002): Silva Fennica 36 (1): 97-125
LONDO, G. (1975): Dezimalskala für die vegetationskundliche Aufnahme von Dauerquadraten. – In: Schmidt, W., Tüxen, R. (Hrsg.): Sukzessionsforschung. Berichte des Symposiums der Internationalen Vereinigung für Vegetationskunde. Cramer, Vaduz: 89-105.
LUST, N., B. MUYS & L. NACHTERGALE (1998): Biodiv. Cons. 7: 249-260.
MASON, W.L. & C.P. QUINE (1995): For. Ecol. Manage. 79: 13-28.
MÜLLER-DOMBOIS, D. & ELLENBERG, H. (1974): Aims and Methods of Vegetation Ecology. Wiley & Sons, New York, 547 S.
NORTON, T. W. (1996): Forest Ecology and Management 85, 1-7.
SPIEKER, H. (2003): Forest Ecology and Management 67, 55-65
SPENCE, J.R. (2001): Trends in Ecology & Evolution 16, 591-593

Acknowledgements

We would like to thank the DFG for funding the research project and the DAAD for the financial support of our Masters student Jürgen Kreyling.

INDUSTRIAL CONIFEROUS PLANTATIONS IN RUSSIA

Igor V. Shutov and Anatoliy V. Zhigunov*

Federal St. Petersburg Forestry Research Institute,
St.Petersburg, Russia
Tel: +7 (812) 552-80-21 E-mail: zhigan@lens.spb.ru

Introduction

The idea that intensive production of wood on plantations contributes to the preservation of natural forests was already formulated clearly in the 20th century (Shutov et al. 1967, 1984, 1997, Bennett 1996, Dykstra 1996, Burley 1997). In many countries with subtropical and tropical climates forest plantations have become widely used (De Freitas 1997, Shariff 1996). However, it should be stressed that this paper does not deal with subtropical and tropical conditions; our interest is dedicated to growing plantations in temperate climate zones (Russia in particular). Russia has vast forested territories. However, it should be pointed our that about half of the Russian forests are located in the permafrost zone, and, moreover, many forests are located on mountain slopes – in the Asian part of the country. In the four largest economic regions of Russia (Northern, West Siberian, East Siberian and Far East), with 90 percent of the total forested area of the country, the forest growth productivity is rather low, decelerated reforestation and high vulnerability of forest ecosystems are typical features. The difficulty innate to most of our forest management in the North and East is underdevelopment of the infrastructure and the extension of communication lines. It is mainly because of these reasons (i.e. economic and natural conditions) that only 22 percent of the forest area is suitable and profitable for forest exploitation. The conditions for forest growth and profitable forest management are more favorable in the North Western, Central, Volga Viatka and Ural regions, covering 8,4 percent (approximately 67,5 million ha) of the total forested area of the country (more than 1,1 billion ha).

Methodology

The investigations on intensive production on wood plantations in the North West and in the Central European part of Russia, i.e. in climate zones that are far from tropical, were given impetus due to the fact that intensive felling is executed here already for some centuries. In a number of regions the average of timber volume per hectare in mature coniferous stands has proved to be even lower than in developing stands. Nonetheless, we are sure that intensive forest exploitation activities in the economical regions mentioned above will increase. The investigations began in 1975 in the Saint-Petersburg Forestry Research Institute in cooperation with the Saint-Petersburg Forest Academy, Forestry Institutes of the Ukraine, Byelorussia, Latvia, Lithuania and a number of forestry experimental enterprises, subsequent to the partitioning organizations.

Russia has extensive historical and present-day experience in establishing and management highly productive man-made forests (Morozov 1930*,* Pisarenko et al.1992, Shutov et al. 1984). Drawing on the foundation laid by our predecessors, our Institute established 320 ha of specific experimental trial plots of Norway spruce (*Picea abies* (L.) Karst*.)* and Scotch pine *(Pinus sylvestris* L*.)* in Southern Karelia (in the central zone of the taiga), Leningrad Region (the southern taiga zone) and Pskov Region (zone of mixed forests). The sites differed in forest growth conditions, soil treatment, density and arrangement of trees, types and quality of planting stock, application of fertilizers and herbicides. The investigation aimed at studying the growth rate, ranking status, and general state of trees, the timber quality, the composition and mass of soil cover vegetation, as well as the most important characteristics of different soils.

Results and discussion

A complex of conditions that provide high productivity of plantations has been discussed in our publications (Accelerated Production … 1991). It should be emphasized that the complex of conditions does not include any extraordinary measures; it is the implementation of the overall set of conditions that is of primary importance.

In the southern taiga subzone and in the mixed forest zone of the European part of Russia are found those conditions for which it makes sense to establish and manage spruce and pine plantations. This is the case only under the forest conditions of Vaccinium myrtillus, Oxilis acetosella and herbosum, which are typical for about half the forest area of the considered region. Under these conditions was found that the class of productivity level is 1 to 1a and wood increment averages 6 to 8 m^3 per ha a year. These plantations may yield not less than 300 m^3 pulpwood per hectare at the age of 50 years, and about 400 m^3 timber wood per ha at the age of 60 to 70 years. For comparison, the average wood volume in already existing mature and "overmature" coniferous stands is 248 m^3 per ha in the North Western region, 257 m^3 in the Central region, 224 m^3 in the Volga Viatsk region, 199 m^3 per ha in the Ural region. It is easy to see that the productivity of forest plantations is much higher than that of the common forests.

About 35,000 ha of experimental forests plantations have been established recently following our recommendations, with the aim to verify them in actual practice (Shutov et al. 1967, 1984). As a result of investigation on the complex experimental production plantations, the following conclusions are made:

- the establishment and management of highly productive forest plantations in the Southern taiga zone and mixed forest zone is very well possible;
- it is also possible to establishment forest plantations in the central taiga zone, but their productivity is lower;
- the establishment of forest plantations also seems to be most promising in the forest steppe zone, in which vast areas of agriculture land have been left bare in recent years (Pisarenko et al. 1992, Shutov et al. 1997).

Hence, our suggestion to preserve most of the boreal forests of Russia as an ecological reserve can not be overruled by economical reasons, because it is possible to produce enough wood on plantations and other man-made forests in the more populated areas. It seems quite prudent to conserve the largest possible natural forest areas, considering them as ecological reserves of global significance with the aim to preserve them as the last and thus invaluable living relics of the Earth's remote past. One may wonder if this problem is really urgent to Russia, which is known to be so rich in forests. The following arguments may serve as an answer.

At present Russia is the largest depositary of relic systems of living organisms (e.g. Old Growth Forests). Their origin goes back to the early post-glacial period. We have much to preserve for future generations. Whereas in the future (for example, in the mid-21th century) the Russian forest market capacity (home and foreign) is assumed to equal 300 million m^3 round wood a year, this quantity could be produced on 50 million ha of forest plantations. And even if plantations would only be realized on one tenth of the mentioned area, it would already be possible to noticeably reduce our requirements to the boreal forests as a supplier of raw materials. What is even more important, this development would strengthen in the general idea that not only wood can be harvested, but needs to be produced as well.

It is also important to emphasize the fact that the establishment of highly productive forest plantations creates an additional and intensive sink of carbon from the atmosphere. The accu-mulation of carbon in these forest stands would be of global significance. Considering all these things together, it seems expedient to develop international programs both on presser-vation of the last boreal relict forests and establishment of forest plantations in the European part of Russia. It is obvious that also other countries and international organizations should stand up for this responsibility and contribute to financing, in order to establish intensive wood production plantations.

References

Accelerated Production of Industrial Spruce and Pine Wood on Plantations.: Practical Recom. 1991. Leningrad. LenHIILH: 67 p. (In Russian)

Bennett, A.J. 1996. Sustainable Land Use: Interdependence between Forestry and Agriculture.IUFRO XX World Congress 1995. Congress Report. VI. Tampere: 144-153.

Burley, J. 1997. What is in the World ? IUFRO News-1997. V.26, Is. 2: 1-3.

Dykstra D.P. 1996. Economic Impacts of Environmental Influences on Industrial Use of Tree Crops. IUFRO XX World Congress 1995. Congress Report. V.II. Jyvaskyla: 490-497.

De Freitas, M. 1996. Planted Forests in Brazil. IUFRO XX World Congress 1995. Congress Report. Jyvaskyla: 147-154.

Morozov G.F. 1930. Essays on silviculture. Moscow. 269 p. (In Russian)

Pisarenko, A.M., Redko, G.I. Merzlenko, M.D. 1992. Artificial forests. Moscow. Vol. 1: 239 p; Vol. 2: 308 p. (In Russian)

Shariff, A.H. 1996. Development, Progress, Problems and Future Prospects of Plantation Industry in Malaysia – a Country Report. IUFRO XX World Congress 1995. Congress Report. V.II. Jyvaskyla: 510-516.

Shutov, I., Maslakov, Je., Markova, I. 1967. Wood Supply Plantations in the Forest Zone of European Russia as a Forest policy Option. Proc. 7^{th} An. Conf. IBFRA. Moscow: 191-199.

Shutov, I., Maslakov, Je., Markova, I. et al. 1984. Forest Plantations. Moscow. Lesnaja Promisjlennost': 248 p. (In Russian)

Shutov, I., Maslakov Je., Markova I. 1997. Wood Plantations in Russia: Preservation of Boreal Forests, Additional round wood, Reduction of Costs on Transport. Lesnoye Khozyaistvo, No 6: 4-7. (In Russian)

Acknowledgements

The authors want to thank the researchers from the Reforestation Laboratory of the Karelian Institute of Forests of the Russian Academy of Sciences, the personnel of the Experimental Forestry Enterprise "Mogutovsky Les" (Pskov region), and the Experimental Forestry Enterprise "Siwersky Les" (Leningrad region) for the assistance in establishing forest trials and carrying out inventories in their region.

WOOD PRODUCTION, LITTER FALL AND HUMUS ACCUMULATION ON THINNING EXPERIMENT IN NORWAY SPRUCE CZ 13 – VITKOV

Marian Slodicak and Jiri Novak

Forestry and Game Management Research Institute, Research Station at Opocno, Czech Republic, CZ 517 73. Tel: +420 494 668 391, E-mail: novak@vulhmop.cz

Introduction

Experiment Vitkov is one of the collection of the IUFRO European thinning experiments in Norway spruce which started in fourteen European countries in the early 1970s. The aim of the research is to determine the effects of thinning on production and stability of spruce stands. Experiment Vitkov was established in 1971 in an eight-year old Norway spruce thicket originated from planting at regular spacing with density 2,500 trees per hectare on former agricultural land in the northern part of Moravia (Eastern part of the Czech Republic). The co-ordinates of the series are 49°50´22´´ N latitude and 17°35´25´´ E longitude. The stand lies on 0-5% E (SE) slope on elevation of 600 m above sea level on pseudogley cambisol of 5th Beech with Fir vegetation zone (moist to wet category).

The study focusses on the effect of five investigated thinning treatments on main parameters of wood production, namely on amount, quality and safety (stability) of produced wood. As the spruce plantation was established on agricultural land, the effects of forty-year forest cover on soils and, especially on humus horizons formation, was also evaluated.

Methodology

The experimental design consists of a control plot without thinning, thinning regime 2 with very intensive treatment in top height 10, 12.5 and 15 m, regimes 3 and 4 with treatments in the top height 10, 20 and 22.5 m and regime 5 based on commercial treatment. The study is based on the data measured in 1971, 1978, 1982, 1985, 1991, 1998 and 2000 (top height 4, 10, 12.5, 15, 20, 22.5 and 24 m). Comparative plots are doubled and the area of one comparative plot is 0.1 ha. Furthermore, each plot is divided into ten blocks by 100 m^2. For statistical evaluation of measured data, comparative plots were divided into 2 partial plots consisted of 5 blocks. Finally, four replications (500 m^2 each) are stabilised for each variant of thinning.

Diameters of stems in b. h. of all individuals are measured annually by millimetre calliper and the height periodically by poles on representative sets of trees on every plot. Development and growth of experimental stands has been investigated on the number of trees (N) and BA (G) and resistance to stem-breaks on quotient of slenderness of dominant trees (h/d ratio of 200 thickest trees per hectare).
In 2002, when experimental stands were 39 years old, observation of the effect of thinning on quantity and quality of litter fall and holorganic horizons (L, F and H) was started. Ten collectors in total with an area of 0.25 m^2 each were installed on unthinned control stand (plot 1) and on comparative stand (plot 2) with thinning regime 2. Litter was collected four times per year. Concurrently, holorganic horizons (L, F and H) were investigated quantitatively and qualitatively on identical comparative plots. The steel frame 25 x 25 cm was used for sampling at three replications in October 2002. All samples from particular collectors were dried first on open air and afterward in laboratory at 105 ^{o}C and weighted. Nutrient content was assessed from composite samples from each comparative plot (after mineralization by mineral acids).

Results and discussion

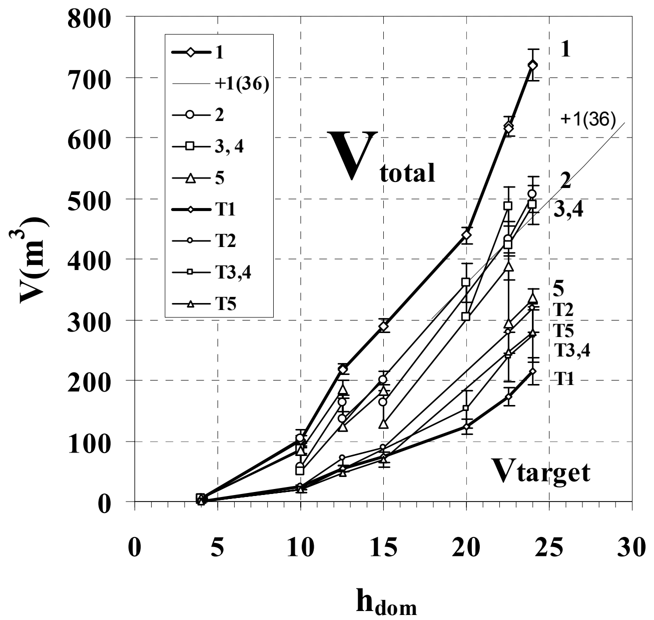


Fig. 1: Volume growth of experimental stands of series CZ - 13 Vitkov

From the evaluation of the data following conclusions can be drawn:

- The highest volume of stem-wood (718.5 m^3) is now (top height 24 m, the age of 37 years) accumulated on control plot 1, but only 30% of this amount on target trees. Treatments 2 and 3, 4 resulted in 507 and 488 m^3 of standing volume with 60 and 56% on selected crop trees (Fig. 1).
- The total production (including salvage cut) is the highest (754.3 m^3) on control variant without thinning.
- Volume accumulated on thinned variants 2, 3 and 4 is similar (from 467.1 m^3 to 509.3 m^3) and about 200 m^3 lower than on control, but the volume of the mean stem is two times higher (0.35 m^3 on control and 0.66 – 0.76 m^3 on thinned variants).
- The lowest standing volume was found on variant 5 (388 m^3 less comparing to control and 134 – 177 m^3 less comparing to thinned variants 2, 3 and 4). In favour of this variant should be noted that 95 m^3 of crop was removed in marketable wood (with mean stem volume of 0.44 m^3).
- Thinning significantly affected the stability of experimental stands. H/d ratio of mean stem, which ranged from 72 to 75 before the first thinning, increased on unthinned comparative plot to 107. All thinning regimes supported the diameter increment and therefore h/d ratio of thinned stands was kept in significantly lower level around 80 (Fig. 2).

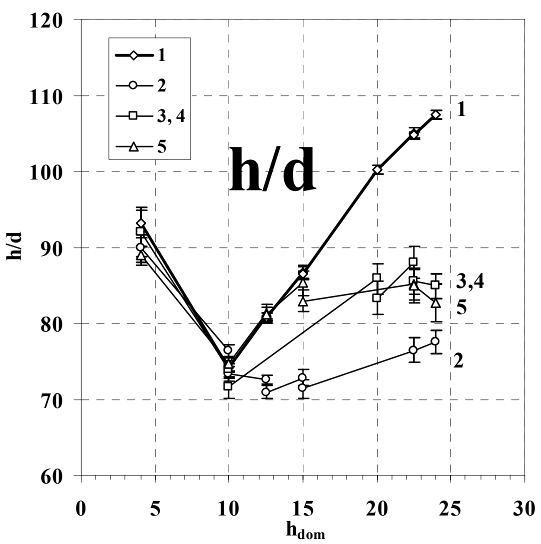


Fig. 2: Development of h/d ratio of mean stem on experimental stands of series CZ - 13 Vitkov

- The total weight of litter fall under 39 years old Norway spruce stand represented about 8,700 $kg.ha^{-1}$ on control stand 1 without thinning and about 8,500 $kg.ha^{-1}$ on heavily thinned stand 2.
- On the other hand, dry biomass accumulated in horizon L (litter) under experimental stand varied from 13,700 (control plot) to 10,800 kg (thinned plot) per hectare (Fig. 3). This means that horizon L contained biomass of 1 – 2 - year litter fall.
- In second horizon F (fermentation), from 22.9 (control) to 15.1 (thinned) thousands kg of dry biomass per hectare are stored. Most of dry biomass (about 60 thousands kg per hectare on both plots) is accumulated in horizon H (humus).

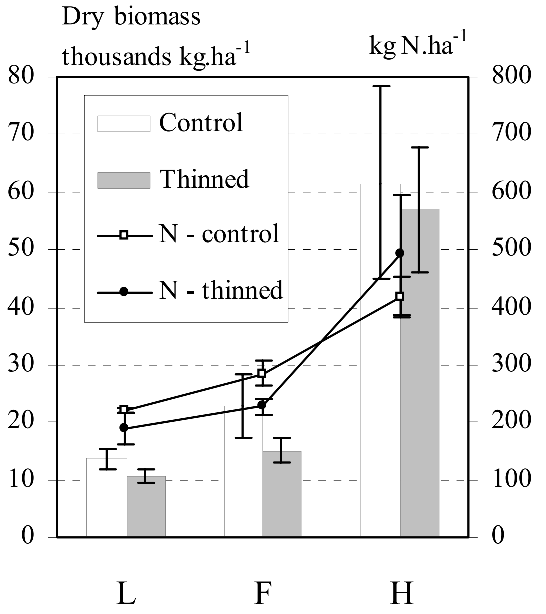


Fig. 3: Amount of dry biomass (columns) and Nitrogen (lines) in holorganic horizons L (litter), F (fermentation) and H (humus) with standard deviations (Sx) on control unthinned stand and on heavily thinned stand of European thinning experiment in Norway spruce CZ 13 – Vitkov in 2002 (age 39 years).

- Norway spruce monoculture produced (as litter) after almost 40 years from first planting on former agricultural land between 86 – 96 thousands kg of dry biomass per hectare, which are in holorganic horizons (L, F and H) stored now.

Norway spruce stands in Central Europe frequently grown as even-aged monocultures are heavily endangered by snow, ice and wind. The preventive measures against these harmful factors are based on keeping the most endangered young Norway spruce stands in loose canopy. This silvicultural practice is commonly accepted as a mean of stabilization to damage caused by abiotic factors - snow and wind (e.g. Chroust 1968, Persson 1969, Abetz 1976, Kramer 1980, Johann 1980). Results of the experiment Vitkov CZ – 13 confirmed this strategy and specified the main points of treatment, especially the beginning of thinning and its intensity. At the same time, very heavy thinning according to investigated programs did not cause any significant production losses.

The effect of examined Norway spruce stands of the first generation on forest soil was found very important. Detected litter-fall (8,700 - 8,500 $kg.ha^{-1}$) was higher than upper limits in other experiments. In experiment Polom (Podrázský 1996), annual amount of litter-fall varied from 1,800 to 4,800 $kg.ha^{-1}$ during the period of observation (the age of the stand 27 – 37 years). Similar result was found by Bille-Hansen and Hansen (2001) in forty years old Norway spruce stands. The foliar litter-fall at Ulborg, Lindet and Frederiksborg (Danish Norway spruce experiments) varied between the years from 1,100 to 5,700 $kg.ha^{-1}$. On the other hand, dry biomass accumulated in humus horizons L+F+H under experimental stand on former agricultural land varied around 86 – 96 thousands kg per hectare and it is only half of the amount found in forest soils under spruce cultures in experiment Polom (Novak, Slodicak 2004).

References

Abetz, P. 1976. Allg. Forst u.Jagdztg., 147:72-74.
Bille-Hansen, J. and Hansen, K. 2001. Scand. J. For. Res., 16:127–137.
Chroust, L. 1968. Lesnicky casopis, 14: 943-960.
Johann, K. 1980. Schriften Forstl. Fak. Univ. Göttingen..., 67:269-286.
Kramer, H. 1980. Schriften Forstl. Fak. Univ. Göttingen.., 67:224-235.
Novak, J. and Slodicak, M. 2004. Journal of Forest Science, 50, (3):101-108.
Persson, P. 1969. Thinning and mechanization, IUFRO Meeting, Stockholm. 169-174.
Podrazsky, V. 1996. Lesnictvi – Forestry, 42:237–241.

RESEARCH, COMMUNITY FORESTS, AND CITES FAVOR SUSTAINABLE SILVICULTURE OF MAHOGANY (*SWIETENIA MACROPHYLLA* KING) IN NATURAL TROPICAL FORESTS

Laura K. Snook[1,2]

[1]Center for International Forestry Research (CIFOR)
P.O. Box 6596 JKPWB, Jakarta, 10065, Indonesia
[2]Address as of June 18, 2004: The Elms, The Walk, Islip OX5 2SD, UK,
Tel. 44-1865-376-904; Email: l.snook@cgiar.org

Introduction

The most commercially important timber species in the Neotropics, mahogany (*Swietenia macrophylla* King) is still obtained from natural forests in Central and South America. Mahogany is at the crux of debates about the feasibility of sustainable forest management in the tropics, the role of logging in extinction, the potential of CITES to protect timber species, community forestry as a development strategy, and illegal logging. In 2002, mahogany was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES), largely due to the difficulties of ensuring regeneration of this shade-intolerant species after selective logging. Mahogany has been found to regenerate abundantly after catastrophic disturbances that create clearings, of which the most common in Central America are hurricanes followed by fire (Snook, 1996).

CITES listing requires that exporting countries produce mahogany sustainably. The most advanced efforts to do so are those of 125 communities that harvest multiple products from 800,000 ha of production forests on Mexico's Yucatan peninsula. Over the past 20 years, their foresters have developed inventories and management plans and overseen enrichment planting efforts while researchers have established experiments and studies, to evaluate how to overcome the difficulties of regenerating this species. Results of studies carried out over the past 7 years were presented at a workshop in Mexico in November, 2003, and government agencies and community organizations decided in January of 2004 to modify both their management guidelines and their forestry programs to take into account the new insights obtained.

Methodology

Studies were established in the production forests of the Mexican ejidos and Belize an to answer three key questions about mahogany regeneration ecology and silviculture: 1) what are the dynamics of seed production? (Snook et al. in review); 2) how large an opening is necessary for mahogany regeneration to survive and grow? (Snook et al. in press) and 3) what is the best way of creating clearings to favor mahogany regeneration (Snook & Negreros 2004)? A complementary study tested whether cleaning competing vegetation around mahogany seedlings favored their survival and growth. Experiments evaluated natural regeneration, seeding, and planting of mahogany seedlings.

Results and Discussion

Among 82 sample trees of which the seed production was quantified over 6 years, it was determined that trees > 75 cm dbh were by far the most productive of seed, as well as producing seed more consistently from year to year (Snook et al. in review). Since mahogany seeds have short viability retention of seed trees is crucial to ensure reproduction, whether natural or artificial. Retaining trees > 75 cm dbh represents a challenge in light of the current practice of harvesting down to a minimum diameter limit of 55 cm, which has depleted large mahogany trees on up to 80% of permanent forest reserves. Discussions are underway to decide which large mahogany trees should be retained for seed production.

Eight clearings 50 m X 100 m were created using each of three different methods: complete felling, machine-clearing, and slash and burn techniques. Mahogany seedlings were planted in the center of each clearing, and on controls under the forest canopy. Five years later, 50% of seedlings survived on machine cleared and burned clearings, but 32% on felled clearings. Only 5% of seedlings survived under the forest canopy. Seedling growth was also highest on burned and machine-made clearings, where mahogany trees had reached 6 m at 5 years. Cleaning of naturally regeneration of other species around mahogany seedlings was found not to significantly increase growth, except on felled clearings, but it did increase, more than three-fold, attack by the *Hypsipyla* shootborer. Creating favorable conditions for mahogany establishment (high light, absence of competition, control of sprouting potential) is both necessary and sufficient for successful regeneration and growth. Patterns were similar on experiments of natural regeneration on 5 replicates each of areas of 2700 m^2 downwind of mahogany seed trees, which had been treated in 4 different ways. Mahogany seedlings became successfully established on clearings produced by bulldozer, or by felling and skidding all trees, but not where overstory trees were girdled or left untreated (Toledo & Snook in press).

Experiments on 8 randomized complete blocks compared survival and growth of mahogany seedlings on complete clearings of 4 different sizes (from 500 m^2 to 5000 m^2), and under the forest canopy. Five years later, 47% of mahogany seedlings had survived on all clearings, but all seedlings planted under the forest canopy had died. Growth increased with opening size, but these differences were not statistically significant, possibly due to poor quality of some seedlings (Snook et al. in press).

These experiments confirm the futility of planting mahogany seedlings under the forest canopy and reveal that natural regeneration, sowing or planting, can be successful if conditions are created that mimic the hurricanes followed by fire, and shifting agricultural fields, that have favored mahogany regeneration in this region over past centuries. No additional treatments are necessary, at least during the first 5 years after mahogany establishment, to ensure survival and growth. While future mortality is unknown, it seems reasonable to expect that 100 mahogany trees could reach maturity on each hectare of clearing. This means that the number of mahogany trees currently harvested could be replaced if clearing and regeneration treatments were applied on 3-6% of each annual harvest area. Clearings should be at least 5000 m^2 in size.

When these results were presented and discussed among foresters, forest owners and government agencies in Chetumal, Quintana Roo, they agreed that guidelines for establishing seed tree reserves and implementing enrichment planting treatments, should be modified accordingly. None felt that they represented significant obstacles to sustainable production of mahogany from their forests.

References

Snook, L.K., 1996. Bot. J. Linn. Soc., 122, 35-46.
Snook, L. and P. Negreros-Castillo. 2004. Forest Ecology and Management 189:143-169.
Snook, L.K., Santos Jimenez, V.A., Carreón Mundo, M., Chan Rivas, C., May Ek, F. J., Mas Kantún, P. , Nolasco Morales, A. , Hernández Hernández, C., Escobar Ruíz, C.. 2003. Unasylva 214/215, Vol 54:68-73
Snook, Camara-Cabrales & Kelty. *In review*. Forest Ecology and Management.
Toledo & Snook. *In press*. Recursos Naturales y Ambiente.
Snook, Negreros-Castillo & O'Connor. In press. Recursos Naturales y Ambiente.

Acknowledgements

Experiments and studies in Mexico were funded by the World Wildlife Fund, US/USDA, by US MAB program, the Biodiversity Support Program (WWF, TNC and USAID), the US Dept of Education, Duke University, the Rockefeller Foundation, Mexico, Iowa State University, Caterpillar Inc., the Consejo Nacional para Ciencia y Tecnología (CONACYT), Mexico; the Dirección General de Educación Tecnológica Agropecuaria/Secretaría de Educación Pública (DGETA-SEP), Mexico and CIFOR, and carried out on the ejidos of the the Organización de Ejidos Productores Forestales de la Zona Maya (OEPFZM), facilitated by Victoria Santos. Experiments in Belize were funded by the EU, through the Programme for Belize; CIFOR, Duke University, the Tropical Resources Institute of Yale School of Forestry and Environmental Studies, the Park Foundation, and Caterpillar, Inc.

RESTORING BOTTOMLAND HARDWOOD FORESTS: A COMPARISON OF FOUR TECHNIQUES

John A Stanturf[1], Emile S. Gardiner [2], James P. Shepard [3], Callie J. Schweitzer[4], C. Jeffrey Portwood5[5], and Lamar Dorris[6]

[1] USDA Forest Service, 320 Green Street, Athens, GA 30602 USA;
Tel: +1-706-559-4316; E-mail jstanturf@fs.fed.us
[2] USDA Forest Service, Stoneville, MS USA
[3] National Council for Air and Stream Improvement, Gainesville, FL
[4] US Forest Service, Normal AL, USA
[5] Temple-Inland Forest, Diboll. TX, USA
[6]US Fish and Wildlife Service, Hollandale, MS, USA

Introduction

Large-scale afforestation of former agricultural lands in the Lower Mississippi Alluvial Valley (LMAV) is one of the largest forest restoration efforts in the world and continues to attract interest from landowners, policy makers, scientists, and managers. The decision by many landowners to afforest these lands has been aided in part by the increased availability of public and private incentive programs such as the Wetlands Reserve Program (WRP). The WRP provides a landowner with a one-time easement payment, technical expertise, and reimbursement for part or all of the afforestation costs. Large-scale afforestation is occurring on thousands of hectares in the LMAV (King and Keeland 1999; Stanturf et al. 2000; Schoenholtz et al. 2001).

Early results from the WRP were discouraging (Stanturf et al. 2001a); seedling and acorn survival rates were low, despite much available information on planting and direct seeding techniques (Stanturf et al. 1998). Although the basic techniques for afforesting native hardwood species have been worked out, few studies compared several techniques on the same site. In response to questions from managers, we undertook a study to compare operational techniques for afforesting bottomland hardwoods. In addition to standard approaches of planting bare-root seedlings and direct seeding acorns, we included an interplanting technique using a fast-growing, native species (*Populus deltoides* Bartr. ex Marsh.) with an oak species (*Quercus nuttallii* Palmer) and another treatment of doing nothing and depending upon natural invasion. The specific objectives of the study were to demonstrate and compare four restoration techniques in terms of survival, accretion of vertical structure, and species diversity.

Methodology

The study was located in Sharkey County, MS (N32°58’ W90 °44’), in the Yazoo River Basin. The land was actively cropped until the study was established. The hydrologic and edaphic conditions of the study site were typical of land available for restoration in LMAV. Soils were mapped as the Sharkey series of very-fine, smectitic, thermic chromic Epiaquerts. Sharkey soils consist of poorly drained clays formed in fine textured sediment in slack water areas in the Mississippi River floodplain. The shrink-swell nature of Vertisols results in 2 to 10 cm wide cracks up to 1.5 m deep that form under dry conditions, and close when saturated.

The experiment was a randomized complete block design with three replicates located in different portions of the tract. Treatment plots were 8.1 ha and approximately rectangular. Treatments were chosen to represent a gradient in restoration intensity, from natural invasion, direct seeding Nuttall oak, planting Nuttall oak, to interplanting eastern cottonwood with Nuttall oak. The natural invasion treatment was the baseline to compare passive versus active restoration. Direct seeding and planting bareroot seedlings are routinely used restoration techniques in the LMAV under federal incentive programs (Stanturf et al. 2000). The interplanting technique combines a fast growing species, eastern cottonwood, as a nurse crop for the slower growing oak. The cottonwood can be harvested in as little as 10 years, providing a financial return to the landowner (Stanturf and Portwood 1999).

Direct seeding and planting treatments were installed in February 1995 and the cottonwood was planted in the interplanting treatment in March 1995. Acorns for the direct seeding treatment were collected from nearby natural stands, placed in water and non-viable acorns that floated were discarded. Acorns were stored in ventilated polyethylene bags at 1.7 ^{o}C until sowing. Acorns were machine sown by Fish and Wildlife Service staff in May 1995. Spacing was 1.1 m by 3.7 m, with one acorn placed at each planting spot. Bareroot 1-0 Nuttall oak seedlings were obtained from a commercial nursery. Oak seedlings were machine planted by Fish and Wildlife Service staff in March 1995 at 3.7 m by 3.7 m spacing.

Eastern cottonwood cuttings were hand planted according to procedures used operationally by forest industry (Stanturf et al. 2001b). Four commercially available clones were planted at 3.7 m by 3.7 m spacing. Three clones had been selected from native populations along the Mississippi River (ST66, ST72, ST75) and one was from an east Texas population (S7C1); all four clones are used operationally. Clonal material was provided by Crown Vantage (now Tembek) and grown in their nursery at Fitler, MS. Two growing seasons later (March 1997), Nuttall oak seedlings were interplanted under the cottonwood. Oaks were planted between every other cottonwood row so the cottonwood can be harvested without damage to the oaks. Spacing for these oak seedlings was 3.7 m by 7.4 m.

Four permanent measurement plots were installed in each treatment plot in autumn 1995. Survival, height and diameter growth were measured in the active restoration treatments annually through the fifth growing season. Height and diameter data were collected for all woody stems in the natural invasion treatment annually beginning with the second growing season. The interplanted oak seedlings, planted after the second growing season of the overstory, were measured annually.

Results and Discussion

There were no significant differences in soil chemical properties at any depth between the four restoration treatments. Soil bulk density was not significantly different for the treatments, although there were significant differences between blocks. After five growing seasons, the cottonwoods were the tallest trees and had the greatest density. Height of planted oaks averaged almost 1.4 m and was significantly taller than the direct seeded and interplanted oaks, which did not differ. Even though the direct-seeded oaks had been growing on the site two years longer than the interplanted oaks, they were not significantly taller. The direct-seeded oaks had greater diameter than the interplanted and they accumulated more biomass

The abandoned soybean field was invaded over time by woody species disseminated by wind and by birds. Swamp dogwood (*Cornus stricta),* common persimmon (*Diospyros virginiana)*, green ash (*Fraxinus pennsylvanica)*, sugarberry (*Celtis laevigata)*, American elm (*Ulmus Americana),* hawthorns (Craetaegus species), cedar elm (*Ulmus crassifolia)*, honeylocust (*Gleditsia triacanthos)*, and deciduous holly (*Ilex decidua)* were the woody species found in the measurement plots.

This project was designed to test one alternative afforestation technique that combines a faster growing species with a slower growing species and to contrast this technique with more traditional approaches of planting bareroot seedlings or direct seeding of acorns. The control treatment for this study is to do nothing and allow natural invasion to occur. The early growth of cottonwood allowed for the rapid establishment of a forest canopy. The advantage of this canopy is that it may lend itself to accelerating natural succession by attracting birds and small mammals that are vectors for dispersal of heavy seed. The major disadvantage of pure cottonwood plantations to wildlife may be the paucity of hard mast. Although some may also feel that the intensive cultivation needed to establish cottonwood works against restoration goals, other studies have found that wildlife importance values for all wildlife food plants in cottonwood plantations studied peaked in the fourth, fifth and sixth growing season. The interplanting scheme under study here will provide for hard mast; once cultivation ceases after establishment, other herbaceous plants will establish.

Literature Cited

King, S.L. and B.D. Keeland. 1999. *Restoration Ecology* 7: 348-359.

Noss et al. 1995

Schoenholtz, S.H., J.P. James, R.K. Kaminski, B.D. Leopold, and A.W. Ezell. 2001. *Wetlands* 21: 602-613.

Stanturf, J.A., E.S. Gardiner, P.B. Hamel, M.S. Devall, T.D. Leininger, T.D. and M.L. Warren, Jr. 2000. *Journal of Forestry* 98: 10-16.

Stanturf, J.A. and C.J. Portwood. 1999. Pages 66-72 *in* J.D. Haywood, editor, Proceedings tenth biennial southern silvicultural research conference. U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, NC. General Technical Report SRS-30.

Stanturf, J.A., C.J. Schweitzer, and E.S. Gardiner. 1998. *Silva Fennica* 32:281-297.

Stanturf, J.A., S.H. Schoenholtz, C.J. Schweitzer, and J.P. Shepard. 2001a. *Restoration Ecology* 9:189-200.

Stanturf, J.A., C. van Oosten, M. Coleman, D. Netzer, and C.J. Portwood. 2001b. Pages 153-206 *in:* D. Dickmann, J. Isebrands, and J. Richardson, editors, *Poplar Culture in North America*. National Research Council Press, Ottawa, Canada.

SILVICULTURE FOR RESTORATION OF DEGRADED TEMPERATE AND BOREAL FORESTS

John A Stanturf[1], Palle Madsen[2], and Emile S. Gardiner[3]

[1] USDA Forest Service, 320 Green Street, Athens, GA 30602 USA
Tel: +1-706-559-4316; E-mail: jstanturf@fs.fed.us
[2] Danish Forest and Landscape Institute-KVL, Vejle, Denmark
[3] USDA Forest Service, Stoneville, MS USA

Introduction

Throughout the temperate and boreal zones, human intervention has influenced landscapes and forests for millennia. The degree of human disturbance has only been constrained by the technology and resources available to different cultures and by time since initial habitation. Humans have influenced forests by regulating populations of browsers, clearing for agriculture, keeping domestic livestock, cutting trees for fuel, building material, and fibre, introducing new species, using fire and suppressing fire. Today's forests are the result of all these disturbances, along with climatic change and species migration into postglacial landscapes. The ability of humans to affect forest ecosystems increased dramatically after the Industrial Revolution. Management has been extended to native forests over larger areas; at the same time, the switch from biomass to fossil fuels changed traditional forest management. Combustion emissions affect forests directly and through climate change.

Restoration is important for many interest groups in all countries, and in most countries occurs on both publicly- and privately-owned land. Nevertheless, the motivations for attempting restoration are diverse, reflecting the complexity of ecosystems, their current state and past land-use, and the human context of culture, economics, and governance. Restoration is undertaken within the policy framework of increasing sustainability by enlarging the area of specific ecosystems, enhancing biodiversity, or repairing ecosystem functions. The most common specific objectives for restored forests include timber, wildlife habitat for game species, or aesthetics. Increasingly other objectives are considered, including carbon sequestration, biological diversity, non-game mammals and birds, endangered animals and plants, protection of water quality and aquatic resources, and recreation.

Forest Restoration

Although widespread, there is little agreement on what constitutes forest. Broadly defined, it encompasses efforts to counteract negative effects of conversion to other land use (reconstruction, reclamation, replacement) and disturbance and stress on existing forests (rehabilitation, reclamation). In temperate and boreal forests, the focus is on restoring native forests and landscapes (Stanturf and Madsen 2004). Much of the literature focuses on restoring historic forests, although many restoration ecologists recognize that attempting to recreate historic forests is doomed to fail because the conditions under which they developed cannot be replicated (Hobbs 2004; Davis and Slobodkin 2004). A pragmatic approach to active restoration is to restore a desired species composition, stand structure, and natural functions within an acceptable time interval. Objectives are important and may depend on spatial or temporal scale. While sustainability values of biodiversity conservation and maintenance of ecological services increasingly are important objectives, private landowners who participate in restoration seek other values such as financial return. Long-term stability of restored forests will be assured if the full range of objectives is met.

Where remnants of the putative natural forest remain, or can be reconstructed from the historical record, the question of what is natural is hotly debated. Nevertheless, even these forests have been altered. It would be easy to conclude that there is no scientific basis for restoring natural forests because humans and climate change have so drastically changed the whole biosphere. Indeed, some restorationists conclude that choice of endpoint is inherently political, not scientific. Nevertheless, such choices are necessary in a restoration program and the rationale for the choice must be conveyed to the public. The task for restorationists is to interpret the scattered scientifically based knowledge of forest history, stand development, and natural processes, and combine it with practical experience to design objectives that improve sustainability. Understanding the dynamism of forest stands is critical to identifying appropriate operations for restoration. Changing concepts of forest ecology and how they have been applied to management and conservation include the shift from viewing forest ecosystems as closed, steady-state systems with predictable development patterns to the present view of open systems that operate opportunistically, with multiple developmental pathways following disturbance. To be successful, restoration efforts must adopt this dynamic view of forests. To be effective, restorationists will have to educate the non-technical restoration enthusiasts as well as the general public in this new paradigm.

Reconstruction

Forests are amazingly resilient and functioning forest habitat will develop whether or not we intervene, given sufficient time; for example large areas of agricultural land in the Tropics and the Commonwealth of Independent States appear to revert to forests annually (FAO 2001). Afforestation is an important component of forest reconstruction, particularly in Europe where forestland area has expanded in the 20th century, driven initially by the need of the war industry and the fear of a wood shortage. Afforestation and agricultural policy has been examined in tandem at the European level since 1968; afforestation was a way to address problems of agricultural overproduction and rural unemployment. Increasingly, afforestation is undertaken for ecological and amenity reasons. Perhaps the most important lesson learned from the European experience is that not everyone welcomes afforestation, even when programs are voluntary. In predominantly agricultural landscapes, planting trees may be seen as an assault on rural culture and traditional landscapes. Certainly there has been a backlash in many countries to the former afforestation practice of planting conifer species.

Rehabilitation

Because restoration requires on-going management, the silviculturist plays an important role in bringing to bear time-tested techniques to shape the development trajectory of a stand toward the desired condition, and to maintain the restored ecosystem. In boreal forests, the emphasis is on altering forest management to incorporate consideration of landscape-level concerns (biodiversity, disturbance regimes) as well stand structure and coarse woody debris. In temperate Europe, the main issue is conversion from single-species conifer plantations to broadleaved or mixed stands. In North America, present forests are composed of native species, however distributions and structures are not the same as they were before the influence of European settlers. In the western United States, the issue is restoration of fire disturbance regimes and reestablishing historic forest types and structures. These issues dominate thinking about forest restoration in the United States, and approach the notion of re-creation. Although logging, grazing and fire suppression have heavily impacted these forests, ample remnants of relatively undisturbed conditions remain. Alternatively, such "natural" forests can be discerned from the historical record or through stand reconstruction techniques such as dendrochronology. They are similar to approaches in boreal Europe.

Common Themes

Some similar concerns cross continental as well as national boundaries; for example, disturbance is a common theme. Besides the obvious link of disturbance to degradation and the need for restoration, restoring natural disturbance regimes is often a stated or implied goal. Fire in particular is a disturbance agent in specific ecosystem and natural fire regimes have been disrupted by decades of suppression.

What is natural is an issue; in addition to the effects of climate change on geological time scales, altered forest composition and structure due to human intervention can be found in all continents. Because of the dynamic nature of forest ecosystems, even without anthropogenic disturbances it is difficult to specify a natural forest in a given place and time. Nevertheless, a recurring theme is the return of forests to more natural conditions using nature-based silviculture to accomplish that goal. Native species are emphasized, although a case can be made to use what are clearly exotic species under some conditions. Even native species may be discriminated against if they are not site-adapted, which is one motivation for conversion of Norway spruce in Europe or other pines to longleaf pine in the southern United States.

Defining a "natural" stand structure is even more arbitrary. Given the luxury of large areas of contiguous forest under a single or a few owners, it is possible to restore to a diversity of stand structures on the landscape in roughly the same proportions as occurred historically with little human influence; that is to say, under mostly natural disturbance regimes. These conditions appear to exist in western North America; they may also exist in boreal Europe and Central and Eastern Europe. In more populous regions, however, nature-based silviculture that emphasizes restoring complex stand structures should stress the positive aspects of structural diversity in terms of stand stability. A cautionary note is in order. Restoration is not necessarily a win-win effort, especially for private landowners, and changing landscape conditions does not appeal to everyone. Restoration will succeed over the long-term if activities are framed in an economic perspective, with distinct, measurable objectives.

References

Davis, M. A. and Slobodkin, L. B. 2004. *Restoration Ecology* 12(1): 1-2.

Food and Agriculture Organization (FAO). 2001. *Global Forest Resources Assessment 2000*, FAO Forestry Paper 140, Rome.

Hobbs, R. J. 2004. *Frontiers in Ecology* 2(1): 43-44.

Stanturf, J. A. and Madsen, P. 2002. *Plant Biosystems* 136(2): 143-.

Stanturf, J.A. and Madsen, P., editors. 2004. *Restoration of Boreal and Temperate Forests.* CRC Press, Boca Raton. In Press.

GESTION DES PRODUITS FORESTIERS NON LIGNEUX EN AFRIQUE CENTRALE : REALITES ET PERSPECTIVES

Mathurin Tchatat* et Ousseynou Ndoye**

* Programme Forêt et Bois, Institut de la Recherche Agricole pour le Développement (IRAD) B.P. 2067 Yaoundé Cameroun E.Mail : coraf-foret.ac@iccnet.cm
** CIFOR Afrique Centrale B.P. 2008 Yaoundé- Cameroun E.mail : o.ndoye@cgiar.org

Introduction

Selon la FAO (1995), les PFNL sont formés des biens d'origine biologique autre que le bois ainsi que des services dérivant de la forêt et des systèmes d'utilisation de terre apparentés. Les forêts d'Afrique centrale sont des écosystèmes extrêmement riches en ces produits. Leur exploitation et leur vente fournissent des revenus non négligeables, en particulier aux populations rurales et urbaines les plus pauvres. Malgré cette importance, ils ne sont pas pris en compte dans les objectifs d'aménagement. Dans le cadre de cette étude, nous nous limiterons aux PFNL d'origine végétale.

Méthodologie

Cette étude s'est déroulée dans six pays du Bassin du Congo (Congo Brazzaville, RCA, Cameroun, Gabon, RDC et Guinée Equatoriale). Dans chacun de ces pays, nous nous sommes attelés à collecter des données primaires et secondaires. Les données primaires ont été obtenues à travers des enquêtes semi-structurées auprès de personnes concernées par la gestion des PFNL : chercheurs, décideurs, entrepreneurs privés, paysans et Organisations Non Gouvernementales (ONG). Les données secondaires ont consisté essentiellement en la recherche des ouvrages, articles scientifiques, rapports disponibles (y compris ceux de la littérature grise) et en leur synthèse.

Résultats et discussions

Modes d'exploitation des PFNL par les populations

Les PFNL sont exploités au quotidien par les populations, certains de façon très intensive d'autres moins. L'intensité de l'exploitation est fonction de la demande domestique et/ou commerciale du produit. L'impact de cette exploitation sur la structure et la composition de la forêt est étroitement lié à cette intensité mais aussi à l'organe végétal prélevé (fruits, feuilles, écorces, exsudats, tiges …).

En général, l'exploitation des fruits de petits arbres (*Trichoscypha, Garcinia, Coula*, etc.) ou des jeunes arbres productifs cause peu de dégâts sur la structure forestière en raison de l'accessibilité de leurs cimes. Par contre, lorsque l'arbre, devenu trop grand, n'est plus accessible aux cueilleurs, deux situations se présentent : soit ces derniers attendent la chute des fruits (si on utilise l'amande, cas des *Irvingia*, de *Ricinodendron*), soit ils abattent l'arbre afin d'en récolter facilement les fruits (cas des fruits juteux comme *Dacryodes macrophylla, Annonidium mannii*). Cette situation a été également observée au Gabon par Ada Ntoutoume (1997). Les méthodes d'exploitation par abattage ou ramassage total des fruits tombés sont aussi courantes mais, malheureusement nocives et typiquement non durables.

En Afrique Centrale, les feuilles des PFNL sont récoltées pour plusieurs usages et la récolte concerne les ligneux (arbres, palmiers) comme les herbacées. Parmi les espèces récoltées on peut citer les feuilles des arbres comme Bosqueia angolensis au Congo Brazzaville, *Dorstenia sp*. et *Hilleria latifolia* en Centrafrique, celles des palmiers raphia (*Sclerosperma mannii*, *Raphia vinifera*, *R. textilis*…) et de *Gnetum* (*G. africanum*, *G. buchholzianum*) dans toute la sous-région. L'exploitation du *Gnetum* est très intense et les méthodes utilisées sont particulièrement destructrices dans la plupart des pays. La méthode d'exploitation des feuilles d'emballage, espèces de la famille de MARANTHACEES permet la repousse des rejets.

L'exploitation des écorces médicinales (*Pausinystalia johimbe* et *Prunus africana* vendues sur le marché régional et international par les populations est très destructrice. D'autres espèces comme *Garcinia kola, G. lucida, Scorodophleus zenkeri* et *Afrostyrax* lepidophyllus écorcées plus ou poins intensément dans tous les pays. sont Pour le cas du Cameroun, des études comme celles de Sunderland et al. (1998), Ndjebet Ntamag (1997), Van Dijk (1998) et Guedje (1998) sont édifiantes.

Les racines de *Mondia whitei*, *Garcinia* spp., les sèves des certains palmiers, les tubercules du genre *Dioscorea* sont très exploités dans la sous-région. C'est le cas du peuple Téké-Tsaaya de la forêt dense humide du massif du Chaillu en République du Congo (Makita-Madzou et Profizi 1996).

L'effet genre et l'exploitation de la ressource
Les activités de production (cueillette, ramassage…) et de commercialisation des PFAB sont « partagées » entre hommes et femmes. En règle générale, les activités qui exigent un gros effort ponctuel dans le temps sont réservées aux hommes tandis que celles qui consomment plus de temps sont exercées par les femmes. Cette répartition du travail selon le genre a un impact sur la gestion des ressources en forêt. La variabilité de cet impact dépend de plusieurs facteurs parmi lesquels l'ardeur ou l'opiniâtreté à la tâche et la valeur du produit (économique et socioculturelle) sont les plus importants.

Influence des connaissances locales sur la gestion des PFNL
Les populations locales possèdent des connaissances approfondies en systématique et en écologies de leur écosystème en général et des différents PFNL qu'on y trouve en particulier. Ces connaissances peuvent utilement servir à la réalisation des inventaires, à l'exploitation et la domestication des PFNL La connaissance de la ressource et la maîtrise de son potentiel sont en effet des étapes essentielles à tout aménagement durable.

Réglementations forestières, tenure des ressources et gestion des PFNL
Nous entendrons par « tenure » des ressources le mode d'acquisition / d'appropriation des terres et/ou des arbres par un individu ou une collectivité, conférant ainsi à son bénéficiaire des droits sur le foncier et/ou les arbres et leurs produits. Les problèmes liés à la tenure sont le plus souvent délicats et déterminants pour l'avenir des arbres et des PFNL en particulier. Nous tenterons ici, d'examiner quelques problèmes liés à la législation forestière et à la tenure et leurs influences sur une possible gestion durable des PFNL dans la sous-région.

Exploitation de bois d'œuvre, Sylviculture et PFNL
L'exploitation forestière a un impact sur l'écosystème et les PFNL en particulier. En effet, l'implantation des infrastructures préalables à l'exploitation (route, campement, etc.), l'exploitation proprement dite (prospection, abattage, débardage, etc.) causent des dégâts sur la biodiversité en général mais, le tribut payé par les PFNL est bien plus lourd. De même, un nombre important de méthodes sylvicoles testées en Afrique centrale avant les indépendances sont encore pratiquées aujourd'hui. Elles utilisent la régénération naturelle et/ou artificielles. Les opérations sylvicoles (délianage, éclaircies, layonnage, etc.) inhérentes à ces méthodes sylvicoles et pratiquées naturellement en faveur des bois d'œuvres entraînent une destruction massive d'espèces potentiellement productrice de PFNL

Perspectives : aménagement pour le bois d'œuvre et les PFNL
Aujourd'hui en Afrique centrale, les nouvelles législations en vigueur ou en préparation mettent en général l'accent sur l'aménagement des forêts pour la seule production de bois d'œuvre. Pourtant, la question qui doit être posée est celle de savoir comment inclure la gestion et la production des PFNL dans les objectifs d'aménagement, y compris dans les forêts destinées essentiellement à la production

de bois d'œuvres. A notre avis, deux approches d'aborder la question s'offrent à l'aménagiste : une approche protectionniste dans les forêts où les PFNL ne constituent pas l'un des objectifs de l'aménagement (cas de la plupart des forêts de production) et une approche interventionniste dans les forêts où les PFNL constituent l'objectif principal ou secondaire de l'aménagement. C'est le cas de certaines forêts de production de bois, des forêts communautaires et des espaces agroforestiers. Ces deux approches ont besoin de l'appui de la recherche (notamment dans le domaine de l'écologie et de la domestication) et de l'Etat pour ce qui concerne les aspects réglementaires liés à la tenure des ressources (foncières et végétales).

Références bibliographiques

Ada Ntoutoume, E. 1997.- Etude des produits forestiers non ligneux alimentaires du Gabon. PAFT-Gabon

FAO. 1995 – Summary of recommendations. In report on the expert consultation on non-wood forest products, Yogyakara, Indonesia, 17-27 January 1995. Non-Wood Forest 3. FAO Rome.

Guedje, N., 1998. Ecologie et gestion de quelques PFNL de la région de Bipindi-Akom II (Sud Cameroun). Communication présentée à l'atelier Internationale sur la gestion durable des forêts denses humides africaines aujourd'hui. Forafri, Libreville-Gabon.

Van Djick, J.F.W., 1999. Non-timber Forest products in the Bipindi-Akom II- regions, Cameroun: a socio-economic and ecological assessment. Tropenbos Cameroun serie, The Netherlands.

Remerciement

Nous tenons à remercier sincèrement la Coopération Française, le CIRAD, le CIFOR et CARPE qui ont assuré le financement de cette étude à travers le Projet FORAFRI. Nous remercions également le CIRAD-FORET pour avoir révisé le document 18 de la série FORAFRI que nous avions rédigés et qui a largement inspiré le présent papier.

MANAGING FORESTS FOR NON-WOOD FOREST PRODUCTS: OPPORTUNITIES AND CONSTRAINTS

Paul Vantomme

FAO, Forestry Department, Forest Products and Economics Division,
Viale delle Terme di Caracalla, 00100 Rome, Italy
E-mail: Paul.Vantomme@fao.org

Introduction

For the past quarter century, non-wood forest products (NWFP) have been receiving increasing attention for their potential to improve the income of forest-dependent people. Since the 1992 United Nations Conference on Environment and Development (UNCED), NWFP have also been recognized as important elements in the conservation of forest biological diversity. The Convention on Biological Diversity (CBD), in its expanded Programme of Work on Forest Biological Diversity, advocates an "ecosystem approach" for conservation, sustainable use and benefit sharing of forest resources (www.biodiv.org/programmes/areas/forest/workprogramme.asp).

The concept of a balanced approach between conservation, sustainable use, and access & benefit sharing (ABS) of forest derived products and services (and which includes NWFP) is also endorsed by other (inter) national initiatives like: The Forest Principles, Criteria and Indicators for Sustainable Forest Management (like the Montréal Process, www.mpci.org/criteria_e.html); Forest Certification schemes (like the Forest Stewardship Council on non-timber forest products, www.fscoax.org/principal.htm); the "Model Forests Program"(www.rcfa-cfan.org/english/profile.16.htm); and by many national and local-level policies, programmes and projects by governments, donors and NGO's.

Can forests really be managed to accommodate these goals? What are the challenges for forest managers/silviculturalists to apply an "ecosystem approach" when managing forests for biodiversity conservation, for NWFP production, for income generation and ABS? Do we have the required technical knowledge to put into practice the concepts already endorsed by the above-mentioned initiatives? How best can we apply our current silvicultural knowledge and identify research needs to address these challenges?

Methodology

The conservation of forests, the sustainable use of forest products and services, and ABS are very complex and include a wide range of many different issues from social, financial, economic, silvicultural or environmental related fields. The conservation of forests and their biological diversity may be addressed through an "ecosystem approach", while the "use" of forest products is "species" based. ABS is more governed by socio-economic and (forest) policy considerations. This paper focuses on the impact of trade in NWFP on the forest resources, their management and biodiversity conservation; and on how trade in NWFP impacts on poverty alleviation and "social" equity along the chain from forest gathers to consumer.

NWFP are mostly for subsistence or non-commercial uses. Subsistence use is not a major threat to forests and their biodiversity; neither does it generate major silvicultural challenges or income. The resource supply for NWFP subsistence uses can be adequately covered through resource access/ harvesting permits. It is the commercial use of NWFP and particularly the increasing globalization of trade that causes major challenges for forest managers to protect the forest, its biodiversity, access and income of forest gatherers with their traditional knowledge, and for achieving more social equity along the producer-consumer chain. The key challenge for silvicultural research is how to assure a sustainable supply of NWFP for commercial use, and on the implications of global trade (in NWFP) for the forests, its management and for the (NWFP) producers.

By documenting production and trade statistics of key NWFP from selected countries and analysing their trends over the last decades, NWFP can be identified which see their production and trade increasing from those which are (becoming) obsolete. This helps to understand some of the underlying causes for the commercial success or failure of given (types of) NWFP and provides additional insights for forest managers, owners and researchers regarding which forest management and silvicultural interventions/research may be(come) more appropriate.

Results

Quantifying the production of NWFP in countries and their international trade is still a very challenging task as NWFP are most often under estimated or combined with agricultural statistics. However, at the country level, there are some remarkable examples of reliable time series on NWFP production and trade; such as for resins, gum Arabic, shea nuts, cork, bamboo and rattan (FAO).

The case of Brazil is a remarkable example of data availability for a large number of NWFP. Despite its huge forest resources, rich in NWFP, and the many efforts done over the last decades to promote NWFP commercialization, their (relative) economic importance is decreasing. The total production value in 2001 of 32 NWFP reported in IBGE amounts to 445 451 000 R$ (US$ 193 million at an average exchange rate for 2001: 1 US$ = 2.3 Real). This represents 12 % of the reported value of the declared wood output. With the exception of Açai (*Euterpe spp.* mainly from Para), maté (*Ilex paraguariensis* from southern Brazil, although cultivated) and piaçava (*Leopoldina piassaba* mainly from Bahia), there has been a significant reduction in the production quantities of the reported NWFP over the last 30 years, while during the same period wood production increased manifold.

A review of the available data showed that production levels of many NWFP (for commercial use) are declining in several countries over the last decades. The decline results from factors, like: (1) deforestation leading to a loss (extinction) of the resources; (2) social economic trends, which entails migration to urban areas, evolving towards more intensive and specialized farming systems with fewer people and less time left for NWFP gathering activities and increasing rural labour costs; (3) global trading practices leading to low(er) prices paid to producers (as several NWFP are (can be) imported or produced cheaper elsewhere) and; (4) shrinking markets for several types of NWFP due to cheaper substitutes (either synthetic's or farmed products).

Some NWFP are export commodities and have their own product code (HS) and data visible in (inter) national trade statistics (Comtrade). Most of these are exported in raw or semi-processed form. The world's total declared import value of 26 of the most important "NWFP" (globally traded) increased from US$ billion 1.9 in 1992 to US$ billion 2.1 in 2002, while the value of all declared international trade increased 2.5 times over the same period. For half of these 26 NWFP, their trade value declined or stagnated during the last 10 years, while the value of trade increased significantly for: natural cork, mosses and lichens for bouquets, truffles, mushrooms (other then *Agaricus*), chestnuts, bamboo, palm hearts and maple syrup. Interesting to note is that the NWFP with increasing trade values originate mainly from and are traded among developed countries.

Discussion

Opportunities for managing forests for NWFP are manifold and endorsed (indirectly) by various international Conventions and related initiatives. In addition, among governments, development agencies and particularly among NGO's, there is a high expectation in the possibility that (the commercial use of) NWFP can contribute to biodiversity conservation and income generation for forest-dependent people.

Constraints and challenges for managing forests for NWFP can be summarized as follows:

Technical feasibility: How to “merge” the ecosystem approach (or “close to nature forestry” and which may be well fit to conserve biodiversity with NWFP subsistence uses), with “species-based” silviculture for sustaining the supply of commercially used NWFP. Increasing commercial use/success of given NWFP species pushes silviculture to more intensive and specialized production-oriented forestry with lower biodiversity levels, and ultimately to (pure monoculture) plantations (such as in the cases of bamboo, pines or maté plantations).

Economic returns: (Global) trade (in NWFP) leads to increased competition to improve productivity/quality among producers and among products (and their substitutes). Commercially successful “NWFP” are increasingly being produced through farming/plantation systems; making “forest” based or gathered production and products less competitive and/or of lower quality (jungle rubber); ultimately reducing the economic value of these species in the forests in which they occur naturally. This may lead to clearing the forest for farming the crop (oilpalm).

Social equity: ABS issues related to the non-commercial uses of NWFP can be well addressed through forest access regulations and harvesting permits. For commercial NWFP, the forest gatherers tend to become more and more marginalized as trade volumes increase and their production becomes more intensified. In those cases, benefits go to the traders and farmers.

Key References

Comtrade data at: www.unsd.org/comtrade
IBGE, Instituto Brasileiro de Geografia e Estatistica Yearbooks. Diretoria de Pesquisas, Departamento de Agropecuária, Produção da Extração Vegetal e da Silvicultura, from 1972 till 2003 at www.ibge.br
FAO, Waicent at www.fao.org/waicent
HS. Harmonized Commodity Description and Coding System at: http://www.wcoomd.org

CONSTRAINTS AND OPPORTUNITIES FOR BETTER SILVICULTURE PRACTICE IN TROPICAL FORESTRY: AN INTERDISCIPLINARY APPROACH

Bradley B. Walters[1], Cesar Sabogal[2], Laura Snook[3] and Everaldo de Almeida[2]

[1] Geography Department, Mount Allison University,
Sackville, N.B. Canada E4L 1A7. Tel: +1-506-364-2323; E-mail: bwalters@mta.ca
[2] CIFOR Regional Office, Embrapa Amazonia Oriental, Trav. Eneas Pinheiro S/N,
66.095-780 Belem-Para-Brazil
[3] Center for International Forestry Research (CIFOR), Bogor, Indonesia

Introduction

Barriers to successful adoption of novel silvicultural practices are rarely just technical in nature (Walters, 1997; Pattanayak et al., 2003). Simply put, why do some forest users practice better silviculture than others? Diverse perspectives in the social sciences have been brought to bear on this question, but most efforts suffer from theoretical or methodological biases which undermine their utility for answering questions of interest to forest policy-makers (Yapa, 1996). This is because real world settings are complex and varied, and policy-makers need to understand this to predict whether specific practices are likely to be adopted by targeted end-users. In short, the adoption of novel silvicultural practices needs to be understood as a historical process, unfolding differently in different places.

We argue that research on silviculture practice can better serve the needs of policy-makers if it is approached more holistically and with the intention of answering clear questions about why particular users have, or have not adopted desired practices in particular situations. To achieve this, researchers should embrace a range of theoretical possibilities and deploy diverse methods as required to explain the adoption (or non-adoption) of particular silvicultural practices. Guided by open-ended “why” questions, researchers can then consider the potential influence of diverse local and non-local influences (Vayda and Walters, 1999). In so doing, they can identify with precision and in particular contexts the key mechanisms that have fostered adoption of desired practices, as well as critical barriers or constraints to such adoption. To illustrate this approach, we present three case studies of research on tropical silviculture practice from each of the Philippines, Amazonia and Mexico.

Results and Discussion

Mangrove tree planting and management in the Philippines

Silviculture of mangroves is uncommon, but policy-makers view it increasingly as essential to addressing challenges of mangrove restoration and management (ITTO, 2002). In the Philippines, recent attempts to emulate existing, long established “success stories” of local mangrove planting and management have met with little success. Research was undertaken to better understand and learn from two of these well known, successful cases. Specifically, the study sought to explain why mangrove planting and management had emerged and successfully spread in these cases, but not in others.

Evidence suggests that mangrove planting emerged in these two cases in the early- to mid-1900s, and spread as a response to local scarcities of construction wood. Yet, individual motivations to plant vary and have changed over time. For example, since the 1960s people increasingly plant to protect homes and fish pond dykes along the shore from storm waves and winds; to establish tenure claims over mangrove areas; and to appease government officials who now promote planting under various programs (Walters, 2004). The level of technical knowledge and experience also varies considerably among planters, and this can influence planting success. Mangrove planting in most villages was introduced and continues to be practiced most vigorously by a minority of intelligent, entrepreneurial persons. There is surprisingly little active knowledge sharing between planters: most learn by observing and imitating other successful planters. But even capable planters are often precluded from doing so because of lack of access to foreshore lands or because environmental conditions preclude successful establishment of seedlings.

Silvicultural practice and factors influencing their adoption in the Brazilian Amazon

The practice of silviculture in natural production forests of the Brazilian Amazon is a rare activity, in spite of several decades of extensive research and experimentation efforts with various silvicultural options and the legal obligations to undertake post-harvesting silviculture. Research was designed to identify and evaluate practices being used by forest enterprises, rural communities and farmers in different contexts and to gain a better understanding of factors influencing a wider adoption of silviculture by these actors.

Silvicultural practice in the region is restricted to local, isolated initiatives mainly from better organized forest enterprises and progressive small-scale farmers in traditional or older settlement areas. We identified a wide range of silvicultural experiences in the region, mainly using native tree species. Enterprises were mainly involved in commercial tree planting, and were primarily motivated to plant to secure medium to long term supply of raw materials, although the obligation by law to compensate extracted trees from natural forests with planted trees was also a factor. By contrast, small-scale farmers were mostly planting or tending the regeneration of preferred tree species as part of their agricultural systems. Silvicultural practice by them was viewed typically as an investment in the future for the benefit of their children and grandchildren. Planting was also viewed by many as a means to strengthening tenure claims to land.

The main factors constraining successful implementation and maintenance of tree plantings in the region were related to difficulties in obtaining and manipulating planting material, scarce knowledge about the management of native species, pests and diseases, poor technical support and a lack of financial resources. The availability of appropriate/relevant technical and economic information on selected native tree species and techniques, the strengthening of existing networks for seed banks and seedling production, the establishment of well designed extension programs, the access to financial resources and key adaptations in the legal framework were among the most needed recommendations given by forest users and other relevant stakeholders in order to encourage the development of a viable, competitive silviculture in the region.

Adoption of silvicultural practices by the ejidos of Quintana Roo, Mexico

The ejidos of Quintana Roo are communally owned areas which were granted to settlers starting in the 1930's, under Mexico's Agrarian Reform program. In 1984, as part of a nationwide transition, rights to harvest and sell industrial timber were granted to forest-owning ejidos whose timber had previously been concessioned to parastate forest industries. Today, over 150 ejidos in Quintana Roo are involved in commercial timber production, from a total of nearly 800,000 ha of permanent forest reserves. The most valuable timber species in these forests is mahogany (*Swietenia macrophylla* King), which has presented such regeneration challenges that it was listed on the Convention on International Trade in Endangered Species (CITES) in 2002 (Snook 1998; Blundell & Gullison 2003).

The Quintana Roo ejidos are global leaders in applying and refining silvicultural techniques to sustain this species in natural forests from which it is harvested. This reflects several factors: 1) Mexican forest laws, regulations and policies; 2) the personal commitment of trained, licensed foresters, most of them children of ejidatarios, to the development of successful forestry ventures by the ejidos; 3) the communal ownership and organization of ejidos, which provide both an incentive to manage for the long-term and the obligation of dedicating ones labor to agreed-upon communal projects, such as tree planting. These have been complemented by financial support from international donors, and the involvement of researchers who have carried out studies on sustainable silviculture on the permanent forest reserves of the ejidos, in collaboration with the foresters who write the management plans for these forests.

In conclusion, findings from these diverse studies indicate that a variety of factors may influence whether or not silviculture practices are widely adopted by forest users. These range from characteristics of the local environment and individual users (knowledge, motivation, etc.) to wider geographical, economic and political forces. Forest researchers and policy-makers can better identify key constraints and opportunities for silviculture in particular contexts if they approach research with clear questions and an interdisciplinary approach.

References

Blundell, A.G., and R.E. Gullison. 2003. For. Policy Econ. 5:395-405.

ITTO. 2002. Report of the ITTO International Mangrove Workshop. International Tropical Timber Organization, Yokohama.

Pattanayak, S.K., D.E. Mercer, E. Sills and J-C. Yang. 2003. Agrofor. Syst. 57:173-186.

Snook, L.K. 1998. *In:* R.B. Primack et al. (eds.) Timber, Tourists, and Temples: Conservation and Development in the Maya Forest of Belize, Guatemala, and Mexico. Island Press, Washington, D.C. pp. 61-80.

Vayda, A.P., and B.B. Walters. 1999. Human Ecol. 27:167-179.

Walters, B.B. 1997. For. Ecol. Manage. 99:275-290.

Walters, B.B. 2004. Human Ecol. 32:177-195.

Walters, B.B., A.M. Cadelina, A. Cardano, and E. Visitacion. 1999. Agric. Syst. 59:193-214.

Yapa, L. 1996. *In:* C. Earle et al. (eds.) Concepts in Human Geography. Rowman & Littlefield, Lanham, Maryland. pp. 231-270.

SILVICULTURAL STRATEGIES IN FOREST ECOSYSTEMS AFFECTED BY EXOTIC PESTS

Kristen M. Waring[1] and Kevin L. O'Hara[2]

[1]Department of Environmental Science, Policy and Management, 151 Hilgard Hall, MC 3110, University of California, Berkeley, CA 94720-3110, Tel: +1-510-643-2025, E-mail: kristen.waring@nature.berkeley.edu

[2]Dept. Environmental Science, Policy and Management, University of California-Berkeley, USA

Insects and pathogens are primary causal agents of disturbance in some forest ecosystems. Resulting damage varies from individual leaf, twig or branch to whole tree mortality to large-scale landscape level mortality. Management strategies for native pests are typically targeted at the stand level, while incorporating landscape level goals. As these pests have become recognized as natural disturbance agents, acceptance of varying levels of damage has increased.

Forest pests that have been introduced from another location (hereafter referred to as exotic) add complexity to the management of forest systems. Because these pests have not co-evolved with their hosts, they have great potential to cause widespread dieback and mortality. This mortality often exceeds damage levels observed under historic ranges of variability, to the extent that a host species' very future may be at stake. Introduction, establishment, and spread of exotic forest pests have been increasing at an alarming rate in the past 100 years, and show no signs of slowing. First line of defense for any country is an international quarantine to prevent future introductions. Eradication is a potential once a pest has been introduced, but is considered feasible only prior to a pest's rapid population growth and expansion. Domestic quarantines can be utilized to limit human vectored pest expansion within the new country. Within invaded zones, integrated pest management strategies may be the best approach to managing exotic forest pests.

Potentially, silviculture, as an integral part of an integrated pest management program, can be an invaluable tool in prevention, mitigation and restoration of forest systems threatened by an exotic pest (Gottschalk 1993). Strategies can be applied at the landscape, forest or stand scale, utilizing general principles of silviculture and pest ecology. Combinations of techniques are necessary to account for as much variability as possible in approaching each situation. While it is not possible to create one prescription for all pests, a focus upon more general philosophies will enable managers to evaluate and prescribe individual strategies for unique situations as they arise.

Preventative techniques are those that act prior to pest arrival in order to prevent or curtail damage. For example, in the case of gypsy moth in the Eastern United States, lowering stand density can slow the spread of gypsy moth across the landscape. Stands that have been thinning tend to show less overall defoliation than unthinned stands, although this may be an effect of both the removal of foliage and changing environmental condition (Liebhold et al. 1998). Taking this one step further, in a situation where only one host tree species is present, a barrier to movement may be created by removing the host species from a wide band around the infestation zone. There is evidence that two separate populations of white pine blister rust in the United States (introduced separately on the West and East Coasts) have not interbred due to a physical boundary – the midwestern United States -- where there is a geographical north -south zone of several hundred miles lacking a suitable host (Hamelin et al. 2000). In this type of situation, removing host species from such a large area is neither desirable nor feasible, but if pest dispersal capabilities were limited in distance, and the infestation zone small, this may be a feasible alternative. Local quarantines would also be necessary to prevent human movement of the pest outside the zone of infestation. Timing of management strategies can also be preventative, and written into management prescriptions. In the Pacific Northwest, restrictions on management activities, and road closures are enforced during the rainy season to prevent and slow spread of *Phyptophthora lateralis,* an exotic that is causing decline of Port-Orford-cedar in California and Oregon (Hansen et al. 2000).

Genetics and regeneration are silvicultural tools that have been extensively utilized in regeneration of tree following exotic pest invasion. In fact, much research undertaken in the 1900's involved questions surrounding tree resistance, interbreeding and accelerated selection. The most extensive programs in the United States involve resistance in the white pines (particularly sugar pine and western white pine) to white pine blister rust and the interbreeding of American chestnut with Asian chestnut. In the former case, efforts are focused upon accentuating and increasing genetic resistance in host trees that is already present (Kliejunas and Adams 2003). In the latter case, researchers aim to breed a hybrid chestnut with primarily American chestnut characteristics, bringing only resistance to chestnut blight from the Asian variety (Griffin 2000). These techniques also need to be coupled with other strategies, as pests evolve more quickly than their host trees, thus the genetic resistance may be quickly overcome.

Similar silvicultural strategies are frequently engaged in more than one phase of a pest invasion, depending upon the management objective. For example, group selection has been used to prevent spread of sudden oak death in Oregon, and as one component of whitebark pine restoration (affected by the exotic white pine blister rust) in Montana (Goheen et al. 2002, Keane and Arno 1996). Pruning, while costly, may allow a species to survive in the forest until reproductive maturity. Use of pruning should only be utilized in situations where pest ecology is fully understood, to prevent a costly investment in dead trees. White pine blister rust requires very specific temperature and moisture requirements for infection of white pine trees. These environmental requirements are more frequently met in certain species, in and around branches low to the ground. In addition, rate of spread within the tree dictates how far from the bole disease symptoms should occur if the tree is a pruning candidate. By removing the lowest branches, the microclimate surrounding the tree is changed enough to prevent pathogen infection.

Silviculture's current role in managing exotic forest pests is evolving from one primarily focused upon genetics to a broader scope, involving varying scales and strategies and a broad understanding of both host and pest ecology. In the future, silviculture has the potential to become even more important, providing the applied link between basic research and on-the-ground management. In particular, there is room for development of new, creative strategies for dealing with exotic pests, and in the realm of forest restoration, all encompassed within an overall matrix of an integrated pest management paradigm.

References:

Goheen, E. M., Hansen, E.M., Kanaskie, A., McWilliams, M.G., Osterbauer, N., and Sutton, W. 2002. *Phytopathology* 92(6 suppl.): S30.

Gottschalk, K.W. 1993. USDA For. Serv. Gen. Tech. Rep. NE-171. 49pp.

Griffin, G. J. 2000. *J. For.* Feb.22-27.

Hamelin, R. C., Hunt, R. S., Geils, B. W., Jensen, G. D., Jacobi, V., and Lecours, N. 2000. *Phytopathology* 90(10): 1073-1078.

Hansen, E. M., Goheen, D. J., Jules, E. S., and Ullian, B. 2000. *Plant Disease* 84(1): 4-14.

Keane, R. E., and Arno, S. F. 1996. Pages 51-53 in C. C. Hardy and S. F. Arno, eds. *The use of fire in forest restoration.* USDA For. Serv. Gen. Tech. Rep. INT-GTR-341, Ogden, UT.

Kliejunas, J., and Adams, D. 2003. CA Dept. For. & Fire Prot. Tree Notes No. 27. 4pp.

Liebhold, A. M., Muzika, R.-M., and Gottschalk, K. W.. 1998. *For. Sci.* 44(2): 239-245.

INVESTIGATING SCALE-DEPENDENT STAND HETEROGENEITY WITH STRUCTURE-AREA-CURVES

Eric K. Zenner

Department of Forest Resources, University of Minnesota, St. Paul, MN, 55108, USA
Tel.: +1-612-625-3733, E-mail: ezenner@umn.edu

Introduction

Understanding structural pathways and determining characteristic patterns of old-growth structure in natural stands are prerequisites for maintaining biological diversity, sustaining forest productivity, and enhancing and restoring old-growth ecosystems within managed ecosystems (Mlandenoff et al. 1993, Franklin et al. 2002). While old-growth forests are purported to exhibit the highest structural complexity, few studies have actually quantitatively evaluated structural complexity. Although structural components such as the average density of large trees, the range of diameters, number of snags, and amounts of coarse woody debris have been shown to be more variable in Douglas-fir old-growth than in mature and young forests (Spies 1990, Spies and Franklin 1991), a high variability in structural attributes may be a necessary but insufficient condition for high structural complexity. Because structural complexity is a spatial concept, processes influencing the spatial patterns of differently-sized neighbors ultimately determine the extent of realized structural complexity. For example, the structure of some old-growth stands in the Central western cascades of Oregon was no more complex than that of transitional forests at the stand-scale (Zenner 2004). On the other hand, structural complexity, like any measure to describe heterogeneity, is scale-dependent (Haila and Kouki 1994) and it is thus conceivable that old-growth stands may be structurally more variable across different scales than mature and young stands. The central objective of this paper was to investigate whether old-growth stands exhibit the highest structural complexity at any of the observed scales.

Methodology

The overall structure and the change in structural complexity of the living tree stratum were examined across scales in a chronosequence of 10 unmanaged natural stands located in the south central Cascade Mountains of Oregon. Both the old-growth index (I_{og}) that measures the similarity of a stand's structural components to those typically observed in old-growth (Acker et al. 1998) and the SCI that measures the three-dimensional structural complexity of forest stands (Zenner and Hibbs 2000) were used to test the hypothesis that old-growth stands have generally a higher structural complexity across scales than transitional and mature stands. To evaluate how the I_{og} and SCI were related to different scales, moving windows of 100, 250, 500, 1000, 2500, 5000 m^2 were randomly overlain onto stem maps of each of ten 1 ha stands. Windows were moved in 1 m increments from the southwestern to the northeastern corner of the plot, resulting in a total of 30,381 I_{og} and SCI values across all scales. At each scale, several statistics that describe the I_{og}- and SCI-distributions were calculated (e.g., minimum, 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th} percentile, maximum, standard deviation, inter-quartile range, and the range between the 10^{th} and 90^{th} percentiles and the range between the 5^{th} and 95^{th} percentiles). Plotting these indices against plot (window) sizes enables an evaluation of stabilization rate comparable to a species area curve. This "structural area curve" can be used in a comparable fashion, enabling contrasts of spatial heterogeneity as well as assessments of sample plot size. A repeated measures mixed model analysis design with a spatial power covariance structure (Littell et al. 1996) was then used to test for differences among three stand types (e.g., mature, transitional, and old-growth stands), a scale effect, and an interaction term between stand type and scale.

Results and Discussion

Multiple iterations revealed that within-stand variability of both I_{og} and SCI was dependent on plot sizes, with variation stabilizing with sub-plot sizes of 2500 m^2 and larger (Fig. 1). I_{og}-values exhibited an increasing variability from mature to old-growth stands at small scales up to 500 m^2. At scales between 500-5000 m^2, transitional stands exhibited the highest degree of variability. At larger scales (e.g., 2500 and 5000 m^2), mature and old-growth stands had generally converged on the I_{og}-values calculated for the whole 1-ha stand. These results indicate that old-growth stands have the highest small-scale structural variation, ranging from patches characteristic of young stands with narrow ranges in tree sizes to those that a highly structurally complex. In turn, at scales of 2500 m^2 and larger, plots incorporated most of the patch variations and exhibited typical old-growth I_{og}-values. All I_{og}-statistics, including both the mean and median I_{og}-values, depended on the scale used to assess them. Old-growth stands exhibited the highest I_{og}-values at all scales given sufficient sampling; larger scales, however, may be required to obtain consistent estimates in highly variable transitional stands.

Although the variability of the SCI was similarly a function of both stand type and scale, old-growth stands exhibited the highest variability in SCI-values at all scales, followed by transitional and mature stands. In all cases, statistics representing the variability of the SCI were significantly different between old-growth and transitional stands, as well as old-growth and young stands; mature and transitional stands were not different in structural variability. Although the minimum, 5th, 10th, and 25th percentiles of the SCI distributions were scale-dependent, differences of least squares means among stand types were not statistically significant. Starting with the median, old-growth SCI-values were significantly higher than those of mature stands. Starting with the 75th percentile, old-growth SCI-values were significantly higher than those observed in transitional stands. Although transitional stands had higher SCI-values than mature stands at the 75th, 90th, and 95th percentiles, maximum SCI-values were not significantly different. It can thus be concluded that the highest variability in SCI-values across all scales observed in old-growth stands are mostly due to the occurrence of greater SCI-values at the upper percentiles. Interestingly, when only analyzing SCI-values above 250 m^2, both mean and median SCI become scale-invariant, i.e., they were no longer statistically related to plot size (i.e., scale).

These findings support the conclusion that despite overall similar stand structural complexities between transitional and old-growth stands, old-growth stands seem to have more structural complexity at within-stand scales than transitional and mature stands. The exact proportions of high- and low-heterogeneity patches within a stand may thus determine if old-growth and transitional stands differ in stand-scale heterogeneity. These findings also have implications for minimum acceptable plot sizes for research projects that aim to characterize structural complexity. Sampling intended to characterize the old-growth condition of a stand using the I_{og} would thus require plot sizes in excess of 500 m^2 to achieve some stabilization across all age classes. The minimum plot size necessary for an unbiased estimate of the SCI may be 250 m^2. A quarter hectare may be a minimum acceptable plot size to compare stand-level structural estimates, and potentially even larger plot sizes may be necessary to estimate the aggregated structural heterogeneity in more complex old-growth forests.

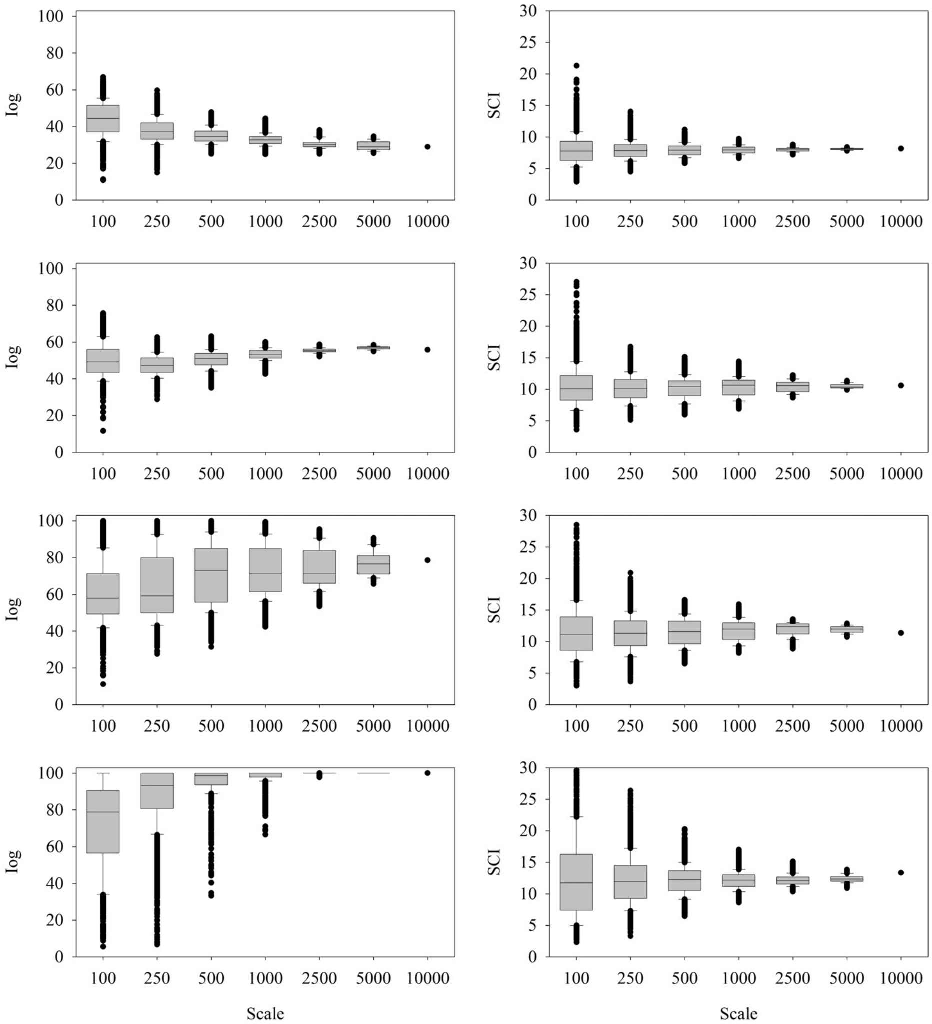


Figure 1. Structural area curves for the I_{og} and SCI across plot sizes. The first row represents a mature stand, the next two transitional stands, and the last an old-growth stand.

References

Acker, SA, Sabin, TE, Ganio, LM, and McKee, WA. 1998. For. Ecol. and Manage. 104, 265-280.

Franklin, JF, Spies, TA, Van Pelt, R., Carey, AB, Thornburgh, DA, Berg, DR, Lindenmayer, DB, Harmon, ME, Keeton, WS, Shaw DC, Bible, K. and Chen, J. 2002. For. Ecol. Manage. 155:399-423.

Haila, Y and Kouki, J. 1994. Ann. Zool. Fenn. 31:5-18.

Littell, RC, Milliken, GA, Stroup, WW and Wolfinger, RD. SAS System for mixed models, Cary, NC. SAS Institute Inc. 633 pp.

Mladenoff, DJ, White, MA, Pastor, J. and Crow, TR. 1993. Ecol. Appl. 3:294-306.

Spies, TA, 1990. Proceeding of the IUFRO's World Congress; August, 1990; pp. 116-127.

Spies, TA and Franklin, JF. 1991. USDA For. Serv. PNW-GTR-285, pp. 91-121.

Zenner, EK. 2004. For. Ecol. Manage. In press.

Zenner, EK and Hibbs, DE. 2000. For. Ecol. Manage. 129, 75-87.

THE FIRST ASPEN PLANTATIONS IN NORTH-WEST REGION OF RUSSIA

D.A. Chabounine, V.A. Podolskaja, and E.A. Bytchenkova

Saint-Petersburg Forestry Research Institute, Institutskii 21, Saint-Petersburg, Russia
E-mail: Shabunin@DS10809.spb.edu

Introduction

Because of change of economic conditions in Russia a lot of unused agricultural grounds have appeared in north-west region of Russia (Leningradskaia, Novgorodskaia and Pskovskaia oblast). These territories are overgrown with a bush now. The part of the grounds can be used for wood production. There were only the coniferous trees plantations up to the present moment in north-west region of Russia. The coniferous trees plantations will be attacked by *Heterobasidion annosum* (Fr.) Bref. in agricultural grounds. The aspen (*Populus tremula* L.) is the most perspective species for cultivation of wood plantations on these grounds.

The aspen is one of fast growing species in natural forests of Russia. But for a long time this tree was considered as undesirable species. However, since the 19th century due to works of Nesterov (1894), Kunitzkii (1888) and number of other scientists the attitude to an aspen has started to change a little. Now aspen wood is more and more used in various branches of a national economy. There is an interest to grow the healthy aspen wood.

Unfortunately, despite of many positive qualities of an aspen, it is subject to heart decay disease too much. In the age of 30-40 years up to 25 % and more trees are already infected (Iablokov, 1963). In mature age up to 100% of stems are attacked by disease in natural aspen woods. There is an assumption, that the large diffusion of heart rot is a consequence of an intensive negative selection of the best aspen stems and thus one is a result of human activity.

The aspen clones with fast rate of growth and tolerant to heart rot was found in Russia. Some of them are triploid. The great amount of aspen clones was found in virgin woods of the Kostroma oblast by A.S. Iablokov (1963). The collection of these clones is maintained in the nursery of Kostroma Forest Experimental Station now.

For the first time in Russia the works on wood species tissue culture were begun 1959 in Leningrad in Forestry Academy (Bytchenkova, 1978) and now proceed in Saint-Petersburg Forestry Research Institute.

Methodology

The initial materials (shoots) of 5 different aspen clones were received from nursery of Kostroma Forest Experimental Station and from Ivanteevka Forest Nursery (Moscow oblast). It was the following clones: No 15, 30, 34, 35, 36. No 15 is ordinary tolerant. No 34, 36 are gigantic female diploid. No 30, 36 are triploid.

The *in vitro* cultures of microshoots were created by two ways 1) differentiation of shoots from bud explants; 2) shoot induction in callus. For cultivation of the collection the MS medium (Murashige & Skoog, 1962) is used. Cultural conditions were maintained at 24°C using 24 h photoperiod.

Results and Discussion

The collection of aspen clone in axenic culture (*in vitro*) was created. This collection is maintained *in vitro* since 1999. It was found out that in January, February and March the cultures of microshoots cease to grow and the addition of phytohormones in medium is required. The additive of 0.1 mg/1 BAP (benzylaminopurine) and 0.02 mg/1 NAA (naphthaleneacetic acid) was effective for elimination of this phenomenon. The utilization in the beginning of year the phytohormones free medium only has resulted in loss of several lines of clones.

Aspen propagation with shoot cuttings and seeds is difficult. The method *in vitro* was used for aspen propagation. The technology of clonal micropropagation was developed. The clones No 15, 30, 34, 35, 36 were used. Then the stock was grown up in greenhouse.

The plantations were created in forest and agricultural lands in Gatchinskii, Boksitogorskii and Volosovskii district of the Leningradskaia oblast. After out planting of the first lots of the stock in plantations the large death of the planted trees was observed (50–70%). The structure of epidermal tissues generated in a greenhouse resulted in development of leafs and young shoots necrosis after out planting. The damaged trees badly have overwintered.

The best results were achieved in Boksitogorskii district. Preliminary acclimatization of plants after a greenhouse before out planting there was carried out. The plant losses after winter were within 10%. The plantation was created on agricultural ground. The planting places were placed 1x6 m. The weeds were removed with partly herbicide treatment.

The cultivation of aspens of elite genotype will increase the biodiversity and tolerance of the artificial phytocenosis.

References

Bytchenkova E.A. 1978. Callus proliferation and organogenesis in *Populus balsamifera* L. leaf tissues cultivated *in vitro* // Physiology of Plants, 25(2) – P. 274–281. (in Russian)

Iablokov A.S. 1963. Education and cultivation healthy aspen – Moscow, Goslesboomizdat, – 441p. (in Russian)

Kunitzkii B. 1888. Botanical and forest characteristic of an aspen with the notes concerning its use. Year-book of the St.-Petersburg institute, vol.2, – SPb (inRrussian)

Murashige T., Skoog F. 1962. A revised medium for rapid growth and bioassays with tobacco tissue Cultures. Physiol. Plant., Vol. 15 – P. 473–497.

Nesterov N.S. 1894. Importance of an aspen in Russian Forestry – Moscow,– 77 p. (in Russian)

THE STRUCTURE AND POSSIBILITY OF NATURAL REGENERATION IN THE MANAGED AND NON-MANAGED BEECH AND FIR FORESTS IN CROATIA

Tomislav Dubravac[1] Valentin Roth[1], Miroslav Benko[1] and Juro Čavlović[2]

[1]Forest Research Institute, Jastrebarsko, Cvjetno naselje 41 10450 Jastrebarsko, Croatia
Tel: +385 1 631-1583 E-mail: tomod@sumins.hr
[2]Forestry Faculty, Svetošimunska 25, Zagreb, Croatia

Introduction

The condition of fir selection forests today can be described as having a disturbed and often unstable selection structure, which leads to a sequence of changes. The following can be emphasised: absence of natural fir regeneration, decrease or increase in growing stock in relation to normal, and decrease in increment. Further changes are: ageing, physiological weakening and dieback of dominant trees, accentuated negative effects of climatic changes (warming and drought), acid rain and other pollutants of air, water and soil. Changes in the stand micro-climate should be stressed, which are caused by climatic and stand (structural) factors, forest soil degradation by weeds, erosion, decreased micro-biological activity, or accumulation of raw humus, the appearance of secondary pests which accelerate tree dieback, and aggressive accession of beech at the expense of fir. In view of the interaction of all these factors, some of which cannot be controlled, a possible answer lies in the formation of a selection structure by the application of correct and timely silvicultural interventions, in order to overcome the unfavourable effects.

Development of forests in natural conditions, in the area of the national parks in Croatia, and the possibility of natural reforestation, has been investigated by Dubravac, Benko and Čavlović (2003). All these authors advocate natural reforestation by assisting positive natural processes, for the purpose of permanent self-reestablishment (sustainability) of these stands. Growth and development of the fir in the management forests is currently investigated by Čavlović, Dubravac and Benko (2003), Benko, Dubravac and Čavlović (2003). Gersonde and O'Hara (2003), Laiho and Lähde (2003), Zingg and Gerold (2003) are investigating the structure and models of growth in mixed uneven-aged forests of fir, spruce and beech. Some authors study growing space efficiency, including Webster and Lorimer (2003), Maquire et al (1998). It was reported that different stand structure also conditions growing space efficiency, O'Hara et al (2001).

Methodology

Experimental plots, 100 by 100 m, were laid out. All trees on the plot larger than 7.5 cm in diameter were marked by numbers, and basic data recorded (dbh, tree heights and stem lengths), on the basis of which structural indicators (number of trees, basal area and volume) were calculated. For the purpose of monitoring the possibility of natural reforestation on the sub-plots, records were taken of the structure and numbers of young growth, as well as of the shrub layer, on an area of 360 m^2 (three strips, 2 x 60 m), and classified in height-age classes.

Research results and discussion

Distribution of the number of trees on both experimental plots indicates the entire absence of fir of the smallest diameter degrees, as well as the absence of medium diameter trees (Figs. 1 & 2). With the increase in dbh this difference disappears in the medium diameter trees (above 55 cm), and above this diameter there is an excess of large diameter trees. The results confirm that the accession of fir from natural regeneration has not occurred for some decades, the consequences of which are visible in the natural situation with dominance of the beech, i.e. showing the exchange of species. This situation was massively utilised by the beech, the distribution of which is essentially different. Thus, it filled in the lack of fir trees of the smallest diameter degrees. Biologically more aggressive beech filled the space in the underwood storey. The underwood part of a stand and its quality represent biologically important, perhaps the most important, part of the sand, which, with regard to the sustainability and structure maintenance of these stands, has enormous importance for the future.

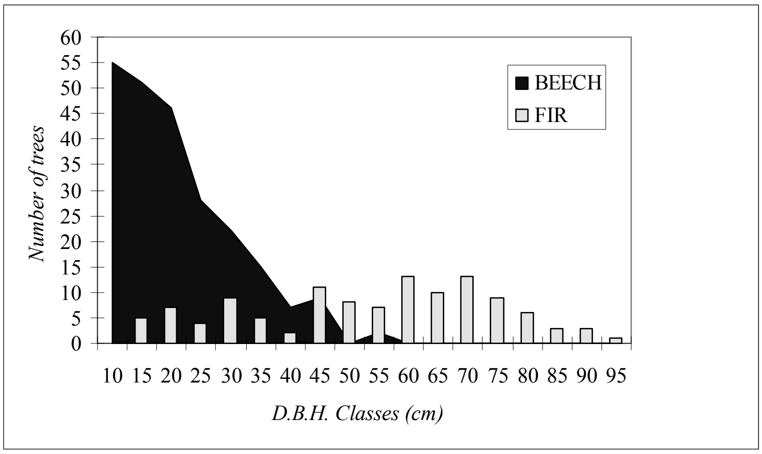


Fig. 1 Frequency distribution of the number of trees by dbh classes; plot in non-management forest

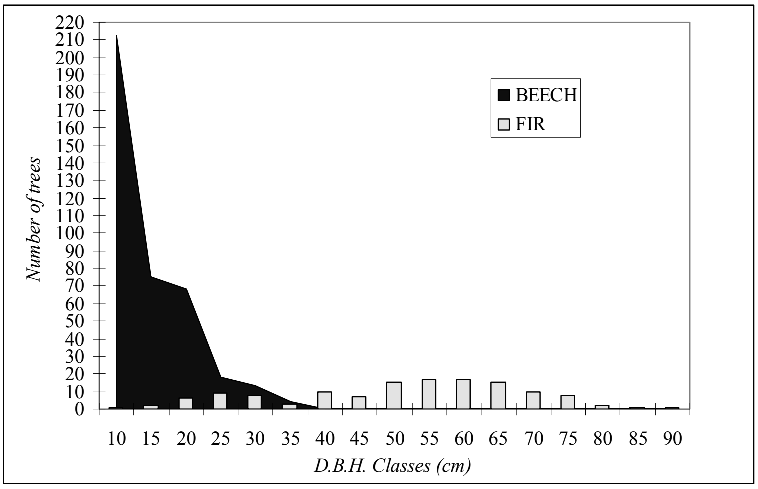


Fig. 2 Frequency distribution of the number of trees by dbh classes; plot in the management forest

On the basis of measurements taken of the state of the structure and the number and quality of young growth in the investigated stands of beech and fir on two experimental plots (Tables 1 & 2) it was confirmed that natural reforestation of the fir is doubtful. A considerable number of fir plants, amounting to 20 056 per hectare (without cotyledon), was registered on the plot in the national park. However, the majority of plants are in the seedling stage, as many as 92%, and only 8% in the development stage of young growth. In the Management forest the situation is still worse with regard to the number of fir plants. An insufficient number of fir plants was recorded of 4 250 plants per hectare (without cotyledon), out of which seedling plants amounted to 88% and young growth 12%. Thus, on both plots not one fir plant higher than 30 cm was recorded. It should also be stressed that the appearance and quality of this small mount of fir young growth is endangered by deer game.

Table 1. Number of saplings, young plants and young trees per hectare; plot in the non-management forest

Height-age class of vegetation (cm)		*Tree species*			
		FIR	*BEECH*	*OTHER TREES*	*SHRUBS*
Saplings		11111			
to 30	One year	18417	83	7056	556
	Several years	1639	3833	9333	2833
Sub-total to 30		**20056**	**3916**	**16389**	**3389**
31-60			1194	139	2361
61-130			417	28	1333
131-150			28		
151-200			83		
201-250			139		
251>			361	28	
Total		**31167**	**6138**	**16584**	**7083**

Table 2. Number of saplings, young plants and young trees per hectare; plot in the management forest

Height-age class of vegetation (cm)		*Tree species*			
		FIR	*BEECH*	*OTHER TREES*	*SHRUBS*
Saplings		11361			
to 30	One year	3722			
	Several years	528	500	31861	3139
Sub-total to 30		**4250**	**500**	**31861**	**3139**
31-60			55	56	1472
61-130					667
131-150			28		
151-200			28		28
201-250					56
251>			28		55
Total		**15611**	**639**	**31917**	**5417**

All the results indicate the questionability of satisfactory natural reforestation and future existence of these stands. Namely, permanent, continuous natural reforestation is the fundamental condition for the existence of adequate structure in the preservation of biological diversity, and the basic aim of the stability of the investigated forest stands.

Conclusion

Distribution of the number of trees indicates the entire absence of fir of the smallest diameter degrees, and the absence of medium diameter trees. With the increase of dbh this situation changes in the medium diameter trees (over 55 cm), and above this diameter there is an excessive number of large-diameter trees. The beech, with essentially different distribution, aggressively took advantage of this situation. In the smallest diameter degrees it filled in the lack of fir trees. This confirms that for several decades accession of the fir from natural regeneration has not taken place, the consequences of which are visible in the exchange of tree species. Numbers, quality and vitality of young growth on the observed experimental plots, does not ensure further development of the expected normal process of natural reforestation. The results of the measurements of young growth indicate that the appearance and quality of even this small number of young fir growth is further threatened by the deer wildlife.The results presented suggest the questionability of satisfactory natural reforestation and survival of these stands. The stability of continuous natural reforestation is the basic condition for the existence of permanent and stable selection structure in the preservation of biological diversity, and basic objective for maintaining the stability and sustainability of the investigated stands.

References

Benko, M., T. Dubravac, J. Čavlović 2003: Growth and increment of fir in selection forests of Croatia. IUFRO Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation), 6 pages.

Čavlović, J., T. Dubravac, M. Benko 2003: SD simulation model as support in regulation of selection stands with irregular structure and absence of recruitment. IUFRO Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation), 6 pages.

Dubravac T, M. Benko, J. Čavlović 2003: Application of digitalisation in studying the structure of uneven-aged stands in non-economic forests of Croatia. IUFRO Internacionalni Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation), 5 pages.

Gersonde, R., K. O`Hara 2003: Developing stocking guidelines for uneven-aged mixed-conifer forests using a process oriented growth model. IUFRO Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation).

Laiho, O., E. Lähde 2003: Proposal for stand structure classification. IUFRO Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation), 4 pages.

O`Hara, K.L., E., Lähde, O, Laiho, Y. Norokorpi and Y. Saksa 2001: Leaf area allocation as a guide to stocking control in multi-aged, mixed-conifer forests in southern Finland. Forestry 2, pp. 171-185.

Maguire, D.A., Brissette, J.C. and GU, L., 1998: Crown structure and growth efficiency of red spruce in uneven-aged, mixed-species stands in Maine. Can. J. For. Res. 28, pp. 12333-1240. Abstract-GEOBASE. Full Text via CrossRef.

Webster, C.R. and C.G. Lorimer 2003: Comparative growing space efficiency of four tree species in mixed conifer-hardwood forests. Forest Ecology and Management, Volume 177, Issues 1-3, April, pp. 361-377.

Zingg, A., D. Gerold 2003: Stand structures and patterns of diameter and height growth in uneven-aged stands. IUFRO Interdisciplinary Conference and Field Tour, «Uneven-aged Forest Management: Alternative Forms, Practises, and Constraints» Finland and Sweden, june 8-17, 2003., (oral presentation).

IMPACT OF FARMERS' PRACTICES ON ECOLOGICAL PROCESSES OF *VITELLARIA PARADOXA* (SHEA TREE) IN THE PARKLAND OF SOUTHERN MALI

Bokary Allaye Kelly [1], Nicolas Picard [2], Sylvie Gourlet-Fleury [2] and Jean-Marc Bouvet [2]

[1] Institut d'Economie Rurale, Programme Ressources Forestières Centre Régional de la Recherche Agronomique de Sikasso, BP 178 Sikasso, Mali
[2] Cirad –Forêt, Campus International de Baillarguet, TA 10C, BP 5035, 34035 Montpellier, France,
E-mail: jean-marc.bouvet@cirad.fr,

Introduction

Parklands, defined as a regular, systematic and ordered presence of trees in the fields (Sautter, 1968, cited by Bagnoud *et al*. 1995), are the result of a long evolutionary process during which association between natural elements (trees and shrubs conserved, maintained and enhanced because of their utility) and crops happens within a regularly exploited space (Raison, 1988). *Vitellaria paradoxa* (karité in French or shea butter tree) is an important tree species in sub-saharan parklands. Butter extracted from the kernel of this tree species is used for local consumption and is an important source of income for rural women.

Human practices through the management undertaken according to the type of land use are likely to have an influence on several aspects in particular on the dynamic of trees species, which are elements of the system. The dynamic of *V. paradoxa* may therefore be well influenced by human activities ; authors like Pélissier (1980) stated that the expansion of *V. paradoxa* is linked to human activities

However it is noticeable that the impact of human practices on the ecology, the spatial distribution, and the genetic diversity of *V. paradoxa* has been poorly investigated and a strong research is needed. We carried out this study in Southern Mali (West Africa) with the objectives of studying the impact of human practices on:

- the spatial distribution of *V. paradoxa*,
- the phenology and natural regeneration of the species, and finally,
- the genetic diversity dynamics.

Methodology

Two sites (MPeresso and Koumantou) and three stands (field, fallow and forest) where retained. In each stand, karité trees were marked, measured, monitored for spatial, and dynamic studies. Descriptive statistics were used to study the growth of adult trees and the dynamic of natural regeneration. Flowering and fruiting were described and analysed using logistic regressions. The spatial distribution of trees were analysed using spatial statistics (Ripley's K-hat function) (Kelly et al., 2004a). Molecular markers (microsatellites) were used to study the structure of the genetic diversity and its temporal and spatial dynamics (Kelly et al., 2004b).

Results and Discussion

The spatial pattern of *Vitellaria paradoxa* became progressively more aggregated from field to fallow and to forest (Kelly et al., 2004a). Hence in fields, the spatial pattern was just a little aggregated (case of Koumantou) or tended to be regular at small distances and then randomly distributed at other scales (case of Mperesso). The aggregation may be explained by the seed dispersal mode of *Vitellaria paradoxa,* but its superiority at Koumantou may be due to the intensity of the regeneration and the higher production of fruits at this site - as observed during two years of phenology monitoring (Table 2). The more aggregated pattern can also be explained by different agro-climatic conditions, which are more favourable at Koumantou compared with Mperesso (1000 – 1100 mm versus 680 mm of annual mean rainfall), and the level of land use pressure (higher at Mperesso compared to Koumantou because of the high level of cotton production, using more mechanised agriculture).

The distribution of the regeneration, its density and its growth were found different when comparing the fallow to the forest. In the fallow, the regeneration was met across the whole parcel whereas in the forest it appears in patches very often under *Vitellaria* trees or under other trees species. Table 1 shows the averaged values of several parameters measured on the natural regeneration of *V. paradoxa*.

High level of flowering and fruiting was observed in all treatments at Koumantou, whereas at Mperesso, only the field shows a high level of flowering and fruiting (Table 2). Variations according to year were also observed in each site.

Table 1. Average parameters of natural regeneration of *V. paradoxa* in the two stands (fallow and forest)

	FALLOW		FOREST (type of patches)						FOREST (all types)	
			RUV		RUOS		RWACA			
Averaged Parameters	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**
H (cm)	152.4	139.4	105.7	103.2	117.8	137.1	87.0	84.8	105.1	107.2
CGL (cm)	13.4	12.1	9.2	8.7	9.5	10.6	5.4	9.5	8.4	8.6
CBH (cm)	13.0	12.2	8.0	6.6	8.0	6.3	5.3	9.5	7.38	6.7
Density of seedlings (nb/ha)	6330	7060	12997	15196	5343	5561	20354	18424	1100	1086

H: height; CGL: Circumference at Ground Level; CBH: Circumference at Breast Height;.
RUV: Regeneartion Under Vitellaria trees; RUOS: Regeneration Under Other Species; RWACA: Regeneration Without Any Cover Above

Table 2. Results of the monitoring of flowering and fruiting for *V. paradoxa* at Koumantou and Mperesso in southern Mali

	KOUMANTOU						MPERESSO					
	Field		Fallow		Forest		Field		Fallow		Forest	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Marked	100	100	100	100	100	100	100	100	100	100	100	100
Monitored	100	100	100	100	100	92	100	98	99	99	100	100
Flowered	97	99	96	94	77	69	82	95	10	15	16	23
Fruited	91	97	93	94	61	60	60	61	0	0	5	7
Died	0	0	0	0	7#	8#	0	2#	1¤	1¤	0	0

7 individuals died in the forest at Koumantou in 2001 were cut by the farmer; another trees was also cut in yielding to 8; the 2 individuals died in field at Mperesso were also cut by the farmer.
¤ 1 individual was broken by wind in the fallow at Mperesso.

From logistic regressions, it appears that site is very important factor explaining flowering of *Vitellaria paradoxa*. This analysis allowed also to realise that site is not the only important factor since treatment i.e. the way the stand is managed by the farmers in each site as well as parameters of individual trees like the girth are or could be important in explaining the flowering.

As far as the genetic diversity is concerned, the inbreeding coefficients were not significantly different from zero in most cases ($F$is = -0.025 in forest and 0.045 in fallow), suggesting that the species is probably outbreeding. There was a weak decrease of *F*is with age, suggesting inbreeding depression. Differentiation of stands within each cohort was weak (*F*st = 0.026**, 0.0005ns, 0.010ns for adults, juveniles and regeneration), suggesting extensive gene flow. Cohorts within each stand were little differentiated (*F*st = -0.001 and 0.001 in forest and fallow, respectively). The spatial genetic structure was more pronounced in the fallow than in the forest where adults showed no spatial structuring. So, despite the huge influence of humans on the life cycle of *Vitellaria paradoxa* growing in parkland systems, the impact on the pattern of genetic variation at microsatellite loci appears rather limited (Kelly et al., 2004b).

It appears from this study, that human activities through land management (field, fallow, forest) influence many aspects of *V. paradoxa*. The intensity of this impact varies however according the studied domain. For instance when considering the spatial distribution, the phenology, and the natural regeneration, the impact of human practices is obvious in the sense that the field appears to be highly better than the fallow and forest in regularity of the distribution of trees, in flowering and fruiting. Because of human activities, the fallow appears to be better than the forest in installation and growth of natural regeneration because of previous activities and management mode. But when considering the genetic diversity and its structure, the impact is less obvious (weak variation of genetic diversity parameters, weak differentiation of stands and cohorts, weak spatial genetic structure) possibly because of the buffering effect of extensive gene flow among unmanaged and managed populations.

Acknowledgements

We are very grateful to EU and INCO DC (contract no. ERB I C18-CT98-0261) for the financial assistance and the way the project was managed, to IER (Mali) and Cirad-forêt (France).

References

Bagnoud N, Schmithüsen F, Sorg J-P. 1995. *Bois et Forêts des Tropique*, n° 244, 9-25.
Pélissier P. 1980. ORSTOM
Petit RJ. 2001. *Forest Ecology and Management,* 5692, 1-22.
Kelly BA, Bouvet J-M, Picard N. 2004a. *Agroforestry Systems*, 60, 3-11.
Kelly BA, Hardy O, Bouvet J-M. 2004b. *Molecular Ecology*, 13, 1231-1240.

PLANTATIONS FORESTIERES ET GESTION DE LA FORET NATURELLE : OPPOSITION OU COMPLEMENTARITE DANS LE BASSIN DU CONGO ?

Bernard Mallet [1] et Jean Noël Marien [2]

[1] Cirad Campus international de Baillarguet, BP 5035, 34032, Montpellier Cedex 1, France
[2] UR2PI, BP 1264, Pointe Noire, République du Congo

Introduction

Le Bassin du Congo est l'un des trois grands massifs de forêts tropicales avec l'Amazonie et l'Asie du Sud Est. Bien qu'une surface importante soit encore à l'état de forêt « primaire » et que des populations indigènes y vivent, l'exploitation du bois d'œuvre y a été initiée il y a plus d'un siècle. Cette exploitation a d'abord été initiée pour l'approvisionnement en bois (*Okoumea klaineana, Terminalia superba, Entendrophragma utile, Entendrophragma angolense*, …) des métropoles à l'époque coloniale, et s'est poursuive et amplifiée après les années soixante pour l'approvisionnement des marchés tant européens que locaux, et plus récemment des marchés asiatiques.

Les administrations forestières de ces pays se sont souciées dès le début du vingtième siècle de la pérennité de la production de bois d'œuvre de qualité, et ont commencé à enrichir ou à replanter sur des surfaces limitées certains massifs forestiers surexploités, avec des résultats très variables suivant les contextes.

Ce n'est que plus récemment, vers les années 70/80, que les recherches forestières ont été réorientées vers la gestion des forêts naturelles, débouchant vers les années 90 que les stratégies conjointes des bailleurs de fonds et agences de coopération (GTZ, CDC, AFD, UE, …), des organisations internationales (FAO, OIBT, UICN, …), des administrations forestières nationales et de sociétés d'exploitation forestière ont convergé sur la nécessité de la définition puis de la mise en œuvre de plans d'aménagement.

On estime cependant à près de 500.000 ha (FAO, 2001) les surfaces annuellement déforestées dans le Bassin du Congo.

Méthodologie

Différentes études ont été initiées ou menées au cours des cinq années passées, sur les dynamiques passées et présentes en matière de plantations forestières, en particulier en République du Congo, au Gabon, au Cameroun, et en République Démocratique du Congo.

Ces études ont porté à la fois sur les réalisations effectives, sur les dynamiques en cours, et sur les déterminants de ces évolutions.

En complément, les actions en cours relatives à l'aménagement des forêts naturelles ont été examinées et analysées, qu'elles concernent l'évolution des politiques et des outils économiques, les réalisations opérationnelles ou les déterminants des positions des acteurs.

La place des réalisations de plantations forestières, d'interventions en enrichissement ou d'actions de restauration écologique est ensuite examinée dans une perspective à la fois d'aménagement durable des massifs forestiers et d'aménagement à l'échelle du territoire.

Résultats et discussions

Les plantations, des actions anciennes : Les études ont montré que des programmes de plantations ont d'abord été initiés par les administrations forestières, des années 1950 à 1980 avec la mise en place d'arboreta, puis la réalisation de plantations d'espèces locales de lumière à croissance relativement rapide, comme l'Okoumé ou le Limba. L'objectif en était de permettre d'assurer un approvisionnement durable avec ces espèces, en particulier dans les zones de proximité des ports et des unités de transformations. Ces plantations sont souvent encore présentes, mais avec des stratégies de gestion souvent incertaines

Des programmes de plantations avec des espèces exotiques comme les eucalyptus (*eucalyptus uroxgrandis*), les pins (*pinus caribaea*), les acacias australiens (*acacia mangium*) ont ensuite été initiés dans les années par des sociétés mixtes associant capitaux privés et intervention de l'état (Sogacel, Cellucam, UAIC, …), avec comme objectif le développement de plantations pour la production de pâte à papier. A l'exception de la république du Congo, ces plantations ont souvent été abandonnées faute d'un tissu industriel permettant de la valoriser, voire ont été réorientées vers d'autres objectifs (bois de feu, bois de service).

Des actions d'enrichissement (plantations sous layons d'espèces locales de valeur, en particulier) avaient été développées dans les années 50, avec des résultats considérés comme assez mitigés même si peu d'études approfondies ont été réalisées sur ce type de plantations. Les nouvelles considérations relatives au maintien de la biodiversité, voire aux enjeux de la certification redonnent une nouvelle jeunesse à ces approches par le biais de la restauration écologique des forêts après exploitation.

Les nouveaux enjeux des plantations : un aménagement durable des formations forestières naturelles ainsi que la prise en compte des enjeux de la conservation de la biodiversité avait entraîné une forte diminution de l'intérêt pour les activités de plantations dans le Bassin du Congo, parfois considérées comme décalées par rapport aux vrais enjeux de la région.

De nouvelles questions sont apparues au cours de la décennie passée, permettant de ré aborder la question de l'outil « plantations » dans un contexte nouveau :

- le développement de villes de plusieurs missions d'habitants, consommant un volume croissant de bois de feu et de charbon de bois, et nécessitant un approvisionnement important en volume d'une biomasse ligneuse,
- le développement des concepts de la restauration écologique, du maintien d'espèces forestières clefs, dans des formations naturelles dégradées par une exploitation trop intense,
- le développement de critères et indicateurs de gestion durable (OIBT, CIFOR, …) en relation avec certains mécanismes de certification (FSC, PAFC, …),
- la possible mise en œuvre du mécanisme de développement propre (MDP) permettant de valoriser le carbone stocké par des plantations forestières.

Les plantations forestières sont donc à considérer dans le Bassin du Congo non pas comme une alternative à l'exploitation des forêts naturelles, mais comme un ensemble d'outils diversifiés dans leurs approches comme dans leurs objectifs, pouvant s'intégrer dans une stratégie de gestion durable des massifs forestiers, comme dans une stratégie plus globale au niveau national d'aménagement du territoire. Le partenariat pour le Bassin du Congo, initiative lancée lors du sommet mondial de Johannesburg, pourrait être une opportunité pour développer une vision plus intégrée de la place des plantations forestières au service de l'aménagement durable des forêts de cette région.

Références

Locatelli, B. Mallet, B. et Guizol, P. 2003. Congrès mondial forestier. Canada.

ITTO, 1993, Policy development 4

FAO, Forest resources assessment, 2001

THE ROLE OF MAMMALIAN HERBIVORES IN FOREST ECOSYSTEMS AND SOCIAL-ECONOMIC CONDITIONS OF THE SOCIETY

Eugene E. Podshivaev

St. Petersburg Forestry Research Institute, St. Petersburg, Russia
E-mail: silvics@NP10489.spb.edu

Introduction

Woody plant damage by mammalian herbivores occur in all forests. This damage is necessary in unmanaged natural forests because it maintain the balance between different components favourable for forest development. Human activity disturbs this balance and leads to increasing negative influence of mammalian herbivores on forests ecosystems.

The damage to forests by mammalian herbivores have not been registered in the Leningrad region until 1950s. The native European beaver *Castor fiber* L. was hunted to extinction in the end of 1800s. The number of elks *Alces alces* L. was minimal in 1930-1940s, being near 4000 elks in 1945 (Timofeeva 1974). Small rodents were not considered harmful for forests in this period.

Heavy forest stand damages by elks were registered in northwestern Russia in 1960-1980s. The main cause was the misbalance between high population level of animals and quantity of food resources. The number of elks increased to a maximum 42800 in 1962 and stabilized on the level of 26500-27200 in the early 1970s (Timofeeva 1974). A great number of clear-cuttings overgrowing with hardwood trees and protection measures were the reason for this fact. The voles of the genera *Microtus* and *Clethrionomys* were paid attention in North-West region of Russia in 1970s-1980s when damage was revealed to planted trees (Podshivaev 1986). The large areas of plantations were established in the late 1960s – early 1970s in this region.

The reintroduction of beaver has been carried out in 1950s in the Leningrad region. It was estimated that there were 15700 European beavers and 500 Canadian beavers *Castor canadensis* Kuhl. in 1987 (Strelkov 1983, Nikanorov 1990). The part of population (10%) was hunted regularly.

The social and economic conditions of society influence potential damage of forests by mammalian herbivores. The poverty of the people and lack of the state control in 1990s led to illegal hunting and caused abrupt decreasing of elk number. The total number of elk population in Leningrad region was near 7000-9000. As a result, the damages of forests by elks lost their economic importance. The uncontrolled increasing European beaver populations caused by reducing beaver-fur demand and hunting became close to the greatest possible values. The total number of beavers of both species was near 23000 in 2002. The annual limit of hunting is 2300 beavers but real hunting reaches 400 beavers (Kozhaev 2002). Stand mortality as a result of flooding became a serious problem. Destructive influence of beaver activity on forest drainage systems prevents from land draining.

Methodology

In the present work an analysis was undertaken of the state of mammalian herbivores population and that of forest fund in Leningrad region in 1980s-2000s, taking into account the tendency of Russia development with particular reference to forestry. The author's own data were used as well as official statistics and research literature. Forest health estimation was conducted according to Mozolevskaya et al. (1984). The number of elks was registered with method of winter transects, small mammals – by the line traps, beavers – by the settlements. (Kozhaev 1986, Rusanov and Sorokina 1984). The density of animals in the particular sites (biotopes) was used as the basic indicator.

Results and Discussion

Leningrad region occupies 85300 km^2 with population of 1.7 million people. About 5 million people live in St. Petersburg. The forests fund is 6078.6 thousand ha including 4741.3 thousand ha (78%) of forest-covered lands. Area of 8500-10000 ha is cutting annually according to official data. This data don't include illegal cutting. Hunting area is about 8530 thousand ha.

The main changes in forest cover of the territory in question were decreasing mature coniferous stands, increasing area of fresh clearcuts, burns, as well as young, mature and overmature deciduous (mainly aspen) stands. Significant factor is reducing spruce (which is edificator tree) presentation in mature stands (Alekseev and Markov 2003). As a result, the decreasing of taiga species and increasing of eurytopic and forest-steppe species are observed.

Based on our examination of damaged stands, species of harmful animals were determined and checked. For the Leningrad region they were elks, bank voles and European and Canadian beavers.

Elks seriously threatened young (up to 15-year old) pine stands and spruce stands (till 20 to 45-50 year-old) till 1980s-beginning of 1990s. The total number of elks was 20000-25000. However, the damage extent is influenced by statial distribution of this animal in winter period, that is by their population density on a particular plot. While mean density of elks in the region was 6.1-7.5 animals per 1000 ha, trophic pressure reached 28-44 elks in calculation per 1000 ha. Up to 78-90% of young pine trees were damaging by elks and sporadic debarking of 20-50-aged spruces were observed. We revealed old wounds on at least 30% of spruce trees in 1980s dated to the period of high number of elk. In the 1990s the intense decreasing of elk density to 1.3-1.8 animal/1000 ha as result of overhunting including poaching was observed. Although new cutting areas still preserved the condition for population growth. The insignificant damages of young pine stands are observed in present time. The winter behavior of elk changed. Animals migrate in remote places where concentrate in herds of 4-10 units. Damage of young pine (to 64-86%) and aspen and willow are happened there. The isolated damage of spruce bark and browsing of branches are also observed.

We estimated that the damages caused to young trees by the bank vole from small mammalian group are most significant for this rodents on North-West of Russia. This rodent dominates on forest plantation areas and has the 4-5-year cycle of number dynamics. Under the number increasing period this vole cause the damage on forest Scots pine plantation – up to 72-76%, larch – up to 45% and spruce – up to 25% of total number of trees. The damages of natural trees are less and no more than 5-6% on Scots pine and sporadic on aspen and willows. The main type of damages is debarking near the base of stem. The debarking of branches and browsing of shoots are also observed. Voles generally damage trees during winter. Therefore, the key factor defining influence of these rodents is the vole density in a wintering population. It depends on vegetation composition and condition and soil fertility. The amount of logging waste on silvicultural areas has a positive influence on survival of voles. Soil cultivation when establishing plantation is favorable for voles.

We estimated the maximum population density to be 61-71 voles/100 traps-night on this areas. Damages by meadow vole *Microtus arvalis* Pall. were observed in present time from 1997 as a rule on former agricultural lands. However, damages of woody plants by this rodent were observed earlier (Novikov et al. 1970). There are the damages of fruit trees by vole *Arvicola terrestris* L. observed in North-West of Russia in 2000-2003. This rodent inhabits forest plantation areas where there is drainage.

In our opinion, the main factor for stability of concrete forest territory is density of beaver populations and its long-time fluctuations, not the total number of animals in region. The estimated greatest possible density of beaver settlements was in the middle part of small forest rivers among of deciduous and mixed 20-60-aged forests. It was 1.2-1.8 settlements/1 km of river to 2.2 settlements/1 km as a maximum on clearcuts with aspen regeneration. We observed decreasing of number of beaver settlements as a result of reducing forage reserve.

The beavers affect forest ecosystems directly by withdrawal of forage trees and shrubs from stands and indirectly by transformation of forest landscapes as a result of intensive damming activity, which was reported also in Finland (Harkonen 1999). The selective harvesting of deciduous plants causes the changes in species and age structure of tree layer. But the main problem of forestry is the flooding that changes the hydrologic condition and causes tree dying. Beavers are positive factor in bottomland forests that are their fundamental habitat. There is no economic loss in these forests. The exception is the upper of small forest rivers with low-lying banks. In this places the flooding of forests and tree mortality are possible on 0.2-1.6 ha area. The negative influence of animals is mainly connected with anthropogenic transformation of natural landscapes. Beavers settled on drain banks and flooding the drainage areas what causes the damages of forest plantation and native stands.

The stability of anthropogenic forests to damaging factors including mammalian herbivores is becoming one of the main problems for forestry. Elaboration of protecting measures is required to take into account not only potential consequences of human activity but also the influence of social-economic conditions.

References

Alekseev V.A., Markov M.V. (2003) The statistical data on forest fund and the changes of Russian forest productivity in the second half of the 20th century. (in Russian).

Harkonen S. (1999) Forest damage caused by the Canadian beaver (Castor canadensis) in South Savo, Finland // Silva Fennica.-Vol. 33(4).-P.247-259.

Kozhaev A.A. (1986) Methodical recommendations on game counting. Leningrad. (in Russian). P.26.

Kozhaev A.A. (2002) Interview to Tchas Peak newspaper. St.Petersburg. (in Russian)

Mozolevskaya E.G., Kataev O.A. & Sokolova E.S. (1984) Methods of Forest Stem Pest and Disease Foci Survey. Moscow (in Russian).

Nikanorov A. S. (1990) The results of acclimatisation and using of beavers. Proceeding of Research institute for Game Hunting and Breeding named after Prof. B.M. Zhitkov. P.62-69. (in Russian).

Novikov G.A. et al (1970). Animals of Leningrad region (Fauna, Ecology and Practical Importance). Leningrad (in Russian).

Podshivaev E.E. (1986) On the number and damage activity of voles of the genera *Clethrionomys* on the silvicultural areas. Proceedings of St. Petersburg Forestry Research Institute. Pp. 156-161. (in Russian).

Rusanov Ya.S., Sorokina L.I. (1984) Forest and *Cervidae*. Moscow (in Russian).

Strelkov P.P. (1983) The mammals. In: The nature of Leningrad Region and Its Protection. Leningrad. P. 144-155. (in Russian).

Timofeeva E.K. (1974) The elk. Leningrad State University press, Leningrad (in Russian).

NATURAL FORESTS OF THE UKRANIAN CARPATHIANS: STRUCTURE, METHODS OF SILVICULTURE, AND OUTLOOK FOR SUSTAINABLE FOREST MANAGEMENT

Yuriy S. Shparyk

Ukrainian Research Institute for Mountain Forestry,
31, M.Grushevskogo St., Ivano-Frankivsk, UA, 76000, Ukraine,
Tel: +380-3422-25232, E-mail: lis@il.if.ua

Introduction

Ukrainian Carpathians are situated at the extreme west of Ukraine and form the north-eastern part of Carpathian Mountains. Start of theirs intense forest exploitation was begining from second half of the 19^{th} century, when over the Uzhotskyj, Veretskyj and Yablunetskyj passes traverse railways were built. Since then the forest area in the region has decreased almost 50% [1]. Plain and submontane oak (*Quercus robur* L. and *Q. petrae* L.) forests, and also spruce (*Picea abies* L.) forests at lower elevations were destroyed especially fast. But there are many forest massifs in upper part of Ukrainian Carpathians, which have no roads and removal of logs here is not possible. Both beech (*Fagus silvatica* L.) and fir (*Abies alba* Mill.) timber did not have a big demand in Europe in the past. That is why on our territory there have remained natural forests at different elevations over a considerable area [2].

Methodology

The structure of natural forests were investigated on 3 permanent plots of Ukrainian Research Institute for Mountain Forestry, which were established in 1963 and were kept without any felling since then. Their areas are close to 1 ha. All living and dead trees with a $d_{1.3} > 6$ cm were numbered, mapped and measured. We have data of 5-6 observations here. A new research plot with an area of 10 ha was established in the beech virgin forest in 2000/2001. The area is divided in 40 subplots of 50 per 50 m. Within the subplots, all living and dead trees with a $d_{1.3} > 6$ cm were numbered, mapped and measured too. The plot-wise inventory enables to analyse the variation and spatial distribution of stand characteristics.

The area of different forest types was estimated according to data of the forest inventory. The logging volume for different cutting systems was calculated according to data of regional forest administrations.

Results and discussion

The forest resource of Ukrainian Carpathians' region amounts to 2.1 million ha. Norway spruce (41 % of woodlands), common beech (35%), pedunculate and sessile oaks (9%) and silver fir (4%) are main species here. The natural forests grow on 60.7% of woodlands. The climax natural forests occupy 56,533 ha. Mainly they are virgin forests or quasi-virgin forests. The climax natural forests are divided on species as follows: beech - 39.1 ths ha, spruce - 7.3, fir - 2.6, oak - 2.0, alder - 0.5 ths ha. Single virgin forests of a Scots pine (170 ha), Arolla pine (55 ha) and mountain pine (47 ha) also have the large scientific value.

Therefore we attracted attention to the structure of spruce, beech, and oak forests. Basic characteristics of forest stand have a stable tendency to increasing (fig. 1). For example, mean diameter increase from 39 to 46,5 cm, what correspond to 2,3 mm of average annual increment. Other parameters also have a same trend. Height of 1^{st} layer trees has increment equal 7.8 cm per year; height of 2^{nd} layer – only 5.3 cm per year, and total volume – 1.75 m^3/ha. Analysis of their dynamic shows its slowing growth over the last 15 – 20 years, clearly visible on the annual growth (increment) graph. In other words, this forest stand mainly is directed one's efforts to reproduction now and its wood product functions are weak. Both facts, that the tree number has a tendency to decreasing and the natural regeneration number has a tendency to increasing, are a satisfaction of our hypothesis. So, the first layer of spruce has a trend to thinning, what is the illustration of its destruction. But during last investigation have noted a very interesting fact, that two trees from second layer are proceeded to first layer. Some disbalance on the A-III plot is with dynamic and volume of the deadwood. A firewood collection by local inhabitants is cause of this.

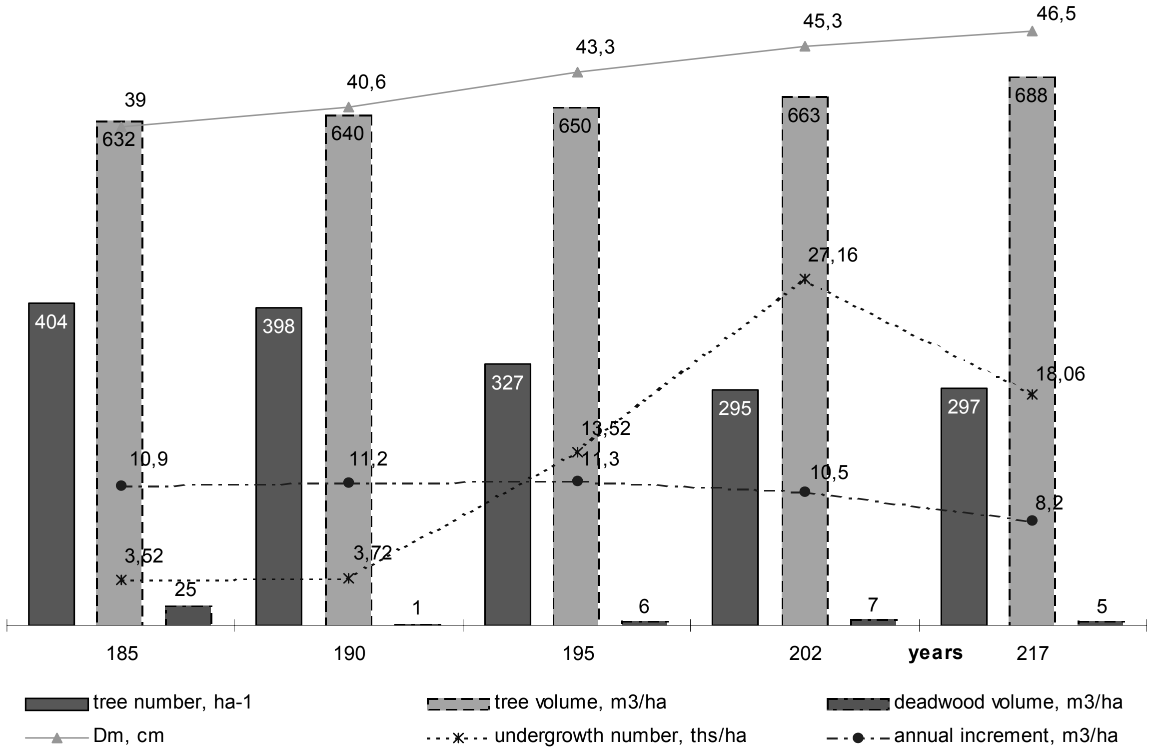


Figure 1 - Dynamic of the spruce natural forest parameters in Ukrainian Carpathians

The same dynamic of the structure characteristics had determined for the Silver fir natural forests on the permanent plot A-II. The changes determinate for both plots are directed to the formation of virgin forests.

The structure of beech virgin forests is quite good investigated in Ukrainian Carpathians [3-5]. Our 10 ha plot in Uholka State Forestry of Carpathian Biosphere Reserve was established for the determination of the minimum area for its development. And data on its structure also were received. In all 40 subplots beech is the predominant tree species. Other species only reach a percentage of 2.6 in the mean (max. 9.2). In 15 subplots no other trees than beech were found. The greatest variation between the 40 subplots of 0.25 ha can be seen in the number of living trees (CV 24.9%) and in the mean diameter (CV 22.9%). Both characteristics are strongly influenced by the number of trees in the low diameter classes ($d^{1.3}$ < 20 cm) which varies strongly between the subplots. If we consider only the 100 thickest trees per ha, the variation coefficient of the mean diameter is halved, the one of the mean tree height even divided by three. The basal area of the 40 subplots varies from 22 to 52 m^2/ha (CV 10.2%), the volume of the living trees from 423 to 1042 m^3/ha (CV 20.4%), the natural regeneration number from 1.0 to 80.4 ths per ha (CV 72.2%). The spatial distribution of subplots with high or low basal area is irregular. The differences are evened out as soon as we regard areas of more than 1 ha.

In each of the subplots of 0.25 ha the diameter distribution goes over a very wide range. There are three main types of distribution curves: a decreasing curve, as it is typical for "Plenterwald", a rather flat distribution with several, more or less equal peaks, and third one that lies between these two types. A “normal distribution”, typical for even-aged forests, wasn’t found. With increasing area of the subplots, the fluctuations in the diameter distribution decrease and the curves become flatter and more even. Between continuous plots of only 3-5 ha, hardly any differences in the diameter distributions can be found. So, the virgin beech forest is very uneven-aged, even on small areas. The small variation between subplots of areas of 3-5 ha and the form of diameter distributions suggest, that an area of 5-10 ha is sufficient for a complete development cycle (steady state).

A vertical structure of the pedunculate oak natural forest is quite different. Mainly the old natural oak forests are not virgin forests. Stand on the A-I plot is only old non-commercial forest. There are two clearly visible different generations and layers here. First – the natural overmaturity oak stand and it is in the destruction phase now. Second – the secondary hornbeam (with birch) stand and it is intensive growing now. In the near future (during next 40-60 years) first layer of this forest will be finally destroyed and we will have only secondary hornbeam stand (may be with birch) here. Founder of the Ukrainian forestry and silviculture, Prof. P. S. Pogrebnyak (1935), contended that in the nature, such stands must have 3 stages in succession cycle: from natural oak stand, through secondary hornbeam and through next secondary birch stand, again to oak stand [6]. That allows us to classify this forest as “quasi-virgin forest”. Perspectives of direct natural reforestation of this forest stand are absent now, because there is not oak undergrowth on this forest area.

The analysis of stand structures on the permanent plots is evidence of the multi-layered and mixed structure (except for oak stands) of the natural forests in Ukrainian Carpathians. The natural regeneration and dead wood are constantly present at these forests.

Total volume of the wood, harvested at Ukrainian Carpathians, is distributed approximately fifty-fifty between clear-cutting and selective methods of felling. For last 5 years is marked increase of a share of selective methods of harvesting. However, the final yield is carried out almost on 90 % by clear-cutting methods. And the selective fellings mainly are intermediate and thinning or sanitation fellings.

The manuals for sustainable forest management were developed on the basis of the analysis of natural forests' structure. Their purposes are use of regeneration potential of natural forests of Ukrainian Carpathians and the gradual transition of the local forestry to selective methods of final yields.

References

1. Gensiruk S.A. 1992: Forests of Ukraine: 408.
2. Shelyag – Sosonko Y.R. and others, 2002: Green book of Ukraine. Forests: 17-24.
3. Smaglyuk K.K., 1969: Pristine Forests of Ukrainian Carpathians. Forestry, 6: 58-68.
4. Stoyko S.M.; Tsyuryk E.I.; Tretyak P.R. and others, 1982: Morphologic structure of the beech virgin forests, flora and vegetation of Ukrainian Carpathians: 178-190.
5. Parpan V.I, Stoyko S.M., 1999: Beech Virgin Forests of Ukrainian Carpathians: protection and cenosis structure. Proceeding of Folklore Institute of Academy of Science of Ukraine, 4: 81-86.
6. Pogrebnyak P.S. 1963: Common silviculture: 366.

Conference Participants

Evgeniy Abakumov
Dep. of Soil Science and Soil Ecology
St-Petersburg State University
Oranienbaum rd., 2,
St-Petersburg, RUSSIA, 198504,
Tel: +7-812-427-70-61
e_abakumov@mail.ru

Ralph Amateis
Department of Forestry
Virginia Tech
Blacksburg, Virginia, USA 24061
Tel: +1-540-231-7263
ralph@vt.edu

Daniel Auclair
INRA
UMR Botanique et Bioinformatique de l'Architecture des Plantes (AMAP)
c/o CIRAD, TA40/PS2
34398 Montpellier cedex 5, FRANCE
Tel:+33-04-67-61-65-34
fax:+33-04-67-61-56-68
daniel.auclair@cirad.fr

Cindy Baker
Forestry, University of Northern British Columbia, 3333 University Way
Prince George, BC, CANADA V2N 4Z9
cbakersmith@netscape.net

Hervé Bescond
Université du Québec en Abitibi Témiscamingue
Rouyn-Noranda, CANADA H2P 2H6
Tel : +1-819-762-0971 #2546
herve.bescond@uqat.ca

Jean-Pierre Bouillet
Cirad-forêt, Campus International de Baillarguet, TA /C
34398 Montpellier Cedex 5, FRANCE
Tel: +33-04-67-59-38-66
jean-pierre.bouillet@cirad.fr

Jean-Marc Bouvet
CIRAD-Forêt
Campus International de Baillarguet,
TA 10/D, B.P. 5035
34398 Montpellier Cedex 5, FRANCE
Tel : +33-04-67-59-38-83
jean-marc.bouvet@cirad.fr

Peter Brang
Swiss Federal Research Institute WSL,
Zürcherstr. 111,
CH-8903 Birmensdorf, SWITZERLAND
Tel: +41-1-739-24-86
Fax: +41-1-739-22-15
peter.brang@wsl.ch

Darwin Burgess
Forestry Research Partnership
Petawawa Research Forest
P.O. Box 2000, Chalk River, ON,
CANADA K0J 1J0
Tel: +1-613-589-9569
dburgess@nrcan.gc.ca

Isabel Cañellas
Silviculture Department
Instituto Nacional de Investigaciones y Tecnologia Agraria y Alimentaria (INIA)
Carretera de la Coruña, Km 7.5
AP 8111, E-28040 Madrid, SPAIN
Tel: +34-91-347-6867
fax: +34-91-357-2293
canellas@inia.es

Marie-Hélène Chevallier
CIRAD Forestry Department, UMR Cefe-Cnrs, 1919 route de Mende
34293 Montpellier cedex 5, FRANCE
Tel: +33 4 67 61 32 62
marie-helene.chevallier@cirad.fr

Mangala De Zoysa
Department of Agricultural Economics
Faculty of Agriculture, University of Ruhuna
Mapalana, Kamburupitiya, SRI LANKA
Tel: +94-41-92385; fax: +94-41-92384
mangalaxyz@yahoo.com

Margaret Devall
Center for Bottomland Hardwoods Research
USDA Forest Service, P.O. Box 227
Stoneville, MS 38776, USA
Tel. +1-662-686-3161
Fax: +1-662-686-3195
mdevall@fs.fed.us

Anton Doroshin
Federal St. Petersburg Forestry Research Institute
St. Petersburg, RUSSIA
Tel: +7-812-552-80-28
adoroshin@AD10039.spb.edu

Frédérik Doyon
Institut Québécois d'Aménagement de la Forêt Feuillue
Ripon, Quebec, J0V 1V0, CANADA.
Tél: +1-819-983-2206
fdoyon@iqaff.qc.ca

Christian Dupraz
INRA, UMR-System, Equipe d'agroforesterie
2, place Viala, 34060 Montpellier, FRANCE.
Tel : +33 4 99 61 23 39
dupraz@ensam.inra.fr

Eric Forni
Département forestier du CIRAD,
Campus international de Baillarguet
TA 10/D
34398 Montpellier Cedex 5, FRANCE
Tel: +33-04 67 59 38 67
eric.forni@cirad.fr

David Forrester
School of Resources, Environment and Society,The Australian National University,
Canberra, A.C.T. 0200, AUSTRALIA,
Tel.: +61-2-6125-2623
david.forrester@anu.edu.au

Alain Franc
Institut National de la Recherche Agronomique (INRA)
UMR Biodiversité, Gènes et Ecosystèmes
Pierroton; 69, Route d'Arcachon
33612 Cestas CEDEX, FRANCE
Tel: +33- 05-57 12 28 99
Fax: +33-05-56-68-02-23
alain.franc@pierroton.inra.fr

Jean Cossi Ganglo
Université d'Abomey-Calavi.
Faculté des Sciences Agronomiques,
Département d'Aménagement et de Gestion de l'Environnement.
01 BP 526 Cotonou, BENIN
Tel: +229-51-05-80; Fax: +229-36-01-22
ganglocj@yahoo.fr

Sylvie Gourlet-Fleury
CIRAD-Forêt
Campus International de Baillarguet,
TA 10/D, B.P. 5035
34398 Montpellier Cedex 5, FRANCE
Tel: +33-04-67-59-38-83
sylvie.gourlet-fleury@cirad.fr

Karen Graham
graham-13257@msn.com

Russell Graham
USDA Forest Service
Rocky Mountain Research Station
1221 S. Main, Moscow, Idaho USA
Tel: +1-208-883-2325
Fax: +1-208-883-2318
rtgraham@fs.fed.us

Arthur Groot
Canadian Forest Service, Great Lakes Forestry Centre, 1219 Queen St. E.,
Sault Ste. Marie, Ontario,
CANADA P6A 2E5
Tel: +1-705-541-5624
agroot@nrcan.gc.ca

Björn Hånell
Dept of Silviculture
Swedish University of Agricultural Sciences
SE-901 83 Umeå, SWEDEN
Tel: +46 90 786 8297
Fax +46 90 786 8414
bjorn.hanell@ssko.slu.se

Minna Hares
Viikki Tropical Resources Institute,
P.O.Box 27, 00014 University of Helsinki, FINLAND
Tel. +358-9-19158634
minna.hares@helsinki.fi

Chris Hawkins
Mixedwoods, University of Northern British Columbia, 3333 University Way
Prince George, BC, CANADA V2N 4Z9
Tel: +1-250-960-5614
hawkinsc@unbc.ca

Per Holgén
Dept of Silviculture
Swedish University of Agricultural Sciences
SE-901 83 Umeå, SWEDEN
Tel: +46-90-786 8438
per.holgen@ssko.slu.se

Mark Hunt
AFFS Forestry Research, Department of Primary Industries and Fisheries,
Queensland, AUSTRALIA, 4570
Tel: +61 7 54820877
Mark.Hunt@dpi.qld.gov.au

Milton Kanashiro
Dendrogene Project
Embrapa Amazonia Oriental,
Trav. Eneas Pinheiro S/N,
66.095-780 Belem, Pará, BRAZIL
milton@cpatu.embrapa.br

Gary Kerr
Forestry Commission Research Agency
Alice Holt Lodge, Wrecclesham
Farnham, Surrey GU10 4LH, UK
Tel: +44-01420-22255;
Fax: +44-01420-520558
gary.kerr@forestry.gsi.gov.uk

Jonathan Kingdon
University of Oxford
Thw Elms, The Walk, Islip OX5 2SD, UK,
Tel. +44-1865-376-904

Raphael Klumpp
Institute of Silviculture, University of Natural Resources and Applied Life Sciences
Peter-Jordan-Strasse 70
A-1190 Vienna, AUSTRIA
Tel: +43-1-47654-4063
Fax: +43-1-47654-4092
raphael.klumpp@boku.ac.at

Daniel Köchli
Swiss Federal Research Institute WSL,
Zürcherstr. 111,
CH-8903 Birmensdorf, SWITZERLAND
daniel.koechli@wsl.ch

Olga V. Lisitsina
Dep. of Geobotany and Plant Ecology,
St-Petersburg State University,
Oranienbaum Rd 2,
St-Petersburg, RUSSIA, 198504,
Tel: +78124277061
e-abakumov@mail.ru

Shirong Liu
Research Institute of Forest Ecology, Environment and Protection,
Chinese Academy of Forestry
Wan Shou Shan
Beijing 100091, P.R. CHINA
Tel: +86-10-6288-9554
Fax: +86-10-6288-4972
liusr@forestry.ac.cn

James Long
College of Natural Resources, Utah State University, Logan, UT, 84322-5230, USA
Tel: +1-435-797-2574
fakpb@cc.usu.edu

Mathieu Lourmas
CIRAD Forestry Department, UMR Cefe-Cnrs, 1919 route de Mende,
34293 Montpellier cedex 5, FRANCE
Tel: +33 4 67 61 32 62
lourmas@cefe.cnrs-mop.fr

Denis Loustau
INRA-Ephyse 69 route d'Arcachon
33612 Gazinet cédex, FRANCE.
Tel. +33 5 57 12 28 51
loustau@pierroton.inra.fr

Palle Madsen
Forest & Landscape Denmark,
Danish Centre for Forest, Landscape and Planning, KVL,
Kvak Møllevej 31,
DK-7100 Vejle, DENMARK
Tel: +45-35-28-17-13
Mob: +45-40-45-30-19
Fax: +45-35-28-15-12
pam@kvl.dk

Henri-Félix Maître
CIRAD-Forêt,
TA 10/C, Baillarguet,
34398 Montpellier, Cedex 5, FRANCE
Tel: 33-04 6759 3787/36
Fax: 33-04 6759 3733
henri-felix.maitre@cirad.fr

Martin Alfonso Mendoza
Colegio de Postgraduados
Apartado Postal 421,
91700 Veracruz Ver., MEXICO
Tel & fax: +52 2299 349100
mmendoza@colpos.mx

Gianfranco Minotta
Dipartimento AGROSELVITER,
Via Leonardo da Vinci, 44
10095 Grugliasco (Torino)
ITALY
Tel. +39-011-6708834
Fax +39 011 6708734
gianfranco.minotta@unito.it

Fernando Montes
Centre for Forest Research.
Instituto Nacional de Investigaciones y
Tecnologia Agraria y Alimentaria (INIA)
Carretera de la Coruña, Km 7.5, AP 8111
E-28040 Madrid, SPAIN
fmontes@inia.es

Olivier Monteuuis
CIRAD-Forêt, TA 10/C, Baillarguet,
34398 Montpellier, Cedex 5, France
Tel: +33-04 6759 3787/36
Fax: +33-04 6759 3733
olivier.monteuuis@cirad.fr

Warren Keith Moser
USDA, Forest Service,
North Central Research Station
Forest Inventory and Analysis Program
1992 Folwell Avenue,
St. Paul MN 55108, USA
Tel: +1-651-649-5155
Fax: +1-651-649-5140
wkmoser@fs.fed.us

Antoine Mountanda
SNR/CORAF, BP 839
Pointe Noire, CONGO
Tel: +242-94-02-79
Fax: +242-94-09-05
mountandaantoine@yahoo.fr

Narayanan Nair
Botany Division, Kerala Forest Research
Institute, Peechi,
Thrissur District, Kerala 680 653, INDIA
Tel: +91-487-22375; Fax: +91-487-782249
kknnair@kfri.org

Philippe Nolet
Institut Québécois d'Aménagement de la
Forêt Feuillue, 58 Principale,
Ripon, Québec, CANADA J0V 1V0
Tél : +1-819-983-2006
p.nolet@iqaff.qc.ca

Jiri Novak
Forestry and Game Management Research
Institute, Opocno Research Station,
517 73 Opocno, CZECH REPUBLIC
Tel: +420 494 668 391
Fax: +420 494 668 393,
novak@vulhmop.cz

Kevin O'Hara
Department of Environmental Science,
Policy and Management
151 Hilgard Hall, MC 3110
University of California,
Berkeley, CA 94720-3110, USA
Tel: +1-510-642-2127
ohara@nature.berkeley.edu

John Parrotta
USDA Forest Service, Research &
Development
4th floor, RP-C, 1601 North Kent Street
Arlington, VA 22209, USA
Tel: +1-703-605-4178
Fax: +1-703-605-5131
jparrotta@fs.fed.us

Yohanes Purwanto
Tanimbar Land Use Planning Project
European Union/CIRAD Forêt /BirdLife
Indonesia, PO Box 7612
JKP 10270 Jakarta INDONESIA
Cirad_tanimbar@cbn.net.id;
triskell@cbn.net.id

Klaus Püttmann
Department of Forest Science, Oregon State
University, Corvallis, OR 97331, USA
klaus.puettmann@oregonstate.edu

Pasi Puttonen
Department of Forest Ecology,
University of Helsinki,
FIN-00014 University of Helsinki
FINLAND
Tel.: +358-9-191-58-118
Fax: +358-9-191-58-100
pasi.puttonen@helsinski.fi

Scott Roberts
Department of Forestry and Forest and
Wildlife Research Center,
Mississippi State University,
Mississippi State, MS 39762-9681, USA
sroberts@cfr.msstate.edu

Ana-Rita Román-Jiménez
Colegio de Postgraduados, Programa
Forestal; Campus México; Km. 36.5
Carretera Federal México-Texcoco,
56230 MÉXICO.
Tel: +52-(595)-952-0246;
Fax: +52-(595)-952-0256
aritacolpos@yahoo.com

Romy Sato
Dendrogene Project,
Embrapa Amazônia Oriental/DFID,
Trav. Eneas Pinheiro S/N,
66.095-780 Belem, Pará, BRAZIL
Tel: +55 91 277-3514
d_gene@cpatu.embrapa.br

Jean-Pierre Saucier
Division classification écologique et
productivité des stations
Direction des inventaires forestiers
Ministère des Ressources naturelles, de la
Faune et des Parcs,
880, chemin Sainte-Foy, 4e étage,
Québec (Québec), CANADA G1S 4X4
Tel: 418-627-8669 ext. 4279
jsaucier@nrcan.gc.ca

Andreas Schmiedinger
University of Bayreuth, Chair of
Biogeography
Universitätsstr. 30,
95440 Bayreuth, GERMANY
Tel: +49 921 552299
andreas.schmiedinger@uni-bayreuth.de

Marian Slodicak
Forestry and Game Management Research
Institute, Opocno Research Station,
517 73 Opocno, CZECH REPUBLIC
Tel: +420 494 668 391, Fax:
+420 494 668 393,
slodicak@vulhmop.cz

Laura Snook
Center for International Forestry Research
(CIFOR) and Dept. of Plant Sciences,
Oxford University
The Elms, The Walk, Islip OX5 2SD, UK
Tel. +44-1865-376-904; +44-1865-373-815
l.snook@cgiar.org

John Stanturf
USDA Forest Service, Southern Forest
Research Station, Forest Sciences
Laboratory
320 Green Street, Athens, GA 30602, USA
Tel: +1-706-559-4316
Fax: +1-706-559-4317
jstanturf@fs.fed.us

Mathurin Tchatat
Programme Forêt et Bois
Institut de la Recherche Agricole pour le
Développement (IRAD)
B.P. 2067 Yaoundé CAMEROUN
coraf-foret.ac@iccnet.cm

Eric Teissier du Cros
Institut National de la Recherche Agronomique (INRA)
Unité de Recherches Forestières Méditerranéennes,
20, Avenue Antoine Vivaldi
F-84000 Avignon, FRANCE
Tel: +33-4-90 13 59 11
Fax: +33-4-90 13 59 59
eric.teissierducros@avignon.inra.fr

Kazuhiko Terazawa
Hokkaido Forestry Research Institute
Koshunai, Bibai, Hokkaido
079-0198 JAPAN
Tel: +81-1266-3-4164
Fax: +81-1266-3-4166
ktera@hfri.bibai.hokkaido.jp

Jacques Valeix
Directeur du CIRAD-Forêt
TA 10/B
Campus international de Baillarguet
34398 Montpellier Cedex 5, FRANCE
Tel.: +33-4-67-59-37-53
Fax : +33-4-67-59-37-55
jacques.valeix@cirad.fr

Paul Vantomme
FAO, Forestry Department, Forest Products and Economics Division,
Viale delle Terme di Caracalla, 00100
Rome, ITALY
paul.vantomme@fao.org

Bradley Walters
Geography Department
Mount Allison University
144 Main Street,
Sackville, New Brunswick
CANADA E4L 1A7
Tel: +1-506-364-2323
Fax: +1-506-364-2625
bwalters@mta.ca

Kristen Waring
Department of Environmental Science, Policy and Management,
151 Hilgard Hall, MC 3110
University of California,
Berkeley, CA 94720-3110, USA
Tel: +1-510-643-2025
kristen.waring@nature.bekeley.edu

Eric Zenner
Department of Forest Resources
University of Minnesota
St. Paul, MN, 55108, USA
Tel.: 612-625-3733
ezenner@umn.edu

Anatoliy V. Zhigunov
Federal St. Petersburg Forestry Research Institute,
St.Petersburg, RUSSIA
Tel: +7 (812) 552-89-23
zhigan@lens.spb.ru

Conference field trip: 16 June 2004

Manade des Baumelles, in the Camargue

IUFRO World Series Publications

IUFRO World Series Vol. 1: *Vocabulary of Forest Management.* Schmid-Haas, P. (ed.) 1990: Vocabulary of Forest Management.,Vienna, IUFRO; Birmensdorf, WSL; ISSN 1016-3263 ISBN 3-7040-1055-3

IUFRO World Series Vol. 2: *Forest Decimal Classification - Trilingual short version.* Forest Decimal Classification; Trilingual short version = Forstliche Dezimal-Klassifikation; Dreisprachige Kurzfassung; Classification Décimale Forestière;Version abrégée trilingue /comp. by IUFRO Project Group P6.01-00. - Vienna : IUFRO, 1990. - XIV, 147p. - ISSN 1016-3263 ISBN 1062-6

IUFRO World Series Vol. 3: *Forstliche Dezimalklassifikation.* Voshmgir, D., Schenker, R. (eds.) 1992: Forstliche Dezimal-Klassifikation. 2. überarbeitete und ergänzte Aufl. Wien, IUFRO. 131 S. ISBN 370401134-7 ISSN 1016-3263

IUFRO World Series Vol. 4: *Long-term Implications of Climate Change and Air Pollution on Forest Ecosystems.* Schlaepfer, R. (ed.), 1993. Long-term Implications of Climate Change and Air Pollution on Forest Ecosystems. Progress Report of the IUFRO Task Force "Forest, Climate Change and Air Pollution". Vienna, IUFRO; Birmensdorf, WSL. 132 p. ISSN 1016-3263 ISBN 3-7040-1165-7

IUFRO World Series Vol. 5: *IUFRO International Guidelines for Forest Monitoring.* Päivinen, R., Lund, H. G., Poso, S., Zawila-Niedzwiecki, T. (eds.), 1994. IUFRO International Guidelines for Forest Monitoring; A Project of IUFRO Working Party S4.02-05 = Directrices Internacionales de IUFRO para la Monitorización de los Recursos Forestales; un proyecto del Grupo de Trabajo de IUFRO S4.02-05. Vienna, IUFRO. 102 p. ISSN 1016-3263 ISBN 3-901347-00-3

IUFRO World Series Vol. 6: *Perspectives of Forest Genetics and Tree Breeding in a Changing World.* Editor: Csaba Mátyás. 158 p. ISSN 1016-3263 ISBN 3-901347-07-0. Vienna 1997

IUFRO World Series Vol. 7: *Developments in Forests and Environmental Law Influencing Natural Resource Management and Forestry Practices in the United States of America and Canada.* Franz Schmithüsen, William C. Siegel (eds.). Selected Contributions submitted to the Research Group 6.13.00 Forest Law and Environmental Legislation. Vienna, IUFRO 1997. - 373 p. ISBN 3-901347-08-9 ISSN 1016-3263

IUFRO World Series Vol. 8: *IUFRO Guidelines for Designing Multipurpose Resource Inventories.* A project of IUFRO 4.02.02. 216 p. ISBN 3-901347-09-7. ISSN 1016-3263. FDC 524.61:524.63. Vienna, 1998

IUFRO World Series Vol. 9-de: *Terminologie der Forsteinrichtung.*. Begriffe und Definitionen in deutscher Sprache - Entsprechungen in Englisch, Französisch, Spanisch, Italienisch, Portugiesisch, Ungarisch und Japanisch. Othmar Griess, Horst Kurth, IUFRO 4.04.07 SilvaPlan und SilvaVoc. ISBN 3-901347-12-7 ISSN 1016-3263; FDC 6-(038):5-(038)

IUFRO World Series Vol. 9-es: *Terminología de Ordenación Forestal* - Términos y definiciones en español - Equivalencias en alemán, inglés, francés, italiano, portugués, húngaro y japonés. Herbert Siebert, IUFRO 4.04.07 SilvaPlan y el proyecto de terminología de IUFRO, SilvaVoc. Viena, IUFRO, 1999. - 176 p. - ISBN 3-901347-17-8; ISSN 1016-3263; FDC 6-(038):5-(038)

IUFRO World Series Vol. 9-jp: *Terminology of Forest Management Planning* (Forsteinrichtung) Terms and Definitions in Japanese - Equivalent terms in German, English, French, Spanish, Italian, Portuguese and Hungarian. Kenji Naito, IUFRO 4.04.07 SilvaPlan und SilvaVoc. Vienna: IUFRO, 2000 - 166 p. ISBN 3-901347-22-4 ISSN 1016-3263; FDC 6-(038):5-(038)

IUFRO World Series Vol. 9-en: *Terminology of Forest Management Planning - in English* Terminology of Forest Management Planning. Terms and Definitions in English - Equivalent terms in German, French, Spanish, Italian, Portuguese and Japanese. M. NIEUWENHUIS, IUFRO 4.04.07 SilvaPlan und SilvaVoc. Vienna: IUFRO, 2000 - 176 p. ISBN 3-901347-26-7 ISSN 1016-3263; FDC 6-(038):5-(038)

IUFRO World Series Vol. 9-fr: *Terminology of Forest Management Planning.* Terms and Definitions in French - Equivalent terms in German, English, Spanish, Italian, Portuguese and Hungarian, Rumanian and Japanese. Pierre Schram, IUFRO 4.04.07 SilvaPlan und SilvaVoc. Vienna: IUFRO, 2003. - 176 p. (IUFRO World Series, Vol. 9-fr). ISBN 3-901347-41-0 ISSN 1016-3263; FDC 6-(038):5-(038).

IUFRO World Series Vol. 9-ch: *Terminology of Forest Management Planning*. Terms and Definitions in Traditional and Simplified Chinese - Equivalent terms in German, English, French, Spanish, Italian, Portuguese, Hungarian, Romanian and Japanese. Shuen Chao WU, IUFRO 4.04.07 SilvaPlan und IUFRO's Terminology Project SilvaVoc. Vienna: IUFRO, 2003 - 189 p. (IUFRO World Series Vol. 9-ch). ISBN 3-901347-44-5 ISSN 1016-3263; FDC 6-(038):5-(038). Price: US$ 30.— plus shipping and handling

IUFRO World Series Vol. 10: *Forging a New Framework for Sustainable Forestry: Recent Developments in European Forest Law.* Schmithüsen F., Herbst P., Le Master D. C. (eds.), 2000: Forging a New Framework for Sustainable Forestry: Recent Developments in European Forest Law. IUFRO Secretariat Vienna; Chair of Forest Policy and Forest Economics, ETH, Zurich, 354 pp.

IUFRO World Series Vol. 11: *Protection of World Forests from Insect Pests: Advances in Research*. Editors: René Alfaro et al. XXI IUFRO World Congress, Kuala Lumpur, Malaysia, 2000. A project of IUFRO Working Parties 7.01.02 Mechanisms of Tree Resistance to Insect Pests; 7.02.10 Epidemic Factors and Global Spread of Pine Wilt, 7.03.00 Management of Insect Pests in the Tropics, 7.03.03 Pest Problems in Planted Forests, 7.03.07 Invasive Insects and Diseases; and 7.03.09 Protection of Forests in the Tropics.

IUFRO World Series Vol. 12: *Modelización del Crecimiento y la Evolución de Bosques.* Klaus von Gadow, Pedro Real, Juan-Gabriel Álvarez González (editores). Vienna, IUFRO, 2001. ISSN 1016-3263. ISBN 3-901347-32-1. FDC 561 : 564.

IUFRO World Series Vol. 13: *Médición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales*. Actas del Simposio Internacional "Medición y Monitoreo de la Captura de Carbono en Ecosistemas Forestales", Valdivia, Chile,18 - 20 de octubre del 2001. Jorge Gayoso y Robert Jandl. ISSN 1016-3263. ISBN 3-901347-31-3 IUFRO Secretariat, Vienna, 2002. Available in electronic form only for download from the IUFRO Web site.

IUFRO World Series Vol. 14: Forestry Serving Urbanised Societies. Selected papers from a conference held in Copenhagen, Denmark, 27-30 August 2002, jointly organised by IUFRO, EFI and the Danish Centre for Forest, Landscape and Planning - KVL. Edited by Cecil C. Konijnendijk, Jasper Schipperijn and Karen K. Hoyer. ISBN 3-901347-49-6. Vienna 2004.

IUFRO World Series Vol. 15: *Meeting the Challenge: Silvicultural Research in a Changing World.* Extended abstracts from the conference in Montpellier, France, June 14-18, 2004, jointly organized by the International Union of Forest Research Organizations (IUFRO) - Divison 1 (Silviculture), USDA Forest Service, CIRAD-Forêt, and the Institut National de la Recherche Agronomique (INRA). John A. Parrotta, Henri-Félix Maître, Daniel Auclair, Marie-Hélène Lafond (editors). Vienna, IUFRO, 2005. - 185 p.

For prices and ordering, please contact:
IUFRO Secretariat
c/o BFW Mariabrunn
Hauptstrasse 7
1140 Vienna
Austria.

Tel: + 43-1-877-0151-0
Fax: +43-1-877-0151-50
E-mail: office@iufro.org
Web site: www.iufro.org