METSÄNTUTKIMUSLAITOKSEN TIEDONANTOJA 512
The Finnish Forest Research Institute, Research Papers 512

FINNISH-CANADIAN FORESTRY SEMINAR

Gustavelund, Tuusula, Finland, May 16–18, 1994

Edited by Eero Paavilainen and Leena Halko

FINNISH-CANADIAN FORESTRY SEMINAR

Gustavelund, Tuusula, Finland, May 16–18, 1994

Edited by Eero Paavilainen and Leena Halko

Metsäntutkimuslaitoksen tiedonantoja 512
The Finnish Forest Research Institute, Research Papers 512

Distribution: The Finnish Forest Research Institute,
Department of Forest Ecology, P.O. Box 18, 01301 Vantaa, Finland
Phone: +358-0-857 051, Fax: +358-0-857 05569

ISBN 951-40-1378-6
ISSN 0358-4283

Paintek Pihlajamäki Oy 1994

Jan Heino
Deputy Director General
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki, Finland
Tel. +358-0-160 2418
Fax +358-0-160 5078

WELCOMING ADDRESS

Dear Canadian Guests, Dear Colleagues!

On behalf of the Ministry of Agriculture and Forestry I have the honour and the pleasure to welcome you all to this seminar. I think I interpret the feelings of all the Finnish participants correctly, when I say that we highly appreciate having you here, Canadian colleagues, and that we appreciate your willingness to spend quite a lot of time and effort on this convent.

This kind of seminar was suggested last spring, although the idea is much older than that. Anyhow, during the 2nd Ministerial Conference on the Protection of Forests in Europe held in June last year, representatives from our countries had a chance to meet and also to decide upon arranging this event. I do hope that we together can gain from these few days together.

There are many good reasons for strengthening cooperation in the field of forestry between our countries. A glance at the map already reveals that there must be considerable similarities in natural conditions. Forestry and forest industries are of extreme importance for the national economies in our countries. Canada is in many respects number one in the world in this sector, e.g. as a producer of forest industry products. If we, however, measure the significance of the forest sector by using indicators such as the value of forest industry export of the total export, or export value of forest industry products per capita, this sector seems to be even more important for us Finns. In fact, we use to say that we live in and by our forests.

Many of the Finnish participants here have actively been involved in cooperation with Canadian organisations and colleagues. My general impression, having listened to these colleagues, is, that we Finns are very satisfied with the collaboration already established.

Objectives with the seminar

I am convinced, that we have in mind numerous, obvious and less obvious reasons for promoting contacts and joint efforts between our countries in this particular sector. This is also the main objective with our joint seminar. Let us during these days come back to these reasons, and let us try to find out mutual priorities in the forestry cooperation between Canada and Finland. From the Finnish side we have not fixed any final priorities in advance. On the other hand, the subjects to be presented here by my colleagues give quite good indications about those fields, where Finland can contribute with good expertise, and thus, hopefully where Finnish forestry and forest research can be of interest for Canadian counterparts.

Concerning the scope of the seminar we have jointly recommended speakers to include practical as well as scientific aspects in their subjects. By doing so, we hope that our seminar could give us a platform for cooperation not only seen from the research point of view, but from the whole forestry sector point of view. I say this realizing that most of us are basically involved in research work. Once more warmly welcome, and now I would like to move on to technical issues.

Structure of discussion

We have three main topics. In addition we have some free time, a visit to our state forest agency, the Finnish Forest and Park Service and a short excursion. After this day and tomorrow we will have a general discussion on Wednesday morning on how to plan for future activities. However, after each section of topics, having the presentations in mind, there is some time reserved for discussion. This is beneficial also from the point of view, that all Finns are not able to be here on Wednesday. All ideas and proposals made today and tomorrow will be compiled by our joint Secretariat. Thus, suggestions made can be used for our discussion on Wednesday. In addition, the Finnish side has prepared three short presentations, case studies, of functioning cooperation projects for the discussion on Wednesday morning.

Last night we agreed upon sharing the chairmanship of our seminar. Eero Paavilainen has kindly accepted to chair todays sessions. For tomorrow we have similar acceptance from Lorne Riley. He is willing to take over and guide our discussions during Tuesday. Thank you already at this stage to both of you.

Forest policy agenda in Finland today

The recession that we have been facing for a couple of years has caused serious problems in most sectors. We have an unemployment rate of 20 %. Forest industries showed negative results in 1991 and 1992 and a diminutive positive result last year. Since Government expenditures must be strongly reduced because of heavy state debt burden and weak state finances, also forestry, governmental or state subsidized organizations including forest research, have to get along with reduced governmental funding. Reorganising and restructuring, therefore, have been the key words during the last couple of years.

Secondly, it is very likely that Finland is going to be a member of the EU next year. This will have some limited influence upon forestry also. In forest research we are able, on an equal basis to participate in European Union research projects. Above all a membership will give our forest industries the same conditions for competing at the European markets as the other member countries have.

Finally, some words about our new environmental programme for forestry. In fact, the programme is the starting point for a new forest policy. Already before this programme was initiated the Act concerning the Finnish Forest and Park Service, our state forest agency, came into effect at the beginning of 1994. The Forest and Park Service is required to apply the principle of sustainable management in regard to the natural resources entrusted to its care. Further, the Forest and Park Service is required to adequately take into consideration the protection and appropriate promotion of biodiversity as essential elements of the sustainable management and use of natural resources.

All the leading environmental forestry organisations in Finland contributed to the formulation of the programme and the committee was unanimous. The most important objective of the programme is to promote the ecologically sustainable development of the forests, with special emphasis on the biodiversity and vitality. Wood production goals have stepped back compared to earlier programmes. However, the forest balance figures prove that the conservation of forest ecosystems will not endanger the raw material supply of our industries

The programme deals with the protection strategy and policy for the forests, the implementation of the conservation programmes, silviculture guidelines, the role of different organisations etc. The realisation of the programme presupposes reforms in the central elements of the Finnish forestry legislation. A general Forestry Act is proposed to steer the forest management in a direction fostering biodiversity in forest ecosystems. The Private Forest Act will be reviewed to include biodiversity aspects. It is likely that the entire act will be replaced by the General Forestry Act. Additionally, the current Forest Improvement Act will be replaced by an Act on Financing of Sustainable Forestry.

Lorne F. Riley
Coordinator Criteria & Indicators
Canadian Forest Service (CFS)
Ottawa, Ontario, Canada K1A 1G5
Tel. (819) 997-1107
Fax (819) 997-7022

FORESTS, FORESTRY AND FOREST RESEARCH IN CANADA: AN OVERVIEW

Introduction

Canada is first and foremost a forest nation. Forests cover almost half the Canadian landscape and are a dominant feature of the country's economy, culture, traditions and history. As in Finland, forests are the basis for Canada's greatest industry, which is also the largest contributor to the national balance of trade. In addition to providing fibre for industry, forests meet a range of other values; they offer tourism and recreation benefits, are a source of clean water, provide a home for wildlife, satisfy cultural and social values, and are a site of genetic diversity. Forests have shaped the cultural, spiritual and socio-economic aspirations of Canada's Aboriginal peoples for centuries.

There are 453 million hectares of forest land in Canada. Of that, some 51 million hectares of heritage and protection forest are unavailable for harvesting by legislation or policy. This amount is increasing as the perceived value of the forest by Canadians at large places demands on responsible administrative agencies and as Canada strives to achieve its commitment to the Forest Principles of the Rio Earth Summit.

Approximately 209 million hectares of Canada's forests are considered commercial forest capable of producing both timber and non-timber products. However, only about 25% of the total forest land base, or 112 million hectares, is currently managed for production. Much of the unmanaged area is to be found in the far north where access is severely restricted and sensitive ecosystems predominate.

Among major forest nations, Canada is unique in that most of its forests are publicly owned (94%). The remaining 6% belongs to more than 425,000 private landowners, a few owning large areas but most owning areas ranging in size from a few hectares to a few hundred hectares only. Of the public lands, provincial governments are responsible for 71%; 23% is the responsibility of the federal government, most of it in the Territories, and the remainder is owned by local governments and municipalities.

The federal government and the 10 provinces each have their own forest legislation, regulations and standards, and forest management programs. The federal government's role in the forest sector is multi-faceted and includes responsibility for industry and market development, international negotiations, trade relations, research, scientific exchange and technology transfer, employment, regional economic development, and the development of Aboriginal land programs. In addition to the timber resource, provincial responsibilities typically include wildlife, freshwater fisheries, parks, recreational opportunities and similar values.

A few additional facts pertaining to Canada's forests:

- 10% of the planet's forest cover
- 15 hectares of forest area per capita (compared with 5.2 in Zaire, 3.5 in Brazil, 1.2 in the United States, 0.6 in Indonesia and 0.1 in the People's Republic of China)
- about 20% of the world's fresh water flows from forested Canadian watersheds
- 350 forest industry dependent communities
- 300,000 direct jobs and 370,000 indirect jobs in forest-based activities

Forest Sector Influences

Three factors have influenced Canadian forest policy in recent years - world-wide recession, changing societal values, and increasing globalization.

1) Recession

The global recession of the 1990s, coupled with lower product prices, increased production costs. Because of its population size and proximity, the United States is the principal consumer of forest products produced in Canada. The Canadian forest industry, as with much of the economy as a whole, is closely tied to economic trends in the US and is highly sensitive to fluctuations in the currency exchange rate between the two countries. An overall appreciation of the Canadian dollar very early in the decade resulted in a decline in export revenues which seriously affected the profitability of the Canadian forest industry. A marked reduction in the exchange rate, in favour of the US dollar, has altered the situation in very recent times but the effect is taking time to trickle down to the industry. Although profitability has improved over the past year, the poor economic conditions resulted in a significant decline in capital expenditures and a number of the less efficient pulp and paper mills and solid wood products mills were forced to close. The industry is now showing signs of recovery and will be generally strengthened by the industry dropout that occurred.

2) Environment

The Canadian public's enhanced awareness of environmental issues has contributed to our redefining the way we view our forests. Forest managers are placing greater emphasis on environmentally sensitive practices and non-timber values. Some environmental groups continue to express concern over clearcutting, the harvesting of old-growth forests, the use of chemicals in forestry, the extensive use of planting to regenerate forests, and effluent from pulp and paper mills. Recycling and green consumerism continue to influence forest policy and the structure of forest industry investments. Governments have enacted stricter regulations on emissions from pulp and paper mills and industry is investing billions of dollars to meet these regulations.

3) Globalization

In recent years Canadians, along with much of the rest of the world, have become aware of such global issues as tropical deforestation, biodiversity, the role of forests as carbon sinks, and the potential role of forests in influencing climate change. Awareness of the environmental value of Canada's forests has grown rapidly and Canadians are determined that Canada shall be in the forefront of international efforts in these areas.

The Bruntland Commission Report, UNCED and new trading relationships and partnerships have all had major impact on Canadian forest policy. Canada is taking an active role in global initiatives towards sustainable development of forests. It was a lead player at the Earth Summit, is directly involved in boreal / temperate zone development of criteria and indicators of sustainable forest management, is collaborating with Malaysia in a north / south dialogue, and has been a keen observer at the various meetings of the Pan-European Roundtable sessions. Most recently, Canada has agreed to house the secretariat for a multi-national initiative to establish criteria and indicators for the world's non-European boreal and temperate zone forests.

Changes are taking place on a number of fronts in response to these pressures and imperatives. More holistic and sustainable approaches to forest management are now almost universally endorsed within the sector and internationally, and are beginning to be put into practice. Forest industry is restructuring to better address present-day market opportunities and constraints. There is increasing cooperation between governments, industry and other stakeholders to ensure that the limited physical and financial resources available to the forest sector are used efficiently and to maximum collective advantage.

The National Forest Strategy and the Canada Forest Accord

New approaches to forestry are resulting in new partnerships among those with an interest in Canada's forests. After a year of public consultation, Canadian governments and representatives of a broad cross-section of interest groups developed a common vision and strategy to manage Canada's forests in a sustainable manner. The completion of the National Forest Strategy, entitled *Sustainable Forests: A Canadian Commitment* has been a significant forest policy achievement. The Strategy identifies Canada's goal as follows: "....to maintain and enhance the long-term health of our forest ecosystems, for the benefit of all living things, both nationally and globally, while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations". The goal represents an evolution from sustained yield management of timber for commercial purposes, to the sustainable development of our forests. This development entails refining and developing new forest practices to manage for all forest values while maintaining the integrity of the forest ecosystem.

The Strategy was finalized in 1992 under the auspices of the Canadian Council of Forest Ministers (CCFM) comprised of ministers from all senior forest jurisdictions across the country. As a blueprint for Canada's forests, the Strategy identifies 96 commitments in nine priority areas including: forest stewardship and research; public participation; economic opportunities; human resource development; and Aboriginal, private land and international forestry. As trustee, the CCFM has created the National Forest Strategy Coalition to oversee implementation of the strategy. The Coalition is this year embarking upon a mid-term review and reporting of progress. Partnerships between governments and a wide variety of non-government groups are essential in meeting the commitments for sustainable forest management nationwide.

The commitment to the Strategy and to sustainable forest management is reflected in the Canada Forest Accord which includes a statement of beliefs and a vision and goal regarding Canada forests. The Accord was signed by all members of the CCFM and by representatives of industry, labour, Aboriginal peoples, environmental and forestry groups, woodlot owners and academics.

As one of the action items under the Strategy, parties representing a broad range of interest groups across Canada have established the Canadian Criteria and Indicators Working Group. This group is responsible for the preparation of a set of criteria and indicators of sustainable forest management for Canada, an undertaking that will lead to a Canadian intervention at the June 1995 meeting of the UN commission on sustainable Development when that body considers progress towards global sustainable forest development as a follow-up to UNCED. The Canadian Forest Service houses the secretariat for the initiative.

Canada's Green Plan

Canada's Green Plan is the national strategy and action plan for sustainable development launched by the federal government in December, 1990. The Plan represents a fundamental shift in the way the federal government views economic development and environmental protection: they are inextricably linked; both are critical to the health and well-being of Canadians. Within the broader program which is Green Plan, there are two major programs aimed at contributing to sustainability of Canadian forests.

Model Forests

A network of 10 large-scale model forests is being developed (9 are in place) to accelerate the implementation of sustainable forest management in Canada, to develop and apply new and innovative concepts and techniques in forest management, and to test and demonstrate the best sustainable forest management practices. The model forests are situated in five major forest eco-regions across Canada. The network covers 6 million hectares, an area more than twice the size of Belgium. Each forest is managed and funded under a partnership arrangement involving the federal government, provinces, industry, universities, environmental and forestry organizations, and other stakeholders. The Canadian model forest program has been expanded to include model forest developments in Mexico, Malaysia and Russia. At present there are two model forests being developed in Mexico while negotiations for those in Malaysia and Russia are in progress. The idea is catching on rapidly and new model forest initiatives are being considered in and by a number of other countries.

Tree Plan Canada

Tree Plan Canada brings the act of tree planting into backyards, neighbourhoods, schools and communities across the nation. It communicates the importance of trees and teaches the basic technique of tree planting. By the end of this season, more than 20 million trees will have been planted nationwide involving over 900 community groups.

Forest Research

Total forestry and forest-related R&D expenditures in Canada in 1990, the latest year for which confirmed figures are available, was about C$343 million. Over the past 20 years, absolute levels of forestry R&D funding, have increased by over 600 percent. In constant dollars, however, using the gross national expenditure index as a deflator, the increase has been about 50 percent. Indeed, in terms of real spending power R&D funding may have actually decreased during that time because the cost of conducting forestry and many other types of R&D has increased more rapidly than the index.

Recent levels of forestry R&D funding have been equivalent to about 0.7% of the total value of shipments from the forestry sector, well below the overall Canadian average of 1.3%.

The major forestry R&D performers in Canada are the Canadian Forest Service of the federal government, the provinces, the universities, and the principal cooperative industrial forestry research institutes - FERIC, FORINTEK, and PAPRICAN - plus some individual forest-based companies. Funding of research, however, is contributed in different proportions. Funders are, in order of contribution level, industry, the federal government, provincial governments and universities with a variety of additional sources contributing lesser amounts.

Canadian Forest Service

The Canadian Forest Service is the federal government's lead agency for forestry matters and is the single largest forestry R&D organization in the country. Its in-house program addresses R&D needs relating to the forest resource and its management. It is a program which focuses on both national and regional concerns and priorities through its 6 regional establishments and 2 national institutes. The program of research is shifting its focus to emphasize more strategic R&D issues in keeping with the Service's national leadership responsibilities. Such issues frequently, though not necessarily, translate into longer-term and/or more fundamental, process-oriented research projects. CFS is not especially well-suited to short-term, client-oriented R&D and extension services and is attempting to avoid unnecessary overlap with the provinces in this regard. Nonetheless, it is most important that CFS be actively involved in the transfer to user agencies of technology developed through its own R&D activities.

Other Federal Departments and Agencies

In addition to the Canadian Forest Service, there are several federal departments and agencies that are involved in supporting and/or conducting forestry or forestry-related research. Departments include the Departments of Environment; Agriculture; Natural Resources; and Industry, Science and Technology. Other agencies include the university granting councils (National Science and Engineering Research Council, Social Sciences and Humanities Research Council) and the National Research Council. The contribution these other departments and agencies make to forestry-related R&D is substantial but mandates are varied and none relates exclusively to the forest sector.

Provincial Forestry Departments

Provincial forestry or natural resources departments are key players in forestry R&D across Canada. The extent and nature of their role varies, however, depending on whether they have in-house R&D capabilities or not. Canada's three largest provinces, Quebec, Ontario and British Columbia, each have a forestry research branch or institute whose principal focus is on applied R&D that stems directly from the province's operational forest management responsibilities. Their undertakings may be short- or long-term in nature but they do not involve a substantial amount of fundamental research. Most of the remaining provinces do not have the fiscal resources to set up viable independent forestry R&D units. These provinces then rely on forest sector partners to meet most of their R&D needs.

Provincial research councils or equivalents exist in most provinces. They have responsibilities for R&D, technology development, advisory services, and commercialization in a variety of fields appropriate to the particular needs and resources of the respective province. Several have developed specialization in fields of relevance to forestry (e.g., biotechnology, forest products, chemical analysis) and serve a number of forest sector clients

Universities

Canada's universities play a vital role as participants, and not infrequently as the lead centres, in forestry research networks and multi-agency or multi-disciplinary collaborative R&D projects. Features of university R&D in Canada are the integral link with undergraduate and graduate training, an ability to respond relatively quickly to developing R&D needs, and generally fewer administrative and bureaucratic constraints. The universities are especially well positioned to bring specialized expertise and depth in more fundamental topics to the overall forestry sector R&D effort, but they also contribute effectively to more applied R&D as well as to some technology transfer and extension service activities. Much university R&D is relatively short-term because of its linkages to graduate training programs and its dependence on grants and contract funds from other agencies.

Close to half of all forestry-related R&D in Canada's universities is now being carried out other than forestry faculties and departments. This is seen as an appropriate balance which reflects the increasingly diverse range of disciplines involved in holistic forest management, especially in the social and environmental fields.

Co-operative Industrial Forestry R&D Organizations

Three co-operative R&D agencies, FERIC, FORINTEK, and PAPRICAN, have well-defined national mandates in forest engineering, solid wood products and pulp and paper R&D respectively. Their work, which is mostly of a generic nature but which includes also some proprietary R&D, is supported by a combination of contracts and contributions from industry and government.

One of the most difficult tasks faced by these organizations is maintaining a reasonable balance between short-term, problem-solving R&D and longer-term or more fundamental research. Given their client base, it is inevitable and appropriate that their programs are focused strongly on immediate R&D needs, developmental work, and technology transfer, and all three organizations have strong capabilities in these respects. To date PAPRICAN appears to have been the most successful in maintaining a reasonable level of more basic research whereas FERIC and FORINTEK, with their smaller total budgets and different client base, have experienced greater difficulty in this regard.

Forest Industry

Individual forest-based manufacturing and forest service companies play an important role in carrying out or supporting near-term, commercially-oriented R&D and in adapting and using the results of R&D carried out by other agencies. At present, industry provides direct funding and in-kind support to the co-operative forestry R&D organizations, universities, and other forestry R&D agencies for work in forest products and forest management. A few of the larger forest-based companies also have in-house R&D capability, focused mainly on new product development of a proprietary nature. In addition, a significant contribution to R&D is made by the many small, innovative forest supply or consulting companies in areas such as information systems and emerging technologies.

Forestry Research Advisory Bodies

The various forestry R&D advisory councils and committees that exist across the country are unlike any of the other agencies considered above. With very few exceptions they are not legally constituted bodies and all have multi-agency representation on them. These agencies provide a vital forum in which forestry R&D priorities and programs can be reviewed and evaluated from a multi-agency perspective. Because of their number and jurisdictional orientation they are able to focus on different geographic areas and their associated concerns and can deal effectively with specific topic areas. Whereas most provinces have their own advisory bodies in this category, the Forest Research Advisory Council of Canada (FRACC) is the umbrella organization which attempts to assimilate the needs and concerns of the entire country and develop national research program guidance for the range of forestry R&D agencies. FRACC provides annual forest research status reports to the federal minister of forestry and his provincial counterparts through the Canadian Council of Forest Ministers.

Canadian Council of Forest Ministers

While not a research-oriented body, the CCFM is instrumental in guiding the development and implementation of research across Canada. Its members control a large segment of R&D funding by virtue of their ministerial roles and have a strong say in the kinds of research that are conducted both nationally and regionally. As is clear for such a group the CCFM's support, or non-support, can be critical in determining the general direction that research will take at any given time.

The Forest Science and Technology Agenda

Results from earlier forest research programs have allowed Canada's forest practices to progress from simple exploitation to sustained yield management to the threshold of sustainable forest management on an ecosystem-wide basis. Our knowledge of forest ecosystem functioning and response to human intervention is far from complete, however. Canada's forest science and technology programs must be focused on these information gaps so that the challenges and opportunities of sustainable forest development can be successfully addressed.

Although it does not cover, nor does it purport to cover, all concerns and programs of forest-related research in Canada, the Canadian Forest Service Strategic Plan for the period 1995-2000 does signal the tone that most Canadian forest R&D agencies are adopting in light of current-day demands and pressures. The strategic objectives from that Plan, the text of which has just been approved, are listed below.

1. Understanding the fundamental process, functions and dynamics of Canada's forest ecosystems

2. Providing national and international leadership in forest ecosystem monitoring, data compilation and analysis

3. Developing and promoting better ways for protecting and enhancing the health, diversity and productivity of Canada's forest ecosystems

4. Developing the integrated knowledge, tools and techniques required for the implementation of holistic and sustainable management of forest ecosystems

5. Contributing to the future viability and competitiveness of Canada's forest-based economies

---

Through sustainable forest management and directed research programs in support of all forest-based values, Canada is determined to be leader in the improvement of the domestic and global forest estates, the latter in concert with its many forest nation neighbours. It will be through collaboration with countries of the boreal zone especially, countries such as Finland with which we have had many years of mutually beneficial interaction, that such ambitions will be realized.

Eero Paavilainen
Research Director
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 470
Fax +358-0-857 05 569

THE STATE OF THE FORESTS AND FORESTRY IN FINLAND

For centuries, the welfare of Finns has been based on the country's forests and forest industry. At the beginning of this century over 85 per cent of Finland's export income was derived from forest industry products. Even now in the 1990s forest industry continues to be one the leaders in the Finnish economy. The share of forest industry products of Finland's export income was in 1992 still 36 %. In the early 1990s Finland was, for example, the world's biggest exporter of printing and writing paper and the third biggest exporter of packaging paper, paperboard and newsprint.

The favourable development in Finnish forestry was stopped for many years by World War II which caused a loss of 13 % of forest area and 26 % of forest industry production capacity in Finland. Effective forest management and investments in timber production were needed to recover from these losses and further increase the growth in forest industry production. The increase in forest productivity by forest improvement was especially important at the beginning of 1960s when the amounts of cuttings were higher than the annual growth.

The most important forest improvement work supported by public funds has been drainage of peatlands and wet mineral soils which has brought about an additional forest increment amounting to approx. 10 mill. m^3 per year and an increase of approx. 2.0 mill. ha in the area of forest land. Forest fertilizers have been applied on an area of 3.3 mill. ha. The amount of planted or sown stands is 4.5 mill. ha. Due to these and other forest improvement measures together with the relatively low amount of cuttings compared to the annual growth in the last two decades, Finland's current forest resources and annual increment are greater than ever before during this century.

In 1994 the total volume of Finnish forests has been estimated at a level of 2000 mill. m^3 and the annual increment between 85-88 mill. m^3. The forest area is approx. 20 mill. ha, and the tree species distribution per growing stock volume is as follows: Scots pine 45 %, Norway spruce 37 %, birch and other deciduous species 18 %.

Small-scale family forestry is practised in the majority of Finland's forests. Private persons own 63 % of country's forests and 75 % of their annual growth. In early 1990's 74 % of raw material for the forest industry came from private estates which have an average size of 32 ha. The share of State forests producing wood raw material was at the same time 8 %, that of industrial forests 6 %, and the share of imported wood was 12 %.

Most private forests as well as those owned by State or companies are treated in accordance with forest management plans, which are based on data measured in the field and on calculations on stand increment and development. This makes possible the long-term practising of sustainable forestry and the steady flow of income from sales of timber.

In Finland, each private owner can decide when and how to fell or otherwise tend his forest estate - as long as the actions taken are according to the regulations of Private Forest Act. The leading principle of this Act is that forests must not be destroyed, i.e. that the owner has, for example, to see to the establishment of new tree crops after regeneration felling. In practice, the treatment of forests is planned in cooperation with the staff of forestry boards and local forest management associations so that the woodlot owner's timber production goals are achieved in the best possible way.

The area of felling operations was 410 000 ha annually in 1987-1991. During this period 25 % of the operations applied were clear fellings on forest land, 21 % fellings using seed-tree or shelterwood methods, 50 % thinnings on forest land, and the rest other fellings on forest land or scrub land. The average size of final felling area in private forests was less than two hectares.

The mechanization of forest work is constantly increasing. For example, over 60 % of the normal cutting volume in industrial and State-owned forests is taken care off by using mechanical felling. Road transport is the most important long distance transport mode. The share of rail transport is only approx. 20 % and that of floating, which has much decreased in the last decades, approx. 10 %.

The health of forests is monitored in Finland by National Forest Inventories and since 1985 on systematically distributed permanent sample plots. So far, acidification of forest soils, global warming and depletion of the ozone layer have not reduced the amount of increment of the growing stock. The degree of defoliation, which is affected not only by air pollutants but also by stand age, climatic factors and local pest and disease epidemics, is in Finnish forests slightly below the European average. Some indicators as for example the occurrence of epiphytic lichens show negative effects of increased air pollution loads in the southern part of Finland. Most severe local damages and losses in the increment of forests are, however, caused by root rot

(*Heterobasidium annosum*) in Norway spruce stands and pine cancer (*Gremmeniella abietina*) in stands of Scots pine.

Time differences in the application of forestry operations and the small size treated at the same time add to the variability of forest ecosystems, and thus help to keep the biodiversity of Finnish forests already at the present time. In the new forest legislation which is under preparation, special attention is paid to the aspects of protection and appropriate promotion of biodiversity as essential elements of the sustainable management and use of the forests.

The preservation of natural biodiversity has been set down as the foremost conservation objective. In 1994 conservation areas (National Parks, Strict Nature Reserves, Wilderness areas and Peatland Reserves) established in Finland in accordance with the current legislation amounted to approx. 3.0 mill. hectares. Conservation areas are concentrated to the northern part of the country: there 17.6 % of the forestry land is under conservation. More conservation areas, especially in old growth forests, will still be established in South Finland. The need for the protection of new areas is somewhat decreased by the fact that the objective of the new forestry policy is to combine wood production, preservation of natural biodiversity, and environmental protection of the Finnish forests into a balanced whole.

Jan Heino
Deputy Director General
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki, Finland
Tel. +358-0-160 2418
Fax +358-0-160 5078

CURRENT AND POTENTIAL AREAS OF FORESTRY COOPERATION

Memorandum of Understanding

The formal basis for cooperation between Canada and Finland is to be found in the MoU, signed at 29 May, 1992. The Memorandum recognizes the cooperation that already exists, both in the public and private sector. The areas of cooperation of specific interest to both countries that are listed in the MoU are numerous. In addition, cooperation need not to be limited to those issues listed in the paragraph concerned. However, para (4) of the MoU gives us a good idea of what the main items are.

The mechanisms of cooperation mentioned in the Memorandum are study tours, seminars and professional exchanges. In addition, the para concerning the implementation widens the scope of mechanisms. The last paras deal with expenses, intellectual property rights and effective date.

The MoU seems, from the Finnish point of view, satisfactory and quite up-to-date. It enables a lot of activities. The MoU is a good tool for further development of cooperation. The question is more, do we have as much capacity to expand as we have willingness to start new cooperation activities.

International fora

Current cooperation activities can be found as well at the international as the bilateral level. There is fruitful cooperation between our countries in several international organizations or processes. I would like to mention some of the most essential fora. Within forest research, the IUFRO network provides a world-wide framework, where the linkage between Canada and Finland is strong.

By the way, after the successful World Congress in Montreal there is quite a responsibility to shoulder for Finland in organizing the next Congress in Tampere next year. We are grateful for the good guidance we have received from you Mr Riley. The experience you gained, that has been transferred to us, is extremely valuable.

Recently, a new international organization has been established with the objective to promote and coordinate boreal forest research. The name of this organisation is IBFRA, International Boreal Forest Research Association. Canada, US, Russia; Sweden, Norway and Finland participate in the work of this Association.

Both Canada and Finland participate in the work of the International Energy Agency. The FFRI take part in IEA groups that arrange meetings as well in Canada as in Finland. During 1987-92 researchers from FFRI attended 6 meetings in Canada. - Finnish researchers have shown interest in the BOREAS project also.

Normal forestry fora where we meet is the FAO, especially its Committee on Forestry. We see the weaknesses of FAO, but on the other hand it is the lead forestry organization within the UN system.

After the Rio meeting the Second Ministerial Conference on Protection of Forests in Europe was held in Helsinki, with observer participation from Canada also. The so called Helsinki process is a major contribution to the practical implementation of the Rio forest principles at the European level. The Forest Principles need to be translated in a form in which they may be used to demonstrate, within each country, the present position in relation to sustainable forestry. We have to build upon the work already done in many contexts, for example the CSCE Montreal Seminar. - There is an evident need for consultations among countries which are willing to continue global discussion on an international instrument on forests. There is also a need for proposals on how to facilitate the review of forest related issues by the UN Commission on Sustainable Development at its session in 1995. Initiatives, such as the one put forward by Canada and Malaysia to convene an international meeting in Kuala Lumpur four weeks ago clearly promoted preparations for the forestry agenda before the UNCSD meeting.

Current bilateral cooperation

There are cooperation activities within forest researchers and research institutions, between forestry authorities and, last but not least, also commercial cooperation. I would like to give you two aspects concerning the commercial sector. The first one has to do with forest industries. The forest products industry seems to be increasingly in the same boat, when environmental trends are concerned. The topics, and their intensity may vary, but the fundamental issues remain the same and cross oceans and continents fast, at the speed of electronic communication. Exchange of information and experience in this matter obviously is of mutual interest.

The second one concerns our commercial relations, that seem to thrive, to put it shortly. Canada and Finland accord each other Most Favoured Nation status. Since our countries are quite similar seen from the economies point of view, a keen interest in commercial cooperation has developed. Long term prospects of trade are good. The export from Finland to Canada has been bigger than vice versa, but we do not mind. The approximate export volume in 1993 was 240 million dollars and the import 163 million. In addition to good prospects for trade between our countries, there ought to be exciting cooperation opportunities for Canadian exporters to work with Finnish firms for sales to the Baltics and Russia also. We would like to say welcome also to Canadian firms to invest in Finland. While our investments in Canada in 1991 totalled 360 mill. dollars, the Canadian investments in Finland were 50 million dollars.

Olli Eeronheimo from The Finnish Forest Research Institute has written a short, comprehensive report concerning the cooperation between Canada and Finland from the point of view of the institute. According to his description

- some 60 out of the 220 researchers have visited Canada during the five year period 1987-91
- five researchers from the Institute have worked for at least a month in Canada during the last five years
- a joint seminar was arranged in Ontario in 1990
- eight study trips took place from the Institute to Canada 1987-91
- the exchange of publications is quite

Potential within the area of bilateral cooperation

Within the forest sector, in general, there seem to be a potential especially in direct contacts and joint projects between Canada and Finland.

Ian D. Thompson
Research Scientist
CFS, Petawawa National Forestry Institute
P.O. Box 2000, Chalk River, Ontario
Canada K0J 1J0
Tel. (613) 589-3046
Fax (613) 589-2275

BIODIVERSITY RESEARCH IN CANADIAN FORESTS: ECOSYSTEMS AND LANDSCAPES PRESENT AND FUTURE

Abstract

Research on biodiversity at the ecosystem and landscape scales is currently taking a several-faceted approach to develop predictive models, techniques and indicators for monitoring and mapping, and management models to establish objectives for components of biodiversity. Most provinces are working to complete ecosystem classification systems for mature forest types, and developing successional models as associated tools. Several research programs are assessing the value of forest ecosystem classification as a tool to predict the presence and abundance of wildlife and plant species, and will link GIS forest data bases to model and predict future conditions. Technical research is developing the means of remotely sensing ecosystems to enable digital data bases for rapid forest classification (Landsat TM, CASI, radar), and of modelling forest and wildlife species occurrence and abundance related to ecosystem types and their inherent productivity. This kind of modelling approach to the biodiversity problem will ultimately enable the predictive assessment of capability for species and ecosystems. Models based on "macro"-variables (weather, climate, topography, soils) have been tested as predictors of forest ecosystem occurrence and physical location. Other programs are trying to assess forest structure and age class had humans not interceded with fire protection and logging, as a means to provide a 'baseline biodiversity of ecosystems as an objective for present forest managers. CFS has developed a series of decision support tools for harvest allocation, wildlife values, economic valuation, and successional development and is assembling these model modules into a broad forest-use DSS tool.

Introduction

All Canadian resource management agencies have embraced the concept of sustainable development, and have begun research into how to develop ecosystem and biodiversity management programs. In forested systems, this includes all provincial wildlife, forest or natural resources departments, and at the national level Natural Resources Canada (Canadian Forest Service), Heritage Canada (Parks Canada), Museums Canada (Museum of Nature), and Environment Canada (Biodiversity Office, Canadian Wildlife Service). There is a new "Canadian Biodiversity Strategy" that articulates the future direction resource agencies should take by setting objectives for biodiversity, and by establishing protocols for improved cooperation among the various levels of government. Current research efforts are aimed at: determining effects of humans on biodiversity, developing alternate techniques and plans for harvesting forests that will maintain the ecosystems, setting objectives for ecosystem management, developing techniques for rapid assessment of ecosystems, developing monitoring techniques and indicators, modelling ecosystem and landscape processes, and linking wildlife populations to habitats and ecosystems.

Research Programs

Anthropomorphic effects / baseline biodiversity

Managers are re-establishing objectives for management units based on sustainable development. A necessary component of such management requiring research is to answer the question of "what biodiversity should we manage for"? We are taking three approaches to this problem: historical reconstruction, modelling principles, and comparison studies between 'second-growth' and natural forests.

Because Canada has a relatively short history, we can 'reconstruct' models of forest ecosystem occurrence on landscapes prior to European settlement from either historical record, by back-dating old stands, or by modelling principles such as fire cycles and known successional patterns. The purpose of this work is the establishment of baseline ecosystem and landscape information including patch size, species composition, and age-class distributions. A second approach to the problem of how to set landscape objectives is through comparison study of old forest and forests regenerating after logging. The latter research is intended to enable the projection of current stands into the future, and to examine differences between natural and managed stands, with a view to altering management practices to somewhat emulate natural disturbance patterns.

Gap analysis is being used in several areas of Canada to determine how well current management / preservation practices are conserving biodiversity. This technique identifies ecosystem types that are rare, and can be used to predict future occurrence based on age class distributions and proposed management actions.

Modelling of current biodiversity

A major focus of current research efforts involves attempts to develop models that are predictive of species associations. There are three general approaches to this problem: modelling of individual species, using forest ecosystem classifications (e.g., Cajander 1909, 1913) as predictors of wildlife communities, and modelling of habitat dependent groups (functional groups). Most often individual species are modelled using habitat suitability indices (HSI), or habitat supply analysis (HSA). In certain specific cases, such as for featured species (e.g., moose) or rare species (e.g., some subpopulations of marten) population dynamics are modelled and linked to various data bases in GIS to predict future population levels under various management scenarios. The most difficult area of endeavour is the grouping of species into functional units to avoid the problem of relying either on indicator species, or having to model all species simultaneously. One approach has been to use habitat dependency groups, constrained by body size and dispersal capability relative to forest fragmentation, linked again to GIS forest data bases to enable prediction. The landscape indices program FRAGSTATS, developed primarily by the US Forest Service, has been adapted for several areas to suit Canadian forest conditions, and is employed in the latter habitat model.

Several jurisdictions have maps of forest ecosystems that were derived from aerial photography, satellite imagery, and ground checking. The provinces of Quebec and British Columbia are particularly advanced in the annotated mapping of ecosystems based on FEC or biogeoclimatic classifications. The latter province is working on 'wildlife handbooks' for various regions of the province to inform managers of species with habitat dependencies. Digital maps with a number of thematic overlays are becoming common and are used to predict species diversity. One project has developed predictions of forest types based on digital 'macro'-variables including: climate, weather, soils, and topography. These data are meshed with an FEC to predict spatial distribution of ecosystem types on a landscape. This technique has been done successfully on pilot areas and is currently being extended to the entire province of Ontario (>1 million km^2). The next step in this program is to link species distributions to these data bases.

Ecosystem process models

A new approach to biodiversity is to develop mapping tools for ecosystems based on process models, such as BIOME-BGC. Concurrent with research into these tools is the ability to use outputs from the process models, such as primary productivity, to drive predictions about wildlife habitat suitability, populations and community structure.

Alternate harvesting strategies

The long-standing notion that clearcutting imitates natural disturbance has recently been questioned by many forest managers and researchers. As a result, numerous field trials are now being conducted to assess ways of harvesting forests in a more ecologically-sound manner. Management scale experiments are being conducted in several ecosystem types to assess harvesting techniques as alternatives to clearcutting. For example, selection harvest in mixed woods, maintaining as much advanced growth as possible in lowland spruce systems, and small patch-cutting in rainforest habitats are being assessed in terms of: site protection, cost effectiveness, impacts on diversity, and for effects on natural succession.

Decision support systems

Much of what has been mentioned above is part of a larger series of modular models for forest management decision support systems. CFS has a major program to link models dealing with forest growth and succession, mapping of ecosystems, wildlife populations, and linking these to harvest scheduling to enable the maintenance of biodiversity.

Ariane Plourde
Research Project Leader
Canadian Forest Service, Quebec Region
P.O. Box 3800, Ste-Foy, Quebec
Canada G1V 4C7
Tel. (418) 648-7616
Fax (418) 648-5849

BIODIVERSITY OF CANADIAN FORESTS AT THE GENE AND SPECIES LEVELS: CURRENT STATUS, CONSERVATION AND RESEARCH

1. Definition of biodiversity

In Canada, we have adopted the definition proposed by the US Government's Office of Technology Assessment which stated that: "BIOLOGICAL DIVERSITY REFERS TO THE VARIETY AND VARIABILITY AMONG LIVING ORGANISMS AND THE ECOLOGICAL COMPLEXES IN WHICH THEY OCCUR." THE TERM ENCOMPASSES ORGANIZATION AT DIFFERENT LEVELS, RANGING FROM COMPLETE ECOSYSTEMS TO THE CHEMICAL STRUCTURES THAT ARE THE BASIS OF HEREDITY.

2. Current status

There are estimated 300 000 species of animals, plants and micro-organisms in Canada and about 200 000 species are found in forests. Species biodiversity varies between and within provinces. Generally speaking, there is a gradient in species diversity from north to south. In the boreal forest zone, 38 species of trees are found, compared with 79 species in the much more restricted Carolinian forest zone.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) lists 195 species of animals and plants as being vulnerable, threatened, endangered or extirpated in Canada in 1990. Amongst these, there are 6 tree species: Cucumber-tree (*Magnolia acuminata*), American chestnut (*Castanca dioicus*), Blue ash (*Fraxinus quadrangulata*), Dwarf hackberry (*Celtis tenuifolia)* Hoptree (*Ptelea trifoliata*).

A survey of genetic conservation activities for tree species in Canada was conducted, covering both *in situ* and *ex situ* conservation efforts (Table 1). The *in situ* conservation (parks and other reserves) activities account for most of the species conservation and all the ecosystems conservation. An estimated 4% of productive forest land is categorized as having a highly protected status. The actual federal government's target of protecting land area is now 12%. Under the Green Plan program, our department is promoting the extension of the forested ecological reserve network to ensure adequate representation of all ecosystems in protected areas.

Table 1. Conservation of Canadian forest biodiversity

Activity	Number	Area (ha)	Other details
1. National Parks	34	5.1 million	Forested lands
2. Other reserves	3.100	38.5 million	Forested lands
3. Reserved stands	458	42 900	
4. Seed production areas	228	8 200	
5. Seed orchards	63	1 875	28 400 families
6. Clonal archives	100	309	43 100 clones
7. Provenance tests	202	950	14 500 provenances
8. Seed bank (seed lots)	33 500		3.15 billion seeds

From: T.J.B. Boyle. Biodiversity of Canadian forests: Current status and future challenges. The Forestry Chronicle 68 (4): 444-453.

3. Research activities

The federal government's Green Plan is also a major impetus to expand research effort devoted to diversity issues. Here are some of the research going on in Canada in different fields related to biodiversity.

3.1 Forest Genetic Resources Conservation

Genetic resources information system	T. Nieman, Petawawa National Forestry Institute (PNFI), Canadian Forest Service (CFS)
Germ plasm storage	P. Charest, PNFI-CFS
Somatic embryogenesis	P. Chares, PNFI-CFS B. Sutton, University of British Columbia, Vancouver, B.C. F. Tremblay, Université Laval Quebec, Quebec J. Bonga, CFS-Maritimes Region A. Plourde, CFS-Quebec Region
Cryopreservation	P. Charest, PNFI-CFS

3.2 Genetic diversity

Western red cedar and Douglas fir	J. Carlson, U.B.C.
Mountain hemlock	G. Edwards, CFS-Pacific and Yukon Region
In natural and plantation forests	J. Loo, CFS-Maritimes Region
In disjunct populations of white pine	A. Mosseler, CFS-PNFI
In natural populations of white pine and white spruce	A. Plourde, CFS-Quebec Region

3.3 Impact of forestry practices on diversity

Species / genetic diversity before and after thinning	Y. El-Kassaby, Pacific Forest Products, B.C.
Impact of selection and breeding on genetic diversity	A. Plourde, CFS-Quebec Region

3.4. Other plant species and organisms

Changes in plant diversity in Douglas-fir stands following the conversion of old growth to second growth	M. Ryan Arenaria Research & Interpretation, B.C.
Variation in Carabid community structure association with forest successional stages	K. Craig, U.B.C.
Biomonitoring of entomological fauna in forest ecosystems	C. Hébert, CFS-Quebec Region
Nematode diversity and distribution in different forest soil habitats	V. Marshall, CFS-Pacific and Yukon Region

Kevin E. Percy
Research Scientist
CFS, Maritimes Forestry Centre
P.O. Box 4000, Fredericton, N. B.
Canada E3B 5P7
Tel. (506) 452-3524
Fax (506) 452-3525

FOREST HEALTH MONITORING: CRITERIA AND INDICATORS

Sustainable forest management is dependant upon proper functioning of forest ecosystems. Ecosystems respond dynamically to a complex of natural and anthropogenic, biotic and abiotic factors many of which may irreversibly disturb the. Individual components of forest ecosystems are also sensitive to varying degrees.

The state of forest ecosystems has traditionally been described in terms of forest health and vitality. The European Forest Health Monitoring Programme, with 34 countries reporting in 1992, and the Acid Rain National Early Warning System, or ARNEWS, in Canada are notable examples. My colleague, Dr. Lachance will speak later in greater detail on the Canadian monitoring systems.

Boreal and temperate forests make a significant contribution to global cycles and to supporting many human needs. Recently, members states (including Canada and Finland) of the Conference on Security and Cooperation in Europe, or CSCE, met in Montreal to consider sustainable development of these biomes. Participants agreed upon a number of criteria as essential for monitoring sustainable forestry. One of the criteria was ecosystems functioning, or health and vitality.

It is difficult, of course, to define forest health and even more problematic to agree upon what constitutes a health forest! Health has been usually been defined in the narrow pathological sense while vitality has often been more vaguely described in terms of general forest appearance.

In Canada we are building upon the CSCE milestones. Currently, we are considering the criterion definition for forest health and discussing indicators by which it can be measured.

We are proposing that forest condition is more appropriate criterion given the recent evolution in monitoring techniques, particularly in Europe. Forest condition requires consideration of a set of health and vitality indicators which, when integrated, provide an overall assessment of the state of the forest. Furthermore, the criterion is intended to ensure that forests are maintained in a healthy and resilient condition. Key elements include major anthropogenic and natural factors which from the complex affecting forest ecosystem functioning.

Key elements of the forest condition criterion condition include the following, although there no doubt many other.

The first element is maintenance of endemic levels of forest insect pests and diseases while suppressing epidemic ones.

I shall return to, the second element in detail later.

The third element is maintenance of appropriate species and genetic diversity to ensure ecosystems balance, resilience and adaptiveness.

The fourth element is minimization of disturbance, except where required for renewal, caused by forest practices and the improvement of forest practices through an integrated approach to forest management.

Soil lysimetry, such as the technique employed by Dr. Mahendrappa at my establishment has proven to be a good indicator of site quality. Lysimeters and temperature probes are installed at various depths. Changes in key elements such as nitrate can be monitored following harvesting or in relation to changing patterns of acidic deposition. Temperature fluctuations can also be assessed vis a vis climate change.

A fifth element is standardization on forest condition monitoring techniques where possible and international adoption of quality assurance protocols. Indicators might include the number of generally accepted techniques and the number of networks having proper quality control and undergoing regular peer review.

The sixth element is strengthened support for collaboration on research and development of new monitoring techniques. Expenditure on directed R and D and the number of new techniques receiving approval are suggested as indicators.

Foremost among anthropogenic factors acting upon forest ecosystems is air pollutants which have been linked to declines in some high- to mid-elevation forests in Europe and North America. In north-eastern North America acidic fog has incited the decline of low elevation red spruce along the coasts of Maine, USA and New Brunswick, Canada. In the same region, deterioration of white birches has been observed since 1979 and fog frequency and acidity linked to foliar browning.

The second key element of the forest condition criterion is reduction of air pollutant concentrations and deposition to levels less than the critical level/load prescribed for sensitive elements of that ecosystem. Canada is at this moment revising its critical level for ground-level ozone and forests.

Considerable progress has been made in the development of indicators to monitor this element. One important indicator is the level of gaseous pollutants, such as ozone or sulfur dioxide, and the wet deposition rate of sulfates and nitrates. One perennial problem , however, has been the lack of pollutant monitors located in forest situations.

A passive ozone monitoring plate has been developed at my establishment by my colleague Dr. Cox. An inexpensive plate seen here at the top of the pole provides adsorbs ozone over prescribed periods. The plates are previously calibrated against known doses in fumigation chambers. Such techniques are required to monitor pollutants in remote areas and construct isolines indicating zones where the potential for forest injury exists.

In Canada we are also close to arriving at critical loadings for forest soils. This work led by Dr Arp of the University of New Brunswick and Dr Foster of the CFS will be described shortly by Dr Foster in the context of global cycles.

Dr Cox is also using branch enclosures as seen situated in a clonal orchard here or in tree canopies to fumigate trees in the field with known doses of ozone and sulphur dioxide. The response to ozone of two phenolic compounds having antioxidant capability is a promising indicator of early stress.

While monitoring networks have developed a high degree of expertise in the detection of crown and foliar symptoms due to pollutants they typically monitor change in forest health after it is visibly manifest. Other indicators for early, pre-visual diagnosis of tree decline due to air pollutants are urgently required. One indicator which has received concentrated effort in both Finland and Canada is needle surface wax physicochemical characteristics and surface properties.

My own area of interest is the leaf surface, specifically the effects of ozone, acidic deposition and lately, enhanced UV-B radiation upon it. Through controlled experiments in the field and laboratory we have described the dose-response characteristics of leaf cuticle response and are now confident in testing the applicability of several measures of cuticle condition on a regional or transnational scale.

As part of an ECE / Canada exchange I am examining needle wax chemistry on healthy and declining Norway spruce trees in Europe. The trees were sampled across a range of sites in different pollution zones. A promising relationship has been identified between wax chemical composition, deposition regimes and tree vigour.

The usefulness of needle surface wax was recently highlighted in a 1993 paper by my colleague Dr Cape in Scotland. A critical level for sulphate of 150 μmol $litre^{-1}$ is proposed for mid- to high-elevation European forests. This level is based largely on experiments showing deleterious effects on leaf surfaces at that equivalent dose which is considerably less than that required to elicit visible injury. Mapping of critical levels in now possible on a larger scale.

Along the coast of Maine and New Brunswick we have been examining needle surface properties on healthy and declining red spruce trees. The 500 km transect includes some of the highest episodic ozone and most acidic fog levels in North America. Needle wax amount was significantly and negatively correlated with fog amount over three age classes. Fog acidity was positively correlated with needle droplet contact angle. Needles receiving the most acidic fog had the lowest contact angles. This relationship has been subsequently confirmed in laboratory simulations.

We have found the droplet contact angle technique to be a highly sensitive, very early warning indicator stress due to air pollutants. A tree year project is now underway with US colleges to develop the necessary quality assurance and control protocols to enable its introduction into forest health monitoring.

An alarming emerging threat to sustainable forestry is enhanced UV-B radiation resulting from stratospheric ozone depletion. Episodic increases of up to 25% above ambient were recorded on several occasions in southern Canada during the last growing season. The role of the cuticle as a UV screen and its potential as an indicator of UV-B induced tree stress is now being investigated in Fredericton. A three phase project which includes screening of Canadian tree species and physiological growth modelling of response has begun under carefully controlled conditions which mimick a natural elevational gradient. The third phase will use genetic engineering to produce lines of hypersensitive and insensitive spruce for use as indicators of UV-B impact.

I have been fortunate to have strong working relationships with a number of Finnish colleagues. Currently, I have ongoing collaborative research projects with scientists at the University of Oulu and the Arctic Centre, University of Lapland.

At my laboratory in Fredericton we had several visits from Finnish colleagues. We are now analyzing the chemical composition of Scots pine needle waxes collected along gradients around the Nikel and Monchegorsk industrial complexes. A second project involves the analysis of waxes collected from a multi-year acid rain / heavy metal exposure under sub-arctic conditions at Kevo Research Station.

Finally, I would like to bring to your attention the upcoming meeting of IUFRO Project 2.05 which will be held in Fredericton, September 7-9, 1994. The meeting is entitled "Air Pollutants and Multiple Stresses". Approximately 15 Finnish scientists have preregistered for this meeting. I have available here with me copies of the second circular for your information.

Denis Lachance
Research Project Leader
Canadian Forest Service, Quebec Region
P.O. Box 3800, Ste-Foy, Quebec
Canada G1V 4C7
Tel. (418) 648-3932
Fax (418) 648-5849

FOREST HEALTH

The Canadian Forest Service is involved in two major forest health monitoring networks. One is the ARNEWS (Acid Rain National Early Warning System), and the other is called NAMP (North American Maple Project).

The ARNEWS is composed of 149 permanent monitoring sites scattered across Canada. It has three main objectives: 1) Detect possible damage to forest trees, vegetation and soils caused by air pollution, 2) Identify forest damage not attributable to management practices or natural causes, and 3) Monitor forest vegetation and soils for changes in health condition. This network was established in 1984 and 1985 and it covers most of the important Canadian tree species.

Each monitoring site consists in a 10x40 m plot, established in a semi-mature natural stand. Originally, because of the precise mandate of monitoring for air pollution damage, plots were concentrated near the major centers of population along Canada's southern border. An expansion of the network by about 50% in 1993 allowed for better coverage of the main forest types as well as a northern extension to better monitor climate change effects it need be.

At plot establishment, all trees 10 cm and more at dbh are located and tagged. Usual dendrometric data on trees and stand are taken. As well, soil and foliage samples are taken for analysis. Full dendrometric measurements as well as soil and foliage sampling is repeated every five years. Annually, evaluation of general tree crown condition and foliage condition, tree mortality, seed production and presence of insect or disease damage or abiotic symptoms on trees is made.

Field activities for the network are carried out by the regional Forest Insect and Disease Survey units (FIDS) of CFS. The forest rangers of these units are trained in forest pest damage evaluation and identification. Finally, it may be useful to mention that the concept of this network is to detect and identify conditions that may affect forest health. It does not pretend truly evaluate health condition of the Canadian forests.

The second network, NAMP (North American Maple Project), is a joint CFS-USDA Forest Service project, concerned mainly with sugar maple. It consists of 233 monitoring sites (62 in Canada) covering the whole distribution range of the species and was established in 1988. Ten States and four Provinces participate in this project. The objectives of the project are: 1) To determine the rate of change in sugar maple condition, 2) to determine if the rate of change is different between a) various levels of acid precipitation, b) stands managed for sugar sap versus non-managed stands, c) various levels of decline as established at the beginning of the study, and 3) determine the possible causes of decline and if a geographical relationship exists between the causes and the severity.

A monitoring site is composed of a cluster of five 20x20 m plots, on which all trees 10 cm dbh and above are identified and tagged. The sites are established in stands with at least 50% sugar maple between 50 and 150 years old. To respond to the objectives of the program, sites were located in areas with various levels of acid precipitation, in stands with different levels of decline and as much as possible, with a managed sugarbush site located in a relatively close proximity to a non-managed natural sugar maple stand. Minimal site conditions and tree dendrometric data were taken. However, great care is taken in measuring tree condition through crown dieback and foliage transparency. These are called critical measurements. Quality control of these measurements, and field technician training and calibration are prominent features of these network. Each critical measurement is taken simultaneously by two raters that must agree on an estimate, and at least 5% of these are remeasured annually by another team for quality control. Day-to-day guidance of the project is provided by Canadian and an American national coordinator and financial support comes from federal and provincial / state funds.

On the research aspect of forest health, I lead a project at the Laurentian Forestry Center in Quebec City entitled:" Effects of environmental stress on the forest". In 1991 we made an experiment in a mature sugar maple stand in which we allowed the soil to freeze deeply by preventing the snow to reach the ground around trees. We thus induced a significant stress and even a severe decline on some trees, much like the one occurring in the Quebec Province since the 1980s. Several physiological, biomass, and soil water parameters were monitored and significant differences in tree responses were observed. Publications on this experiment are presently coming out.

Stephen C. Zoltai
Research Scientist
CFS, Northern Forestry Centre
5320 - 122nd Street, Edmonton, Alberta
Canada T6H 3S5
Tel. (403) 435-7210
Fax (403) 435-7359

GLOBAL CHANGE AND FORESTS: AN OVERVIEW OF RESEARCH BY CANADIAN FOREST SERVICE

The overall objective of this research is to provide reliable answers to questions concerning the impact of climate change on forest ecosystems which can be used as predictive tools to support decisions by forest managers and policy makers at all levels.

The specific objectives are:

1. Develop a set of models which predict the changes in forest ecosystem components, ecosystem disturbance regimes and successional patterns under a changing climate.

2. Develop a carbon budget model for the Canadian forest sector by calibrating and validating a model that is sensitive to changes in climate.

3. Develop climate-sensitive models of forest productivity, tree decline, insect infestations and other disturbances which can be linked to the main ecosystem models.

4. Cooperate with major international and national initiatives to investigate ecophysiological functions in the boreal forest.

In order to deliver this program, the thrust of research was concentrated on three general subject areas, in cooperation with various regional and national institutions of CFS:

1. Intensive study of forest physiology and ecology along a climatic gradient from the semi-arid Aspen Parklands to the Subarctic Woodlands (Boreal Forest Transect Case Study, BFTCS). The ecophysiological and climatic processes are concurrently measured at two sites near the southern end of BFTCS, where transpiration rates, sap flow, and soil moisture levels are measured and related to solar radiation, precipitation, relative humidity, wind, etc. Microsites are monitored to indicate the variations within the studied forests. Related

physiological studies measure the effects of various climatic parameters on the rate of respiration in various tree species. The allocation of energy require to maintain the life functions of the trees and energy available for additional growth will be determined. This information is used to construct reliable models of the ecosystem carbon balance.

The processes affecting the boreal forest succession is investigated by relating successional trends to present and past climates, fires and other disturbances. Past climates and corresponding vegetation changes and productivity levels are determined by pollen analysis and dendrochronology. This information will be used to construct a computer simulation model of successional processes in the boreal forest, with specific reference to changing climate.

Other studies are carried out in support of the boreal forest succession Model. Historical records of infestations by important insects are being related to climate parameters to construct models which predict insect development rates as functions of climatic variables. The soil microflora and fauna is examined in different climatic zones to determine the sensitivity of the forest soil biota to climatic parameters. The frequency of forest fire occurrences will be related to past climatic events to create a predictive computer model.

2. <u>The carbon budget model of Canadian forest sector</u> (CBM-CFS) is being developed to show much carbon is currently stored in Canadian forests, how much do they currently contribute to the atmospheric carbon budget, and finally, how will these carbon pools and exchanges be influence by climate change and forest management. Current work is concentrating on (1) developing, testing and applying a comprehensive CBM-CFS which includes the carbon status of forest biomass, detritus, soil and peat, forest products and forest sector energy use. (2) A retrospective analysis of change in the carbon budget of Canadian forest sector during 1920-1944 was made to test the sensitivity of the CBM-CFS. (3) Projective analyses are being made to simulate effects of the influence of alternative forest management practices, but will consider land use changes and the use of energy and bio-energy. (4) In order to support the CBM-CFS, process level submodels of boreal forest responses to global change as a result of changes in the carbon cycle.

   Supporting research includes the determination of short- and long-term rate of carbon sequestration in different kinds of peatlands. This information will be used to construct models of carbon sequestration in peatlands and to forecast the possible effects of climate change on the functioning of peatlands, especially the change caused by massive thawing of permafrost in the peatlands.

In another experiment over 10 000 litterbags have been placed at 21 different forests in various climatic regions. The decomposition rate will be calculated from annual collection of the bags for ten years to determine and model the influence of climate and stand conditions on decomposition rates.

3. Tree decline studies are conducted in eastern Canada, to examine specific damage of forest trees induced by climate. The maple die-back has been linked to climatic extremes, such as deep soil freezing and low snow cover, during the winter before the die-back. Such conditions were artificially induced to test the limits that have a direct impact on sugar maple health. growth, and metabolism. In another study the die-back of different birch species was experimentally linked to damage caused by a mid-winter thaw, followed by r-freezing. Such studies will provide information to predict future impacts of global change on the broad-leaved forests.

The research by Canadian Forest Service is being carried out in cooperation with international agencies both at the science planning and technical levels. Such collaboration has been initiated with the European Forest Institute on the carbon budget of European forests. We are actively involved in the Global Change and Forest Ecosystem working groups of the International Boreal Forest Research Association. We are an integral part of the Boreal Ecosystem Atmospheric Study (BOREAS) presently being conducted in Canada in cooperation with US scientists.

Erkki Tomppo
Professor, Head of Nat. Forest Inventory
Finnish Forest Research Institute
Unioninkatu 40 A, FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 340
Fax +358-0-625 308

MULTI-SOURCE NATIONAL FOREST INVENTORY OF FINLAND

Abstract

The National Forest Inventory of Finland has produced large-area forest resource information for over 70 years. Line transect sampling, systematic cluster sampling and, in North Finland, two-phase stratified sampling with aerial photos and ground sample plots have been employed. The Finnish Forest Research Institute started to develop a new inventory system in 1989, during the eighth inventory, in order to obtain geographically localized, up-to-date information and for areas smaller than earlier. The method exploits satellite image data (Landsat TM), digital map data and, in the future, other geographical data, e.g. soil and meteorological data, in addition to the ground measurements. Image analysis methods have been chosen in such a way that estimates of all variables of the inventory can be computed for each pixel. The system is now operative and the inventory has been applied to an area of about 16 million hectares, producing theme maps and statistics for large and small areas (even single stands). The data for the whole country will be ready in 1995.

The most serious problem in the application of the method are clouds which often prevent from obtaining imagery of a target area from a specific year. Therefore, a study for developing methods for utilization of ERS-1 SAR - data in large area inventories has been started together with the Space Laboratory of the University of Technology and with a support of ESA, AO-project PP-SF1. Use of other remote sensing data such as airborne scatterometer and imaging spectrometer data are also being developed.

National Forest Inventory has traditionally produced information about biodiversity. Recently, a wide research program for introducing theoretical concepts and measures for assessing biodiversity, its development and factors affecting it has been started with the University of Joensuu. The multi-source inventory method developed by the Finnish Forest Research Institute has been tested, or negotiations about the application are going on, also in some other countries like Sweden, Germany, New Zealand and China.

1. Recent status of inventory

The field work of 8th national forest inventory will be completed this field season (1994). Inventory started 1986. (The long duration is caused by the establishment and remeasurement of another sample plot grid, the grid of 3000 permanent plots which are mainly used for forest health monitoring purposes.) Field measurement for a new updating method will also be carried out during this season. The oldest data of 8th inventory (data from 1980s) will be updated with this method which also utilizes satellite images.

During 8th inventory, quite big changes have been carried out in the inventory. Satellite images were introduced already at the end of 1980s. Satellite images and digital map data are now in an operative use. The whole country with multi-source technique will be ready during the year 1995.

2. Field measurements

Systematic clusterwise field sampling method has been utilized since the year 1964. All plots were temporary still in the beginning of 8th rotation.

The filed measurements were changed during this rotation, in 1992 from the administrative border of North Finland. The biggest change was that one fifth of the plots were marked as permanent. They locate in the same cluster as temporary plots. During the remeasurement, the shape of the cluster will be changed. Another bigger change was that sample tree bucking is not any more carried out during measurements. Only quality classes of saw logs and the heights where the classes changed are recorded. The optimal bucking is carried out by means of a computer program. Some new variables were also introduced. Examples are more precise description of site fertility class of swamps (a kind of mixed type of fertility).

Stratified systematic clusterwise sampling is applied in the northernmost part of Finland, in the area of Inari, Enontekiö and Utsjoki municipalities. The sample plot density is proportional to the proportion of forest and scrub land from the whole forestry land area. The preliminary area estimation was based on a satellite image analysis.

3. Satellite image and digital map data

So far, Landsat TM -images have been utilized, because of its better spectral resolution and because it covers a larger area.

The map themes utilized so far are 1) arable land, 2) built areas, 3) roads, 4) swamp areas, 5) digital terrain model and 6) boundaries of computation units, e.g. municipalities, boundaries of forest holdings of different ownership groups, such as private, state, companies. (Sometimes even digital boundaries of forest holdings of private persons have been used.)

The key point of utilizing of multi-source information is to be able to estimate the results for smaller areas than what is possible with field measurements only.

The image process method has been chosen in such a way that it is possible to estimate all variables of national forest inventory for small computation units (e.g. for municipalities), see Tomppo (1993). The method has been applied also outside Finland, e.g. in China and New Zealand.

4. Research

4.1. Microwave instruments

A big co-operation project with the Laboratory of Space Technology at the Helsinki University of Technology has been started. The objective is to test the applicability of ERS-1 SAR -images and a scatterometer (HUTSCAT) developed by Space Laboratory in large area forest inventory.

HUTSCAT is a helicopter-borne high-resolution ranging scatterometer, (operating at 5 and 10 GHz, 4 polarizations) which has turned out to give very accurate estimates for some forest characteristics (e.g. mean and dominant height).

Six test areas, three in Finland and one in each Canada, China and Russia have been chosen for the study. Soil moisture measurements have been carried out in a subset of the inventory plots because it has turned out that moisture affects heavily on the backscattering coefficient. A digital terrain model and multitemporal imagery throughout the year are used in the data processing.

The seasonal changes of the backscattering properties of boreal forests are investigated by applying a developed semi-empirical forest backscattering model and multi-temporal ERS-1 data from test areas in Finland. Empirical modelling of canopy extinction and volume backscattering coefficients as a function of forest stem volume is based on HUTSCAT -data. Additionally, well-known empirical and theoretical models are used in order to incorporate the effects of seasonal and weather dependent changes in the semi-empirical model, e.g. effects of soil and canopy moisture variations which highly affect the radar response.

The developed semi-empirical model can also be employed to retrieve forest parameters (stem volume) from multi-temporal ERS-1 data using the statistical inversion approach (maximum likelihood inverse solver). Ground reference data points are necessary as a priori data for inversion. The results of inversion experiments will be studied. The reliability of all estimates are evaluated by comparisons with the estimates based on sample plot measurements, standwise estimates and Landsat TM -image analysis.

4.2 Biodiversity studies

Another big research project in the national forest inventory is a study where a system for measuring biodiversity of forests in national and regional level inventories will be developed. This is a co-project with forest inventory group, University of Joensuu and European Forest Institute.

There are four subprojects in the study:

1 Development of methods for measuring biodiversity based on forest characteristics, habitat occurrence and statistical-ecological methods.

2. To study the effect stand structure and silvicultural treatments on the biodiversity and occurrence of species.

3. To analyze of the history and land use during the time originating the present structure and diversity of forests, i.e. from the beginning of 1800s. The interesting land use types are settlement, slash-and-burn cultivation, making of tar and charcoal, pasturing, use of timber, silviculture.

4. To study the effect of forest fire frequencies and land-use history (slash-and-burn cultivation) on forest biodiversity. In the dendrochronological approach, fire-scars present in live and dead trees will be analyzed to develop local forest fire histories for the chosen study site covering the past c. 500 years. Analysis of annually laminated lake sediment sequences will give information about natural fire frequencies and related vegetation changes from the past 2 - 3 millennia, i.e. for the time before any significant anthropogenic influence.

The study will last until the end of 1996, but the methods should be able to be applied already in the 9th inventory which will start 1996.

5. The future of the inventory

During the years 1994 and 1995, the results with multi-source information will be computed for the whole country as well as the updated results for the

South Finland (for 10 southernmost forestry board districts of the totally 19 districts).

The grid of 3000 forest health sample plots will be measured third time during the field season 1995 as a part of Nordic forest health monitoring.

The 9th inventory rotation will start in 1996. The sampling design for South Finland will be changed to some extent. Both temporary and (new) permanent sample plots will be utilized in this inventory.

References

Tomppo, E. 1993. Multi-Source National Forest Inventory of Finland. The Finnish Forest Research Institute. Research Papers 444, pp. 52-60.

Antti Reinikainen
Research Scientist
Finnish Forest Research Institute
Department of Forest Ecology
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +385-0-857 05 423
Fax +385-0-857 05 569

EXPECTATIONS CONCERNING THE MONITORING AND RESEARCH OF BIODIVERSITY AIMED AT THE NATIONAL FOREST INVENTORY (NFI) IN FINLAND

1. Introduction

Since the last decades of the 19th century commercial forestry producing raw material for industries has been important in Finland. Before that time some more native habits of wood consumption had exploited the forest resources not very heavily but in somewhat uncontrolled ways. Fuel wood use, cultivation by burning-over, woodland grazing and tar distilling etc. were guilty to the decrease of forests and change of their quality in such an extent that shortage on certain timber assortments locally existed already in 1850s. As the arising new forestry at first particularly needed high quality saw timber and exploited it selectively it was initially necessary to enter the principle of sustainable forestry into the national law in 1886. This took place in the first place for maintaining the timber quality of the forests. Mainly because the father of Finnish forestry education, A.K. Cajander, was a biologist and biogeographer the methods of forestry from the very beginning were intended to follow the natural dynamics of boreal ecosystems.

In 1921 as the first country in the world, Finland started systematic and covering national inventory of forest land and timber resources (Ilvessalo 1930). In that survey and in the three subsequent NFIs a line transect method was used until in the 5th NFI carried out in 1964-70 sampling based on systematic blocks was adopted. Along the eight inventories finished by 1994 the systematic sample consisting of survey tracts on blocks was removed every time.

In addition to the ordinary forestry statistics NFI has produced a lot of basic information about the Finnish forest and mire nature. The time series data on tree species composition, stand structure, stand age, and vegetation based site types are as important for ecological monitoring as for forestry. Even the idea of linking biological observation to NFI is not a new one. In the 2nd inventory (1932-36) vegetation was partly surveyed and in the 3rd NFI (1951-53) the comprehensive vegetation analysis was accompanied by some taxonomic, faunistic and habitat biological observations. But not until the arise of a certain new social motive the content of NFI would be replenished. The possibilities were outlined by Kuusela (1981) and condensed into a proposition. In the 8th NFI (1985-86) a network of permanent sample plots for ecological monitoring was established (see e.g. Reinikainen 1990).

The Ministerial Conference on the Protection of Forests in Europe has very recently published a list of desirable indicators of biodiversity to be monitored in European countries. The indicators are grouped under different criteria and classified into descriptive and measurable ones. As the core set of the indicators appropriate to the European level will be confirmed in Geneva already on June 23-24, 1994 the classification presented in that list will be used also here when the possibilities of the NFI system are discussed.

2. The general structure of NFI

The NFI is a systematic sample of forestry land in Finland. The country is divided into blocks which were 8x8 km in size in the 7th NFI, for instance. Blocks are presented by tracts located on each corner of a block. The tract is a cluster of sample plots locating with regular (100 - 200 m) intervals. The length of a tract is 2050 m to W - E direction and 2050 m to N - S direction. In the 7th NFI there were maximally 41 sample plots of different sampling intensity categories per one tract on forestry land. The sample plot set has a hierarchic structure so that the most general observations (site type, tree species, age class, basal area etc.) are made on every plot and the most demanding ones are concentrated on fewer sample plots. In the 8th NFI there were about 3500 tracts with about 70 000 plots of the most general category and about 10 000 plots belonging to the most precise class of measuring increment and removal. In North Finland the tract density is lower and aerial photographs are used for completing the field work.

The network of permanent sample plots established in 1985-86 consists of 3009 sample plots located as clusters of four plots on tracts representing 16x16 km blocks in southern Finland. In Lapland 32 km tract interval was used. An ecological observation and measuring program planned partly for the purposes of Finnish Acidification Research Programme HAPRO (Kauppi et al. 1990) and adapted to the working tempo of the ordinary NFI field group was carried out by a biologist member of 12 groups. The menu of biological observations was as follows: (1) precise botanical determination of the site type, (2) determination of the soil type and the depth and quality of the humus layer, (3) quantitative vegetation analysis with a complete species list of vascular plants, genuine mosses and ground lichens, (4) structural analysis of the stand and plant community, (5) estimation of actual and potential yield of economically important berry species, (6) sampling of mushroom flora and estimation of the standing yield of commercial species, (7) counting of the occurrence of 12 polypore species on trees, (8) estimation of forest damages, (9) estimation of the occurrence of epiphytic bio-indicator lichens on conifers, (10) sampling of carpet mosses, one epiphytic lichen species and pine bark for the chemical analysis of aerial deposition.

Inside the permanent plot system there is also a hierarchic structure of smaller samples for more intensive studies. From c. 100 plots, for instance, the total species richness of epiphytic lichens is determined.

The 9th NFI beginning in 1996 will be a turning point in the history of Finnish inventories. A method aided by satellite information will be adapted (Tomppo & Siitonen 1991). After that the system of permanent plots giving very detailed reference information seems to become still more important.

3. NFI as real and potential source of biodiversity data

In principle, any kind of ecological observation and sampling can be linked to the network of NFI. Concerning the biodiversity there is a problem of relevant indicators for different criteria to be observed. We have to think, for instance, how the hierarchic and structural levels of biodiversity are manifested in the forest landscape, how they are measurable and how the measurements must be arranged within the sampling hierarchy of NFI. A certain indicator can be directly observed or measured on a sample plot (number of shrub species, for instance) or must be formed by combining observations on separate variables even of different hierarchic sampling levels (landscape diversity). We have also to be very realistic when the possibilities of NFI and the other alternatives of diversity monitoring are estimated.

Operational diversity characteristics from NFI can be expected concerning all the traditional levels of ecological diversity (alpha, beta and gamma). Due to relatively low density of the NFI sample rare species, sites and habitats are not sufficiently represented in the data. Benefits of the systematic sample without bias and large number of observations are mainly involved in trivial compartments of boreal nature. Thus, NFI can provide an objective picture about the actual diversity of ecosystems and reveal trends of its development. NFI is able to be the basic monitoring system for 'biodiversity in forests managed for production' but it can only produce auxiliar data for the issues 'protection of representative forest habitats' and 'protection of threatened species' on the list of European ministerial conference.

Concerning separate indicators of biodiversity at different levels the following list with rough numbers of sample plots and time scale is presented:

1. *Genetic diversity: proportion of artificial regeneration 70 000, 1921-; genetic variation of Norway spruce, 400, 1985-*

2. *Species diversity (alpha): trees 70 000, 1921- ; shrubs 8000, 1953, 3000, 1985- ; ground vasculars, mosses and lichens 8000, 1953, 3000, 1985; epiphytic lichens, mushrooms and polypores (restricted species list) 3000, 1985.*

3. *Habitat and site diversity (beta): site types 70 000, 1921-; precised botanical site types 8000, 1953, 3000, 1985-.*

4. *Successional diversity: stand age 70 000, 1921-, vegetation 8000, 1953, 3000, 1985- , developmental stage of vegetation on drained peatlands 70 000 1953-.*

5. *Structural diversity: canopy floors, mixed forest structure 70 000, 1921-.*

6. *Landscape diversity (gamma): 70 000, 1921-.*

7. *Proportions of different silvicultural and forest amelioration activities ('manmade gamma diversity'): 70 000, 1921-.*

8. *Fragmentation of forests: 70 000, 1921-*

9. *Dead trees and decaying wood in forest stands: 70 000, partially 1921- ; to be improved.*

Before the beginning of the 9th NFI much work must be done for improving the indicators concerning the criteria mentioned above. Additional sampling for genetic variation of plants and species diversity of some evertebrates seems to be possible. A sample bank for 'unknown' components of diversity is not out of question. Auxiliary methods in compiling new indicators of diversity at higher regional level from NFI data are arising from the new satellite aided inventory (Tomppo & Siitonen 1991). Cooperation between the biodiversity monitoring in statistically trivial forests and in protected and threatened areas seems to be essential.

References:

Ilvessalo, Y: 1930. Suomen metsät viljavuusalueittain kuvattuina. Summary: The forests of Suomi (Finland) described by areas of fertility. Results of the general survey of the forests of the country carried out during the years, 1921-24. Commun. Inst. For. Fenn. 15(4): 1-56.

Kauppi, P., Anttila, P. and Kenttämies, K. (eds.) 1990: Acidification in Finland. Springer Verlag. 1237 p.

Kuusela, K. 1981. From timber surveys to monitoring of the forest ecosystem. XVII IUFRO World Congress, Kyoto, Japan. Sept. 6-17, 1981, Subject Group S4, 02. 4 p.

Reinikainen, A. 1990. Ecological monitoring as a part of the Finnish National Forest Inventory. Annali di Statistica 119, serie IX, vol. 8. Proc. of the Seminar of Ecological Statistics, Rome, 28 March - 1 April 1988. 13 p.

Tomppo, E., and Siitonen, M. 1991. The National Forest Inventory of Finland. Paperi ja Puu / Paper and Timber 73(2). 8 p.

Rauno Väisänen
Head of Research Unit
National Board of Waters and the Environment
Nature Conservation Research Unit
P.O. Box 250, FIN-00101 Helsinki, Finland
Tel. +358-0-695 1705
Fax +358-0-695 1733

COMMENTS ON THE ROLE OF THE NATIONAL FOREST INVENTORY IN RESEARCH AND MONITORING OF BIODIVERSITY IN FINLAND

The presentations by Professor E. Tomppo and Dr. A. Reinikainen showed clearly the great potential of the National Forest Inventory (NFI) in providing baseline information on biodiversity in the Finnish forests. The NFI is also a useful tool for monitoring the general state of forests. It can be further developed by including more indicators of biodiversity, especially measurements of different categories of decaying wood as well as wood-decomposing fungi, at least polypores. Unfortunately, more detailed surveys of forest insects and other invertebrates of conservation concern do not seem feasible in the NFI at present.

The other side of the coin is that all this is simply not enough as regards forest biodiversity. The NFI can provide average values and baseline information, but a lot is still missing:

First, there are biodiversity hot-spots in Finland, e.g. areas with exceptionally favourable edaphic conditions and high fertility, where less common herb-rich forests abound (Alapassi & Alanen 1988). These areas need a much denser network of monitoring sites than the present NFI.

Second, old-growth forests, which lie mostly within protected areas, differ from the surrounding forests in their species composition of certain groups of organisms. Sometimes the difference is drastic as in the case of beetles living in dead fallen trunks of trees (Väisänen et al. 1993; see also 0kland 1994). These remnants of primeval forests need a very intensive monitoring system.

Third, the most interesting species from the conservation point of view are the threatened species which are scattered on certain areas. The NFI cannot provide any comprehensive information on these species. Often they must be approached on a species by species basis. It may added that in Finland the threatened species are reasonably well known (Rassi et al. 1992).

As Dr. I. Thompson said in his presentation, we really need models linked with GIS forest data bases to predict the distribution of biodiversity. Actually we should be able to estimate the biodiversity value of every hectare. This means that we necessarily need much more detailed information on those habitats and species that are known to have suffered from silvicultural practices or are prone to such damage. Thus it is a combination of "hard work" and application of new methodologies. Apparently this is the only way towards ecologically sustainable forestry.

As emphasized by Dr. A. Reinikainen we need much more collaboration between foresters and ecologists. Promising results have been got from joint research efforts in the National Biodiversity Research Programme (LUMO) coordinated by the National Board of Waters and the Environment (Väisänen & Jäppinen 1994). Collaboration has also been started in developing a comprehensive monitoring system of the whole terrestrial environment. Consequently, these comments may not be regarded only as constructive criticism, but also as a description of the recent advances in Finland.

References

Alapassi, M. & Alanen, A. (eds.): Report of the Committee for Conservation of Herbrich Forests. - Ministry of the Environment and Finnish Government Printing Centre, Committee Report 1988: 16, 279 pp. (In Finnish)

0kland, B. 1994: Mycetophilidae (Diptera), an insect group vulnerable to forestry practices? A comparison of clearcut, managed and semi-natural spruce forests in southern Norway. - Biodiversity and Conservation 3:68-85.

Rassi, P., Kaipiainen, H., Mannerkoski, I. & Ståhls, G. (eds.): Report on the monitoring of threatened animals and plants in Finland. - Ministry of the Environment and Finnish Government Printing Centre, Committee Report 1991:30, 328 pp. (In Finnish with an English summary)

Väisänen, R. & Jäppinen, J.-P. 1994: A research agenda for global change in Finland. Research priorities for the conservation and sustainable use of biodiversity. - NATO Advanced Research Workshop: "Biodiversity, Temperate Ecosystems and Global Change", August 15-19. 1993, Le Chateau Montebello, Quebec, Canada. The Nato Science Programme and Forestry Canada, Springer-Verlag (in press).

Väisänen, R., Biström, O. & Heliövaara, K. 1993: Sub-cortical Coleoptera in dead pines and spruces: Is primeval species composition maintained in managed forests? Biodiversity and Conservation 2: 95-112.

Neil Foster
Research Scientist
CFS, Great Lakes Forestry Centre
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700

GLOBAL CYCLES

Indicators for monitoring sustainable forest development will be discussed, using examples largely from Ontario, for impact studies on air / water quality, disturbance of sensitive ecosystems (peatlands) by forestry practices, and hydrological cycles. Indicator performance is being evaluated in boreal coniferous and temperate hardwood forests using three research approaches: observation / monitoring, experimental manipulations, and simulation modelling.

In Ontario the Sustainable Productivity Working Group (Ontario Forest Research Institute / Great Lakes Forestry Centre) is coordinating a manipulation study of harvesting / site preparation impacts (3 levels of biomass removal) at 20 sites in boreal jack pine and black spruce forest. The growth of planted seedlings on sites with different levels of organic matter removal (stems only harvest, full-tree, full-tree plus forest floor) will be examined in a long-term (10-20 yr) replicated field trial. Soils will also be compacted after forest floor removal to examine possible reductions in soil porosity associated passage of heavy harvesting equipment. Microclimate, nutrient availability in soil, and dissolved carbon and other nutrient leaching within and below tree rooting is being monitored at selected sites.

Another example of a manipulative experiment is disturbances of peatland forest by modified harvesting techniques (careful logging) at Wally Creek, a site of Finnish / Canadian cooperation on drainage / fertilization impacts on spruce productivity. Partial harvesting is being contrasted with clear cuts as are full-tree and shortwood forwarding. The biological effects of preserving younger trees, the changes in soil quality as a result of leaving branches on site, and water table fluctuations are being examined. biomass removals, slash retention, nutrient availability, and the nutrition of released regeneration are being evaluated in relation to different levels of canopy removal. The last example relates to assessing nitrogen, carbon and phosphorus dynamics following prescribed burning of a balsam fir ecosystem in western Newfoundland. A 15N isotope study is proposed to study nutrient pathways that will compliment ongoing studies on soil respiration, nutrient uptake and nutrient losses from site at the Glide Lake Fire Project.

An ecological monitoring network, that will likely incorporate existing watershed studies across Canada, is under consideration. An example of a representative site is the Turkey Lakes Watershed an acid rain study site in tolerant hardwood forest and a part of the Economic Commission for Europe integrated monitoring network. Major monitoring and research activities at Turkey Lakes include the following:

- wet, dry and bulk precipitation chemistry and deposition, ground level ozone
- full (Class A) meteorology including solar radiation
- snowpack chemistry and dynamics
- surface water chemistry (headwater streams and lakes) including temporal and spatial variability
- lake physical measurements (heat content, thermal stratification, evaporation, gas exchange)
- groundwater and soilwater chemistry including vertical and spatial variability
- terrestrial basin and lake mass budgets
- lake biological communities (surveys, phytoplancton production, benthic production, palaeoecology, fish populations, fish production)
- waterfowl occurrence and distribution and habitat assessment
- soil physical and chemical characteristics and variability
- wide-scale assessment of timber standing stock
- tree-growth and phytomass element composition
- litterfall and element flux in litter
- throughfall and stemflow composition and flux
- element uptake and cycling in the forest ecosystem
- litter decomposition and element release
- model development for predicting surface water hydrology and chemistry, forest growth, etc.

Similar information has been collected at ten forest watersheds across Canada.

Partial cutting, selection cutting and hardwood-softwood conversion will be studied at Turkey Lakes by watershed manipulation using basis with 15 years of baseline water quality measurements.

A model that simulates changes in nutrient cycling, soil chemistry, and forest productivity has been calibrated for the Turkey Lake watershed and applied to a range of sites in North America and Europe. The model quantifies biomass and nutrient transfer processes within forest stands. Processes addressed are net primary production, biomass respiration, litterfall, nutrient mineralization and translocation, soil weathering, ion exchange, nutrient uptake and nutrient and carbon partitioning within the stand biomass.

A practical application of modelling was to simulate temporal variation in soil water contents at Turkey Lakes, over a 40-year period, with monthly precipitation and mean monthly air temperatures used as primary input variables. Year-to-year variations in radial increment were analyzed using a standardized index for tree growth. Examination of radial growth indices for sugar maple trees suggested that the reductions in growth coincided with low volumetric soil water contents and with low NO3 concentrations in soil solution.

Some of the advantages and disadvantages of using different indices of plant nutrition to assess patterns of nutrient accumulation in jack pine stands, with site and age, will be discussed.

Richard Fleming
Research Scientist
CFS, Forest Pest Management Institute
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700

FOREST ECOSYSTEM PRODUCTIVITY

Overview

The following provides a brief introduction to the Forest Ecosystem Productivity (FEP) criterion in the Canadian criteria and indicators initiative for sustainable forest management. As directed, the focus is on aspects of my own work, but some related work going on in Canada is also touched on.

FEP depends on the absorption and transfer of nutrients and solar energy within ecosystems. Sustainable FEP depends on maintaining both photosynthetic patterns and nutrient and hydrological cycles. Natural disturbances such as fire, diseases, or insect outbreaks often play key roles in ecosystem development and persistence. Because human influences can easily dominate these natural perturbations, human activities should be evaluated in terms of the conditions necessary to maintain ecosystem productivity.

My work falls mainly in the area of natural disturbances; Edgar Robichaud deals with some other aspects of FEP. Recently I have been most active in research dealing with (1) pest impacts on tree productivity, and (2) the response of forest insect populations to climate change. For many years I have also been interested in general system dynamics. This interest has focused maintain their integrity in the face of disturbances which other systems cannot survive.

1. Pest Impacts on Tree Productivity

Most activity in Canada in this area is part of the "Pest Impacts Knowledge Base Development" network. The network includes 10 CFS and 3 provincial researchers. Collaboration with Chile and Sweden is being developed. About 60% of this years $ 200 000 funding comes from the Integrated Forest Pest Management section of the Green Plan.

The network has three main objectives. First, to assess the current impacts of spruce budworm defoliation on the productivity of the white spruce forests of northern British Columbia and Alberta. Second, to develop predictive models to allow forest managers to incorporate pest impacts into forest management decision making and annual allowable cut (A.A.C.) calculations. Third, to elucidate the effects of spruce budworm impacts on selected ecosystem characteristics. These characteristics include: (1) successional relationships, growth rates of host and non-host species, dominance relationships, and vegetational changes; (2) resource allocations and compensatory changes in needle retention, photosynthetic efficiency, and biomass production (leading to the development of foliage driven tree growth models; (3) root rot as a modifier of these relationships.

2. Responses of Forest Insect Pests to Climate Change

Two CFS researcher funded by the Green Plan Climate Change initiative are involved. This research contributes to the Boreal Forest Transect Case Study and is linked to other studies in the Green Plan Climate Change Initiative. These studies include efforts to construct models of crown development, of boreal forest response to climate change, and of the role of northern forests and forestry in the global carbon cycle. Related work is being conducted by Agriculture Canada (Lethbridge, and probably elsewhere as well).

There are two interdependent thrusts to the CFS efforts in this research area. One concerns the concept of biological indicators and involves collaborators from the U. K. at Rothamsted predicting how the occurrence of important forest pests might be affected by the projected climate changes.

<u>Biological indicators:</u> Insect development rates are potentially very useful indicators of the biological impact of climate change because the integrate the effects of a variety of climatic variables (e. g., temperature, humidity, cloudiness) which, taken individually, are relatively poor indicators of potential biological impact. In this research, recent historical data is searched for evidence of the trends in these rates expected as a result of greenhouse warming over the last 25 years. This provides quantitative measurements of the degree to which insects have <u>actually</u> responded to the warming experienced over the last 25 years. These measurements also constitute an essential basis for calibrating the predictive models discussed below.

<u>Prediction:</u> Prediction requires the construction of models describing insect development rates as functions of climatic variables. Using the projected changes in climate (e.g. detailed predictions of global circulation models) as input, these proposed climate-based models of insect development rates could forecast the effects of climate change on insect development rates. Such forecasts permit inferences to be made about changes in the distribution of important (and potentially important) insects in time and space. For instance, new regions could be identified where an insect could

comfortably complete its developmental cycle in the future if the projected changes in climate occur there. Since the geographic range of many insects is limited by climate, this will provide guidelines about potential changes in insect distribution as a result of climate change. Range expansion by insects could provide them with access to particularly susceptible forests. These forests my be particularly susceptible if the defences of their trees are unadapted to this insect, having never experienced it before, or if their defences are already weakened by the physiological stress imposed by climate change.

Changes in the distribution of insect pests in time would probably disrupt any co-evolved pest-host synchrony in life-stage occurrence. This could benefit either the host or the pest depending on the circumstances.

3. Forest Ecosystem Resilience

In Canada this work is being conducted by a small group of university-based researchers. I am aware of no directly funded CFS research in this area.

The challenge is to determine what makes some systems resilient so that they can maintain their integrity in the face of perturbations which other systems cannot survive. Although there is still a long long way to go to meeting this challenge, a little progress has been made. Often, resilient systems have self-organizing, self-correcting abilities to recover from disturbance. Resilient systems are adaptive and can both generate and benefit from change. Hierarchy theory and dissipative structures are closely related areas of research.

As part of the presentation, the forest fire situation in US national parks is used to provide an example of why it is so important to maintain a systems inherent variability if the system as a whole is to be sustained. Certain natural disturbances are often key factors in the system dynamics, and suppression of these disturbances typically results in a slow evolution of the systems biophysical environment until the original system is no longer sustainable and it evolves into a very different system.

Edgar Robichaud
Associate Professor, Soil and Ecology
Ecole de Sciences Forestières
Centre Universitaire St-Louis Maillet
165, Boul. Hébert, Edmundston, N. B.
Canada E3V 2S8
Tel. (506) 737-5249
Fax (506) 737-5373

FOREST ECOSYSTEM PRODUCTIVITY
A CANADIAN PERSPECTIVE

Canada is a large country with a total land area of nearly 1 billion hectares. Of this area over 400 million hectares are forest lands and more then 230 million hectares are timber productive. Most of these forest lands are under provincial jurisdiction (approx. 80%) with less than 10% privately owned. At the provincial level forest lands continue to represent a large percentage of the total land base, varying between approximately 45 % percent in provinces such as Manitoba and Saskatchewan to more than 80% in New Brunswick. The estimated Canadian annual allowable cut in 1991 was estimated as over 250 million cubic meters (190 million as softwood - 60 million as hardwood). Harvest levels were well below these levels for both major species groups at approx. 155 million cubic meters (140 million as softwood and 15 million as hardwood). Again, a similar situation can be observed at the provincial level with harvest levels being well below estimated AAC's for hardwoods in all provinces. In softwoods, provincial harvest levels in 1991 were also well below estimated AAC in all provinces but British Colombia where harvest levels were approximately 2% above the estimated AAC.

In most Canadian provinces, forest site classification systems have or are being established which serve as management tools for the practising forester. These systems generally use a combination of climatic, topographic and geological characteristics to define site regions. Within these regions, site type (treatment units, ecological units...) are generally defined by soil physical characteristics as a measure or index of the moisture regime and vegetation characteristics as a measure of the nutrient regime. Site productivity is either a distinguishing variable (i.e. in New Brunswick) or one of the interpretations associated with the various site types. Other interpretations important in the implementation of sustainable forestry include: erosion hazard; soil compaction hazard; natural regeneration potential, presence of competing vegetation etc. In New Brunswick, for example, nine site regions have been defined on the basis of a combination of surficial geology and climate. For each of these regions, field guides have been developed which include dichotomous keys for the identification of vegetation types (nutrient regime) and soil types (moisture regime).

Combinations of various soil and vegetation types lead to the identification of treatment units which were defined in order to maximize differences in productivity between TU's while minimizing differences in VT's and ST's. Related to each TU are specific silvicultural and management interpretations such as site sensitivity, productivity and regeneration. Similar interpretation are also associated with TU's developed in north-western Ontario and British Colombia.

An important consideration in sustainable forestry is the impact of harvesting (especially whole tree harvesting) on the future productivity of forest lands. Ongoing studies on this topic in Canada include those of M.K. Mahendrappa in New Brunswick which examine the impacts of whole tree harvesting on nutrient cycling. Within this study five different forest types typical of Atlantic Canadian forests are being studied. Three of these sites are located in Nova Scotia, one in New Brunswick and one in Prince Edward Island. The objectives of this study are to compare and evaluate possible changes in nutrient dynamics affected by various harvesting methods. This is being done through lysimeter studies using new lysimeters developed by Dr. Mahendrappa at the Maritimes Forest Research centre in New Brunswick. Three treatments are common to all study sites; 1. conventionally harvested; 2. whole tree harvested and 3. unharvested. In addition extra treatments have been added to specific sites to answer the concerns of specific forest companies involved in the study (i.e. selective harvesting). Treatments are applied to a series of 100 m wide and 300 m long strips along the topographic gradient while a 200 m wide strip is kept as a control. In Ontario similar studies on the impact of biomass removals on the structure, function and productivity of black spruce (A.G. Gordon and others) and jack pine (Foster and others) ecosystems have also been established. These studies involve researchers from both the Ontario Forest Research Institute and Forestry Canada Ontario region through the formation of the Sustainable Productivity Working Group. The objectives of this study are wider reaching than those in the Maritimes study and include:

1. To determine if the removal of greater levels of biomass by full-tree harvesting will cause a reduction of nutrient pools and alter decomposition / nutrient availability processes, thereby increasing recovery times on all sites;

2. to evaluate the impact of reduced nutrient fluxes and accompanying decreased recovery rates on sites of lower site quality, shallow sites and organic sites;

3. to compare the increasing nutrient demands of post harvest seedlings with the cumulative release of available nutrients across a range of sites and harvesting treatments;

4. in terms of nutrient removals and post-harvest dynamics, to determine if the impacts of full-tree harvesting are more closely related to tree length harvesting than they are to total biomass removal;

5. to determine differences between full-tree harvesting and natural disturbance in terms of environmental and physical site factors;

6. to detect changes in water-table levels, surface runoff, and the presence of imperfect drainage caused by rutting and compaction, and to determine if these are influenced as much by site characteristics as by method of harvest;

7. to quantify changes in pH and soil cation depletion that occur as a result of the foliar removals associated with timber harvest.

Treatments examined within these studies include, tree length harvesting, full tree harvesting, whole tree harvesting full tree chipping systems and controls. The treatments are set-up as a series of 30 X 30 m. plots in four replicates, with the control plots being 50 X 50 m.

Jari Parviainen
Professor, Research Director
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 220
Fax +358-0-857 05 361

SUSTAINABLE FOREST MANAGEMENT BASED ON MIMICKING NATURAL FOREST SUCCESSION

Why criteria?

Some centrally important objectives are served by the characteristic of sustainability. As a profession area, forestry should increasingly promote openness towards society as a whole. The consumers of forest products, those who seek relaxation in the forest and the public at large all want to know how the forests are managed. Another function of the criteria is in forming a uniform activity base for persons entrusted with the management of the forests. The diversity of the debate within the forestry profession can be expected to clarify the concept of sustainability. In the field of international collaboration, clearly defined criteria for sustainability serve to alleviate North-South tensions when dealing with forestry issues.

The sustainability has a long history. At least in its more limited sense, the sustainable forestry goes back some 300 years in Europe. The concept is generally understood to have come into being in 17th-18th century France and Germany. The reconstruction following the Thirty Years' War, industrialisation and supply of wood to households became threatened by shortages of wood raw material in densely populated areas. The term sustainability is mentioned for the first time in Hans Carl von Carlowitz's book "Sylvicultura Oeconomica", published in 1713, in which the author expresses his fervent desire to save Europe's supply of wood. The author also makes clear his Christian beliefs and humble admiration for the wonder and beauty of Nature.

In the ongoing international debate, the core idea in sustainability is that of forests being a renewable natural resource. This constitutes an essential difference between forestry and mining, for instance. In order that a renewable natural resource might be emphasised appropriately, ecological and environmental factors should be given more prominence in economic calculations.

Concepts of sustainability

Initially, the basic underlying aspect in sustainability has been that of ensuring even, continuous wood production; i.e. sustainable wood production. All other functions and products provided by the forest were evaluated in terms of realisation of wood production. The constraints given to wood production have been preservation of forest area, obligation to restock harvested sites and retaining the health and growth potential of forests.

Sustainable, multi-purpose forestry is a wider view based on the initial concept of sustainable wood production. The goal in growing forests is to produce not only wood but multi-purpose products such as game, recreation services, berries, mushrooms as well as conservation and landscape values. In Finland, for example, the implementation of this principle has long been the underlying basis in the tending of commercially managed forests. Adherence to this principle is, however, at its best at forest area level. Rarely is it possible within a single forest stand to concurrently apply several functions that partially exclude one another.

The key aspect of the ongoing debate is how to define ecologically sustainable forestry. The objective of assuring the stability of the forest ecosystem's functions has risen to the fore with wood production to be made subservient to it. Ecological sustainability supposes that neither wood production nor any other forest use endangers forest biodiversity, productivity or the ecosystem's functions. Neither shall forest use cause any danger to other ecosystems.

Criteria for sustainability

A resolution concerning the sustainable management of Europe's forests was signed in connection with the Ministerial Conference on the Protection of Forests in Europe held in Helsinki in 1993. This was part of the UNCED process initiated at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The Helsinki resolution defines sustainability in terms of ecological sustainability. Since then, the measurement of sustainable forestry has been on the agendas of several international meetings both at expert level and at forest policy level.

In Europe, the characteristic features of sustainable forest management would appear to be formed of two distinct groups of criteria:

- environmental criteria
- socio-economic criteria

Each of the two main groups include factors whose development is being monitored by means of various indicators. As an example, environmental criteria include the developments in forest area, forest health, biodiversity of forests, ecological cycles, soil and water protection.

An example of environmental indicator at work is when we set out to assess forest health. The measurement practice applied is the result of many years' discussions at the international level with scientific collaboration. Identical techniques are applied when sampling and when monitoring the heath situation. Annual studies provide us with a basis for estimating the change in forest health. A worsening of the situation is a sign for political decision makers; e.g. to place constraints on emissions levels.

Natural forests as models for forest management

It is commonly believed that natural forests serve as models in the management of commercially grown forests. Natural forests have developed without the influence of man; consequently, they provide an ideal opportunity to observe natural succession, the cycle of nature. Forest management needs to have a base, in this approach, natural forest represents the ideal for ecological forest management in the same way as the concept of the normal forest has been the ideal pursued in sustainable wood production in both theory and practice.

Nevertheless, it is necessary to clarify what the development cycle in natural forest means as the ideal model for forest management. When man through silvicultural measures interferes with forest development, forest structure and its functioning deviate from their natural course. Natural forest as such cannot be put forward as the guideline for silvicultural practice. Instead, the essential contribution of natural forest is in that they tell us about the premises of natural forest development and thereby steer us to imitate natural development. In the case of Finnish silviculture, an example of the recognition of this principle is to be found in articles on nature-oriented silviculture written by Professor Kalela in 1948.

While natural forests are usually the rarest of ecosystems and the richest in biodiversity and specialisation, it is too much to expect the forestry profession to be able to reconstruct equivalent ecosystems in commercially managed forests. The only means to preserve the flora and fauna typical of natural forests is by establishing a sufficiently dense and representative network of conservation areas. We should also bear in mind that many experiences gained in the management of commercial forests indicate that good silviculture has made it possible to significantly enhance the resistibility of managed forests when compared to natural forests, the latter being often afflicted by disturbing factors like insect pests or fungal diseases.

In the pursuit of ecological sustainability, silviculture is expected to follow methods that simulate natural events. In other words, management of commercial forests should be based on a natural development pace and stand structures should manifest specific features of natural forests, these being related to biodiversity; e.g. quantity of standing or fallen dead trees, presence of broad-leaved species and charred wood.

When measuring sustainability, attention is paid to the difference in the development of commercial forests as compared to that of natural forests. A central point is that of recognising the regular functional features peculiar to individual forest zones; e.g. the clear developmental difference between boreal forests and temperate forests. In the case of Finland, for example, the way in which silvicultural measures are applied is steered by historical developments (slash-and-burn cultivation, diameter-based selection felling) and, from the viewpoint of natural forests, by forest fires and other natural catastrophes.

Developmental cycle in natural forests

When dealing with the development of natural forests, it is customary to differentiate between the large and the small cycle of succession. In the forests of the temperate zone of Central Europe, the emphasis is on the small cycle; i.e. mature forests regenerate through the deaths and destruction of individual trees. This results in small openings in the canopy. In stands of beech and silver fir composed of shade-tolerant species the stand structure is all-aged. Only rarely does a gale or an insect pest epidemic wipe out a stand and thereby cause the great cycle to recommence.

In the boreal, coniferous zone, however, the large cycle predominates. From time to time, the development of natural forest is halted by disturbances and catastrophes. The reason for the natural destruction of forests used to be fire, but insect pests, gales and snow have also had their role. Time series constructed by means of dendrochronological studies have revealed that forest fires have swept through forests on dry mineral soils as frequently as every 70 years. On moist mineral soil sites this has happened at an average interval of 120 years. Where forests have not been hit by fire, forest development has taken the course of the small successional cycle with individual trees dying.

The size of regeneration openings in boreal forests can be sought by studying what information we have on fire succession. Despite the past few years' extensive and diverse efforts in this field, there are many gaps in our knowledge on the subject. Nevertheless, there are some examples available; last summer, a Scots pine forest over 60 ha in area was burnt near Krasnoyarsk, Russia, in conjunction with an international meeting of forest researchers. It was observed that part of the forest burns completely while in other parts the fire will be confined to the forest canopy. The result is mosaic-like compartments of varying size and degree of burning which depend on stand structure and soil moisture. The tallest pine often survive with charred dead trees left standing here and there among them.

Forest regeneration methods change

Ecologically viewed, regeneration of boreal coniferous forests includes a treeless stage and a catastrophe. This being the case, regeneration felling, for instance, should be assessed in the light of ecological factors different to those applied in Central Europe. A catastrophe prevents the process of invasion by spruce, it promotes nutrients bound in the humus back into the cycle, and allows forest regeneration to take place. There are grounds for opening up the forest cover by means of small scale openings.

Extensive clear felling operations are a thing of the past in the Nordic countries. New regeneration methods have been introduced in their place. In order that the management of commercial forests might more closely resemble the development in natural forests, regeneration sites should be kept small (no larger than 10 ha when using the shelterwood and seed-tree methods) and the felling areas should be restricted to follow the variation in topography and soil conditions. Natural regeneration has always priority. Regeneration sites should have both fallen and dying standing trees left in place. Ecological corridors to facilitate enhanced wildlife movement should be created in the middle and along the edges of the felling sites in accordance with topographic and stand features. In places where the humus layer has to be broken up to encourage restocking, prescribed burning and light scarification are the recommended measures. Due to the predominant private, non-industrial forest ownership structure of the Nordic countries, regeneration felling based on such small openings is typical.

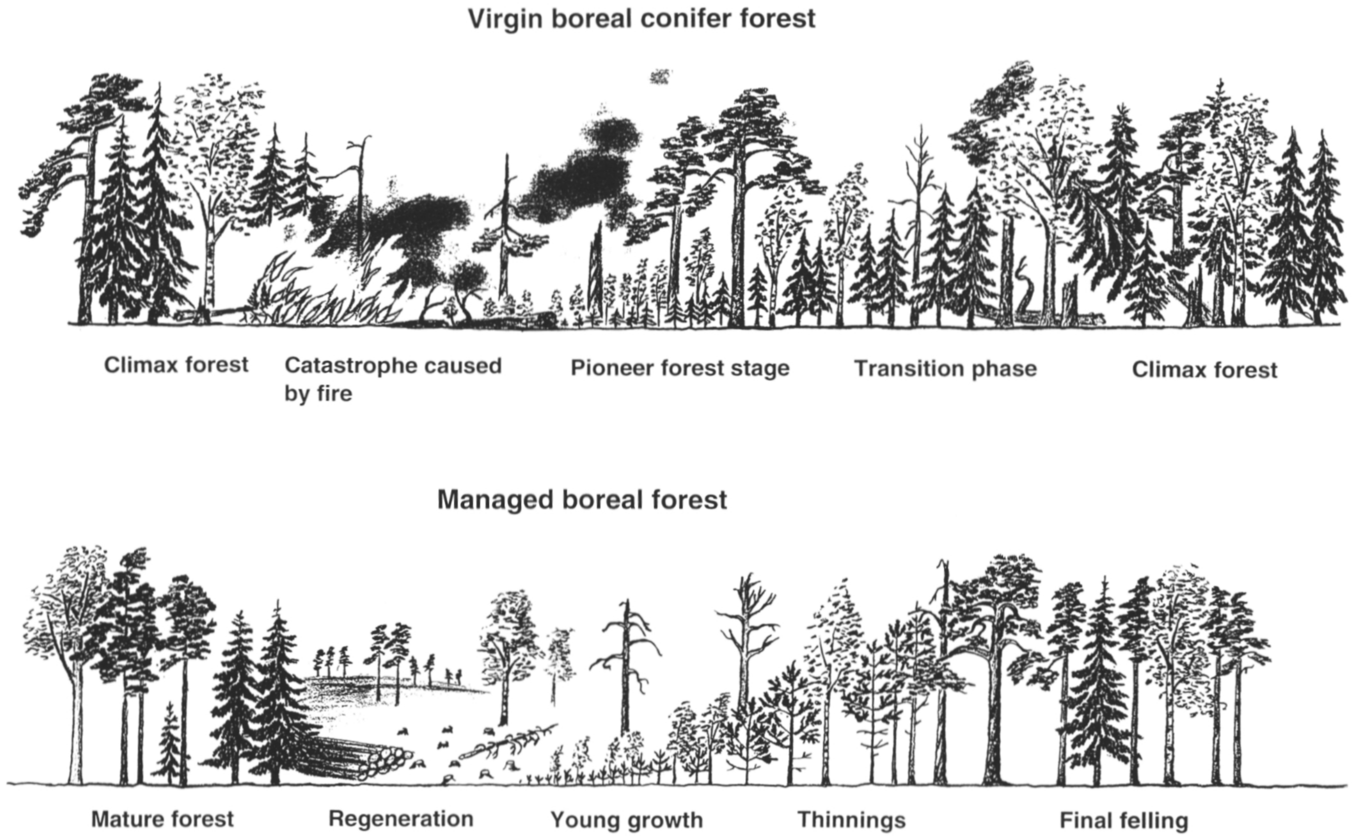


Figure 1. The forests in the coniferous zone may be referred to as catastrophe forests whose natural development is occasionally interrupted by fires, insect pest epidemics or gale. This development is being simulated in the treatment of commercial forests.

Figure 2. Later, the development of natural forests in the Nordic countries leads to spruce taking over from the other tree species. As a consequence, the humus layer increases in thickness and stand regeneration slows down.

Figure 3 As a means of fostering biodiversity, the current practice in the tending of commercial forests is to leave a small proportion of decaying wood both standing and fallen.

Raimo Koskinen
United Paper Mills Ltd
Forestry Department
P.O. Box 32, FIN-37601 Valkeakoski, Finland
Tel. +358-37-713 810
Fax +358-37-571 3839

BIODIVERSITY IN PRACTICAL FORESTRY IN FINLAND

If biodiversity is understood as the natural state of forests, and the lack and endangerment of biodiversity is understood divergence from that caused by man, the state of Finnish forests might not be that bad. The forests are formed of indigenous tree species, they are naturally generated and they usually are mixed forests.

Almost 25 % of the forest area is artificially regenerated, but the tree species are of native provenance and local origin, and most important, about half of the trees have been naturally seeded from the neighbouring forest.

Also the forest ownership structure support biodiversity. Private families own two thirds of the forests. The number of private forest owners is 400000 and the average size of the forest estate is 30 hectares.

Ten per cent of the land area has been included in conservation programmes, apart from forestry.

The most recent environmental research has discovered weaknesses: virgin forests and groves should be protected better. Also rotten and ancient trees are missing in managed forests. Foresters agree on these weaknesses. Something must be done.

New environmental guidelines that take into account the above needs have been developed together with environment researchers. The guidelines are common for all forest owners, meaning private, state-owned and company-owned forests. The guidelines have been instructed to forest owners, foresters, people working in the forests or with forest machinery and foremen for more than a year. More than 10 000 persons have received this training.

A "green change" is taking place, and the results are already visible. People's esteem is changing and the need for environment protection will be emphasised. The need for change is evident, but we can gladly say that there is also an apparent readiness for change in the forest profession.

Pekka Patosaari
Director
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki , Finland
Tel. +358-0-160 3353
Fax +358-0-160 2400

THE HELSINKI PROCESS ADVANCES

The second Ministerial Conference on the Protection of Forests in Europe, held in Helsinki, in June 1993 was organised by Finland and Portugal in cooperation with France and Poland. The Conference witnessed the commitment of the European forest ministers to continue and strengthen their cooperation under the dynamic process initiated in Strasbourg in 1990.

The four Helsinki Resolutions and the General Declaration constitute a joint response of the European countries to many of the forest decisions made at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (UNCED): The Rio Declaration, Agenda 21 and particularly its chapter 11 on combating deforestation, the Convention on biodiversity, the framework Convention on Climate Change and of course the "Forest Principles". The Helsinki resolutions H1, H2 and H4 bring the UNCED decisions to the European level and promote their implementation on national level. Helsinki Resolution H3 brings to a regional level the objective stated in the "Forest Principles" to increase solidarity and cooperation between countries. All four Helsinki Resolutions have been signed by 36 European countries and the European Union and two countries have signed three Resolutions. The follow-up of the Helsinki Conference has become a challenging task due to the current importance of these resolutions, which represent the UNCED follow-up in the European context.

The most essential issue in the international follow-up of the Helsinki Conference has become the need to identify criteria and indicators to be used to measure the extent to which policy objectives are being achieved or not, chiefly as a guide to future action answering questions like in which field, how much, at what degree of intensity, etc. The signatories and observers have already taken action to implement their joint commitments, and with their joint efforts, the European countries intend to compile a pan-European follow-up report on Helsinki resolutions for the meeting of the Commission on Sustainable Development in 1995.

The Helsinki Conference defined sustainable management in resolution H1 as follows: "Sustainable management means the stewardship and use of forests and forest lands in such a way, and at a rate, that maintains their

biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems".
By approving this definition and signing the Helsinki resolutions the European countries committed themselves to develop national strategies and plans on how the conservation of biodiversity and its appropriate enhancement could be considered as an essential part of sustainable forestry in each signatory state. Additionally, many international organisations have integrated these issues in their own work as a complementary and supporting element. The work being done is yet self-supporting and acts as a political motor. The process has proven to be an effective way to focus urgently on the protection of forests and encourage the adoption of the general principles of sustainable forestry and the very first steps of their implementation.

Different working forums and formal follow-up meetings form the series of actions and thoughts through which the European countries will find some answers to how to put into practice the sustainable management of forests and conservation of biodiversity of forests on a national level. At this point emphasis is placed on examining and evaluating the quality of scientifically based criteria and the need to specify them, and identifying indicators to be used in the follow-up. This work is being guided by the co-chairman countries hoping to receive the widest possible political support from other countries located in these biomes and constructive collaboration from all interested parties.

The Helsinki Follow-up is Part of a Global Process

The Helsinki Process is a major contribution to the practical implementation of the Rio forest principles at the European level. In boreal and temperate forests ecological, economic and social conditions differ between regions. Yet, the similarities are overriding and, therefore, development of criteria applicable to all boreal and temperate forests is necessary. This development would constitute a major step towards international cooperation in sustainable forest management and give the countries with boreal and temperate forests a good starting point for the global dialogue on forests.

Also the Forest Principles need to be translated into a form in which they may be used to demonstrate, within each country, the present position in relation to sustainable forestry and any changes with time, either favourable or unfavourable. We have to build upon the work already carried out in many contexts, e.g. the Montreal Seminar. There is an evident need for consultations among countries which are willing to continue global discussion on an international instrument on forests, and there is also a need for new proposals on how to facilitate the review of forest related issues by the Commission on Sustainable Development (UNCSD) at its Session in

1995 and how to promote sustainable forestry world wide through the application of the Forest Principles. All meetings should complement the existing dialogues, processes, workshops and conferences towards a global agreement on forests.

The national, regional and global agenda on forests are wide ranging including a broad spectrum of environmental, socio-economic, trade and cultural considerations closely related to forests. At the global level, in order to facilitate the CSD-process, Finland will also focus on the core items for the coordinated efforts to implement more effectively the Rio commitments on forests at the national and international levels. Finland emphasizes the urgency for adequate preparations on global forest issues:

- to take note of the various initiatives being undertaken in preparing for the 1995 UNCSD session,
- to encourage transparency of these various processes and their outcomes,
- to define priorities for consideration and action needed at the UNCSD in 1995,
- to develop internationally accepted criteria and indicators for sustainable forestry for all types of forests,
- to promote international climate that would facilitate international trade in forest products,
- to enhance economic cooperation with developing countries and transfer of environmentally sound technologies to developing countries in order to promote sustainable forestry.

The diverse interests of the different parties should be taken as the starting point for international forest negotiations. A common objective could be the conservation of forests, their preservation values, and production capabilities for future generations. The constraints and conditions will naturally change when everything else changes, when new discoveries are made and new knowledge acquired. Likewise the interests will change. But the negotiations will always have to take place in the prevailing realistic situations.

Henry Schneider
Forestry Board of Helsinki
Österviksgatan 22 A
FIN-00210 Helsingfors, Finland
Tel. +358-0-672 011
Fax +358-0-672 265

THE CRITERIA AND INDICATORS OF SUSTAINABLE FOREST MANAGEMENT ON A WORKING SCALE

"Key biotopes"

Practical concerns in ecologically sustainable forestry is very often related to preserving and managing key biotopes in the forests. These are valuable for many species, some of them endangered and often consist of biotopes that never or very seldom burned in the natural succession of the forest, e.g. brooks, fertile soils, paludified spruce-dominated forests etc. Planning the management of these biotopes requires a landscape level approach.

Small units in private forestry. The forests in the area of the Helsinki Forestry Board are privately owned by 80%, the average woodlot being about 35 ha. Treatment units (e.g. in regeneration cuttings) are about 1,2 ha on an average. Therefore, there is a possible conflict between this small-scale forestry and the landscape level approach to biodiversity research and management, which certainly is scientifically rational. On the other hand, small-scale forestry in itself certainly creates a more mosaiclike landscape and more diversity.

A possible conflict might also exist between landscape management (from an aesthetic point of view) and ecologically sustainable management of the forest.

How much does the consideration for biodiversity cost? This question should be thoroughly investigated. Preserving biodiversity can and should not be free for the forest owner. Strict limits are obviously impossible to determine because of varying conditions. Proposing that 10% of the older tree generation should be left in each regeneration cutting, like WWF does, doesn't seem rational to me neither from an economic nor an ecological point of view.

Education

The most important group to reach with courses and education in sustainable forest management certainly is the loggers and contractors working in the (private forest).

Attitude problems

Some foresters meet ideas of ecologically sustainable forest management and consideration for biodiversity by showing symptoms of the "this is the way we've always done it"-syndrome. Even if part of this should be true, that attitude is not very positive in a situation when we sincerely want to manage also for biodiversity and show the ecologically aware public that some real changes are happening in the way we manage our forests.

Another problem is a certain tendency of having the consideration for biodiversity as an excuse for bad silviculture. E.g. using natural regeneration on sites appropriate only for clearcutting and planting is not ecologically sustainable forestry.

Richard A. Sims
Research Scientist
CFS, Great Lakes Forestry Centre
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700
email: RSIMS@FCOR.GLFC.FOREST

USING SPATIAL MODELLING AS A DECISION SUPPORT TOOL TO ASSIST ECOLOGICALLY-BASED RESOURCE MANAGEMENT PLANNING IN ONTARIO, CANADA

Introduction

Important and difficult questions are being posed about complex ecological issues such as ecologically-sustainable development and the conservation of biodiversity. If we are to adequately address these questions, we must first clearly identify, characterize and understand those ecological units which are involved. Spatial modelling techniques can be used to examine ecological and resource feature interactions at a range of scales or resolutions. Spatial modelling studies of ecosystems process are currently underway in Ontario, at two levels: regional (e.g., 1:250 000 and smaller) and operational (e.g., 1:200 000 and larger).

A Provincial DEM Framework

A new digital elevation model (DEM) for Ontario has been recently developed. (cf. Mackey et al. 1994, in press) at a 100 m grid spacing using the ANUDEM procedure (Hutchinson 1988). The base for this work has been the national coverage (1:125 000 scale) National Topographic Series digital map-bases (93 maps in Ontario). The resulting gridded network of elevations are being used to help interpret other GIS-based spatial databases.

Derived data layers are being used estimate Primary Environmental Regimes (PERs) of radiation, moisture, nutrient status, etc. for vegetation growth. For example, mathematical surfaces of long-term mean monthly climate have been fitted to a network of about 550 available weather stations for the province using ANUSPLIN (i.e., a thin plate smoothing spline procedure; cf. Hutchinson 1987). Using these techniques, plus ancillary surface interrogation programs, estimates of long-term mean monthly climatic and derived bioclimatic variables (e.g., degree days above a specified base temperature) can be generated at any point in the province (and including statistical error estimates). To date, data on some 40 long-term climate variable have been brought into the climatic database associated with the DEM. Also, by resolving the coefficients at each grid intersection, a regular grid of the climatic variable can be generated so that climate surface maps can be developed.

Results of the province-wide DEM and climate modelling work are being presented in a series of forthcoming papers (see also Mackey and Sims 1994, Sims et al. 1994). These digital models enable the climatic response of taxa (based on either floristic or structural characteristics) to be empirically determined and the potential climatic domain spatially predicted. These spatial data and analytical results are also being coupled to remotely sensed data, mapped data, point data, (e.g., we have integrated a network of some 5500 stations throughout Ontario where there is detailed vegetation, soils and mensurational data), and terrain analyses based on the DEM, to provide spatial predictions about ecosystem processes at a regional scale.

The Rinker Lake Project: An Operational Test Case

At the operational level, a detailed investigation of environment, wildlife and operational forest practices is being undertaken in the Rinker Lake Research Area, north of Thunder Bay, north-western Ontario (e.g., Sims and Mackey 1994). A detailed DEM and other databases are being developed and used to integrate research results into GIS-based models that can be applied to resource management planning. The project consists of a group of research studies (see list, following page).

One principal goal is to assimilate and integrate findings of the various researchers into predictive, over-time ecological models that can applied to resource management planning, and the elucidation of ecosystems processes, especially PERs, at the operational scale. The role of the PERs in boreal forest ecosystems of NW Ontario was previously described by Sims et al. (1989); these researchers showed that the distribution of mature vegetation associations in the forest ecosystems of NW Ontario are strongly related to soil moisture and mineral nutrient regimes.

One primary input into this work is an ANUDEM terrain model constructed at a 20 m grid spacing for the 900 sq km Research Area, and based upon digitized Ontario Base Map information at a 1:20 000 scale. The contour and stream-line data were interpolated using the ANUSPLIN procedure (Hutchinson 1987). Using the ANUSPLIN procedure plus ancillary surface interrogation programs, estimates of derived bioclimatic variables have been generated at field points where detailed field-data collection was conducted. Other spatial databases, mostly at a nominal resolution of about 1:20 000, include derived climatic layers, detailed surficial geology and soils, forest vegetational cover-types (from satellite imagery, interpreted air photos and existing maps), interpreted hydrological flow patterns, and soil moisture indices. Field data collected from throughout the Research Area are being used to calibrate portions of the models.

Some of the component studies currently underway as part of the Rinker Lake project are:

1. Habitat Relations and Dynamics of Forest-Dwelling Birds (principal investigators: D. Welsh, M. Mather and L. Venier, Canadian Wildlife Service - Ontario Region, Ottawa, Ont.).

2. Terrain, Hydrology and Climate Modelling of the Rinker Lake Research Area using a Digital Elevation Model (principal investigators: D. McKenney and R. Sims, Canadian Forest Service - Ontario Region; B. Mackey, Australian National University).

3. GIS-Based Ecosystem Mapping of the Rinker Lake Research Area (principal investigators: R. Sims, K. Baldwin, D. McKenney, K. Lawrence, N. Szcyrek, Canadian Forest Service - Ontario Region; B. Mackey, Australian National Univ., Canberra; J. Ford, Ontario Geological Survey, Sudbury; G. Racey, OMNR, Thunder Bay, Ont.)

4. Description and Modelling of Forest Successional Pathways (principal investigators: S. Walsh and R. Sims, Canadian Forest Service - Ontario Region; other collaborators).

5. Satellite and Airborne Remote Sensing for Forest Ecosystem Classification in north-western Ontario (principal investigators: P. Howarth and P. Treiz, Earth Observations Lab., Institute for Space and Terrestrial Studies, Univ. Waterloo, Waterloo, Ont.)

6. An Ontario Base Map Terrain Analysis Toolbox for Resource Managers (principal investigator: P. Street, Mitig Forestry Services Ltd., Thunder Bay, Ont.).

7. Digital Elevation Model - Calibration Studies (principal investigators: B. Mackey, Australian National University; staff from the Surveys, Mapping and Remote Sensing Sector, Dept. of Natural Resources Canada, Ottawa, Ont.; S. Jensen and collaborators, EROS Data Centre, US Geological Survey, Sioux Falls, South Dakota).

8. Environmental Impacts of Forest Harvesting in Black Spruce-Dominated Ecosystems (principal investigator: D. Morris and collaborators, OMNR, Thunder Bay, Ont.).

Acknowledgements

Most of this work is undertaken at the Canadian Forest Service-Ontario Region (Sims, McKenney, Mackey), but in collaboration with a number of other researchers and agencies, including the Australian National University, Ontario Ministry of Natural Resources, Canadian Wildlife Service, Ontario Geological Survey and others. Principal funding is via the federal-provincial Northern Ontario Development Agreement.

References

Hutchinson, M. 1987. Methods for generation of weather sequences. in Bunting, A. H. (ed.). Agricultural environments: characterisation, classification and mapping. CAB International, Wallingford, UK.

Hutchinson, M. 1988. Calculation of hydrologically sound digital elevation models .in Proceedings, 3rd Internat. Symposium on Spatial Data Handling, Aug. 17-19, 1988, Columbus, Ohio.

Mackey, B.G. and Sims, R.A. 1994. A climatic analysis of selected boreal tree species, and potential responses to global climate change. World Res. Rev. 5. (4): 469-487.

Mackey, B.G., Sims, R.A., Baldwin, K.A. and Moore, I.D. 1994. Spatial analysis of boreal forest ecosystems: results from the Rinker Lake case study. in Proceedings, Internat. Conf. on Integrating GIS and Environmental Modelling, Sept. 26-30, 1993, Breckenridge, Colo.

Mackey, B.G., McKenney, D.W., Widdifield, R.A., Sims, K. Lawrence and N. Szcyrek, 1994. A New Digital Elevation Model for Ontario. NODA Res. Rep. (in prep.).

Sims, R.A., Towill, W.D., Baldwin, K.A. and Wickware, G.M. 1989. Field guide to the forest ecosystem classification for north-western Ontario. For. Can., Ont. Region, Sault Ste. Marie, Ont. and Ont. Min. Nat. Resour., Toronto, Ont. 191 p.

Sims, R.A. and Mackey, B.G. 1994. Development of spatially-based ecosystems models for the Rinker Lake Research Area in north-western Ontario's boreal forest. in Proceedings, GIS'94, Vancouver, British Columbia. Vol. 2: 665-674.

John Nelson
Associate Professor, Forest Operations
University of British Columbia, Faculty of Forestry
Vancouver, B. C.
Canada, V6T 1Z4
Tel. (604) 822-3902
Fax (604) 822-9106

DECISION SUPPORT SYSTEMS: SPATIAL HARVEST SCHEDULING

The Decision Support Systems Program

A common question asked in Canada , and around the world is "what will the forest look like if these management options are implemented"? Failure to provide an intelligent answer to this question virtually guarantees a serious land use conflict, which forestry often loses. To provide useful input to this debate, spatially referenced computer models are now being used to project future forest conditions according to forest dynamics and forest management strategies. In Canada, the Decision Support Systems (DSS) program of the Green Plan is supporting three research projects in spatial harvest scheduling methods.

In the Atlantic Region, the terrain is gentle, stands mature quickly and are frequently attacked by insects, and the forest is comprised of numerous small stands. Provincial legislation dictates that industry must provide spatially referenced plans for the next 25-35 years of harvest. Prof. Glen Jordan from the University of New Brunswick is designing and using simulation models linked to a Geographical Information System (Arc-Info) to assist forest planners in the Atlantic Region. In the Pacific Region, the terrain is rugged, stands have great longevity, and the forest is often comprised of large, homogenous stands. Following the lead of the Atlantic Region, spatially referenced harvest plans are soon to be a legislated requirement. Prof. John Nelson from the University of British Columbia is developing spatial simulation models to meet the special needs of the Pacific Region. The third initiative is being led by Mr. Carey Lockwood from Natural Resources Canada, where simulated annealing algorithms are producing very promising optimization results for a wide variety of forest planning problems across the country.

Applied Projects in British Columbia

For the past three years we have been working on a large forest planning project located near the Rocky Mountains. Harvest units and road networks have been designed for the 500 000-ha Revelstoke forest, and these are used in conjunction with the ATLAS model to produce spatially referenced plans. This research project has two stages. Stage I, which has just been completed, evaluated the economic impacts of applying existing harvest regulations (adjacency and green-up, wildlife habitat, and visual restrictions). This is the first time that the long-term effects of these regulations has been assessed. Stage I revealed that not only are there serious economic impacts associated with the regulations, but they often result in undesirable forest conditions. Forest fragmentation and unlimited human access to wildlife habitat are two cases in point. Stage II of the research project is using spatial models to investigate modifications to the regulations so that they achieve their intended objectives with minimal economic impacts.

The second project was done in the coastal region where the economic impacts of proposed biodiversity guidelines were assessed using the ATLAS model. The biodiversity guidelines require establishing forest ecosystem networks (fens) throughout the forest, and the retention of green-trees within harvest units. Three fen designs (permanent, replacement, and selection silviculture systems) were assessed in terms of timber supply, road network activity, and delivered wood costs. This modelling study was replicated in three coastal forests that have quite different logging histories.

Current and Future Research Initiatives

There are tremendous research opportunities in the area of decision support systems for forest planning. These range from very specific operational and environmental issues at the watershed level right up to the general implications at the global level. The modelling of forest dynamics and management strategies can provide important and timely information on acceptable and unacceptable forest practices. We need to collaborate with international research expertise, there are great opportunities for Canada and Finland to play an important role in this international research effort.

The research topics that we are pursuing fall into three broad categories; 1) economic and environmental impacts associated with forest operations, 2) mathematical programming techniques, and 3) data acquisition, manipulation, and information displays for planning projects on a regional scale. In the first category, some specific problems are defining economic operability limits, optimal sustained yield unit size, strategies for maintaining the road network, and equitable allocation of the harvest to competing mills. In the second category, simulated annealing algorithms, genetic algorithms, and network heuristics are being investigated as methods for improving model solutions. Finally, in the third category we are interested in using satellite imagery and advanced 3-D graphics as important input / output components for modelling forest dynamics and management alternatives on a regional scale.

Ted Needham
University of New Brunswick
Faculty of Forestry and Environmental Management
P.O. Box 4400, Fredericton, N. B.
Canada E3B 5A3
Tel. (506) 453-4506
Fax (506) 453-3538

SILVICULTURE DECISION SUPPORT

RATIONALE, DESIGN AND DEVELOPMENT OF A SILVICULTURE DSS

> What site preparation and competition control method is "best" to artificially regenerate a stand? Is 2000 stems per ha the "best" planting density? When should a stand be commercially thinned? How much basal area should be left and removed in a partial cut to maintain deer habitat?

These questions typify those frequently asked by forest land managers. They are similar in several ways. First, the manager wants to know the most appropriate silviculture to employ. Second, they are worded and imply that there is a single "right" answer. And third, implicit in the questions is a sense that science and research will eventually provide the answer because the questions are worded like convergent problems.

These attitudes and perceptions are consistent with both our educational foundations and many forest management systems used today. At university we were led to believe that there was a "right" answer to each question. In practice, we have come to accept and even demand "Forest Practices Guidelines", "Forest Practices Codes", "Best Management Practices" (BMP'S), and Forest Management Manuals - all of which in fact do provide "the" answer to the question.

Under true management however, there is no single, "right" answer to these types of questions. Instead there are benefits, costs, and risks associated with the multitude of silvicultural treatments available and the "best" choice depends on the forester's understanding of these relative to stand conditions, stand dynamics, stand, landscape and forest level demands, as well as economic, social and political perceptions and realities.

While no single treatment is "best" in all circumstances, appropriate silviculture can be identified. Research has and continues to be conducted and a variety of tools are now available to help. Some of these are only applicable at the stand level and are graphical, such as density management diagrams; some take the form of an expert system (VEGPRO); others are applicable only at the forest level and rely on simulation and optimization techniques, such as FORMAN and FORPLAN, respectively. Some are applicable for short term operational planning (OPLAN) and others for long term strategic level planning (MUSYC). Most are concerned singly with either yield, revenues, or costs (QUICKSILVER); however, some consider all three.

Many are developed as independent systems - as ends unto themselves. Treatment or prescription choice rather than prescription formulation is the objective of most. Until recently, silviculture prescription formulation has been considered a given and the need minimal. In one sense, the job of every silviculturist was prescription formulation, and yet there has really been no reason to do so. Most silviculture has been considered a "point in time" activity and emphasis has been placed on ameliorating a current local condition or fulfilling the rules and regulations specified in a manual. In the New Brunswick Forest Management Manual, for example, stands with less than 35% softwood stocking following harvest must be planted. The implications of these activities on the need or efficiency of future treatments is not considered.

Emphasis has also been placed on the treatments themselves rather than the conditions that are required to best fulfil specified needs. We discuss and argue about clearcutting and selection cutting rather than specific stand structures needed to fulfil objectives. The advent of forest level planning tools with geographic referencing capability, along with public pressure for more accountability has now started to change the situation. As forest planners struggle to expand their silviculture repertoire including atypical treatments with objectives that extend beyond timber production and as foresters try to recover their credibility, silviculture prescription formulation is increasingly becoming a requirement.

Unfortunately, site specific silviculture prescription formulation is a laborious, cumbersome, analytical nightmare requiring recognition of many assumptions and uncertainties. Widely scattered, often incomplete and incompatible information must be amassed and collated into a workable framework, and compatible analysis systems that span temporal, spatial and social dimensions must be available to translate data into useful information from which decisions can be made.

A silviculture DSS designed to facilitate the processes of silviculture prescription formulation is in the initial phases of development at UNB. Unlike other so called silviculture decision support systems (SDSS), ours does not tell the manager what to do - it is not an expert system, rather it provides a mechanism for the manager to efficiently assemble prescriptions and discover the impacts of alternative treatment choices. It is an interactive computer based system that will house a large information base, provide information models and link to a forest management planning system thereby allowing the land manager to examine silvicultural choices in broader spatial and temporal contexts.

The system has two fundamental characteristics. First, it is stand based. While trees are the basic unit of measurement, we consider the stand to be the fundamental unit of forest management and manipulation. As such, the system can be used in isolation of forest or landscape management DSS models. To investigate the impacts of any silvicultural prescription at the landscape or forest level however, output from the silviculture DSS must be consistent with the input requirements of models that operate at these levels.

Second, the proposed system considers all treatments throughout the life of a stand. In Atlantic Canada, while silviculture often implies planting and precommercial thinning, in our system, all interventions that could possibly occur throughout the life of a stand are considered, including harvesting. Treatments are not considered as point in time, independent, isolated actions. Any treatments which incur a cost, affect stand dynamics or affect the cost or outcomes of future treatments must be considered. As such, while the fundamental decision variable is the intervention, the basic element of interest is the prescription describing all interventions throughout the life of the stand.

Michael Power
Project Leader, Pest Management Systems
CFS, Petawawa National Forestry Institute
P.O. Box 2000, Chalk River, Ontario
Canada K0J 1J0
Tel. (613) 589-3008
Fax (613) 589-2275

FOREST PEST MANAGEMENT DECISION SUPPORT SYSTEMS

The Canadian Forest Service has embarked on a multi-year program for decision support system (DSS) development as part of Canada's Green Plan. The objectives of this program are to support development of working DSS in several Model Forests, and to develop and promote Canadian leadership in resource management and information technologies. This program is divided up into six theme areas.

The Spatial Harvest Scheduling theme area is developing tools to allocate harvesting activities in the forest landscape based upon complex spatial objectives. Of all the factors that cause change to forests, harvesting proves to have a significant impact for timber management, wildlife management, maintenance of aesthetics, and control of forest pests. Specific studies are developing a watershed planning system, a grid-based harvest planning tool, an optimal harvest planning tool based on simulated annealing, and a spatial harvest scheduling model.

The Economic and Non-Timber Assessment theme area is investigating trade-offs between values such as timber production, recreation, wildlife, and aesthetics for sustainable forest management. Studies are being conducted on the economic benefits of integrating timber and wildlife planning objectives, a GIS-linked assessment of non-timber values for conflict resolution, and the valuation of non-timber benefits.

The Wildlife Habitat theme area is developing new approaches to describe landscape features and ecosystems that may lead to proactive wildlife or habitat management, as opposed to managing wildlife through constraints or regulations on timber management. Specific studies are on modelling habitat requirements for vertebrate wildlife species, predicting the capability for wildlife species for habitat and populations levels using a forest ecosystem classification, and modelling the viability of an endangered pine marten population.

The Dynamic Biophysical Inventory theme area is developing an engine for combining static land and forest inventories with ecological succession simulation models. The studies are on predicting the spatial distribution of forest ecosystems based on satellite imagery, early succession modelling for post-harvest mixedwood forest types, modelling mixedwood succession based on a forest ecosystem classification, and spatial modelling of primary environmental regimes.

The Silvicultural Decision Support System theme area is developing tools that can balance multiple considerations in selecting or designing optimum treatments. Specific studies are reviewing the research and development needs for silvicultural planning in Canada, developing a white and red pine expert system, and producing a decision support guide for silvicultural treatments in Quebeck.

The Forest Pest Management Decision Support Systems theme area is developing systems to plan control activities, tailor management activities in the presence of on-going insect damage, and to design forests that are less susceptible to pest infestation. Specific studies are leading to the development of decision support systems for the management of four important- forest insect pests.

The intent of the Green Plan Decision Support System Program is to integrate many of the decision support tools from each of the six theme areas, and to demonstrate these in operational settings in at least two of the Canadian model forests. The forest pest management theme area is highlighted as an example of close collaboration and networking between researchers and developers. This interaction has been facilitated by a common system interface and software framework, FOKIS (FOrest Knowledge & Information System), which was developed to connect and deliver analysis and modelling capabilities.

FOKIS is an evolving framework whereby decision support applications can be constructed, extended, and reused with common interfaces and software components. This interface operates under the ARC/INFO (ESRI Ltd.) GIS on SUN Sparcstations. The first operational application has been installed in Newfoundland to support management of the hemlock looper, a defoliating insect that periodically devastates forests. This application of FOKIS provides a powerful, fast, and easy-to-use environment to browse through forest inventory and defoliation maps, to conduct prediction modelling scenarios, and to view resulting maps of these predictions. Annual predictions can be made on the probability of specified levels of defoliation, and subsequent tree mortality and decay. As well, daily predictions can be made on insect life stages.

Applications under FOKIS are well underway for management support of two other important defoliating insects. The Jack Pine Budworm Decision Support Application is being implemented under FOKIS for use in Ontario and Manitoba, and Canadian Forest Service Maritimes is developing the

Spruce Budworm Decision Support Application for use in New Brunswick. Operational applications of FOKIS will provide a continuous feedback from users to those in research and development so they can better understand and design applications that best meets the users' decision support requirements.

FOKIS will help to demonstrate multi-objective decision making by integrating models on many forest activities within the Canadian Model Forests. This framework has also been recently deployed in Finland as part of joint research in advanced DSS frameworks. These advanced frameworks will not only provide excellent interface and model integrating tools, but will also improve the way models and other knowledge can be represented in computer systems. Research and development in better modelling and system architectures based on the object oriented paradigm are underway.

Hannu Saarenmaa
Chief Scientist
Finnish Forest Research Institute
Unioninkatu 40 A, FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 235
Fax +358-0-625 308
email: hannu.saarenmaa@metla.fi

DECISION SUPPORT SYSTEMS FOR ECOSYSTEM MANAGEMENT

Current Challenges in Natural Resources Arena: Environment and Information

- Management focus is changing from forestry and natural resource management to environmental management.
- Social context is changing from bureau-mandated land management to public participation.
- Leadership requirements of have changed from rigid hierarchical style into motivating flexible, creative, and networked organisations.
- Modelling requirements have changed from statistical single-organism models to understanding dynamic processes, biodiversity and interactions at the ecosystem level.
- Data acquisition technology and the need for monitoring changes in the environment are quickly overwhelming our analysis and data management capabilities.
- Organisations and groups solving problems span globally.

Ecosystem Management

is a concept that integrates sustainability, multiple use, forest health, and biodiversity. It tries to answer to many of the above challenges. Its roots are in the West Coast of North America (The FEMAT Report, 1993).

Definition of Ecosystem Management can be stated as follows: The focal point in forest ecosystem management is the maintenance of the state of the forest landscape - not the utility that can be taken away from it at a given time. The state of the forest ecosystem depends on its diversity, its regeneration and self-organizing capacity, the health of its major components, and its productivity. Within the optimization of these aspects at a landscape level, forest can provide products and services for the use of present and future human generations (Society of American Foresters 1993 (Task Force in Ecosystem Management), Saarenmaa 1994 (Folia Forestalia, in print).

Implementation of Ecosystem Management is not yet available. One of the most important step in the implementation is the analysis of its information needs.

Information Needs of Ecosystem Management

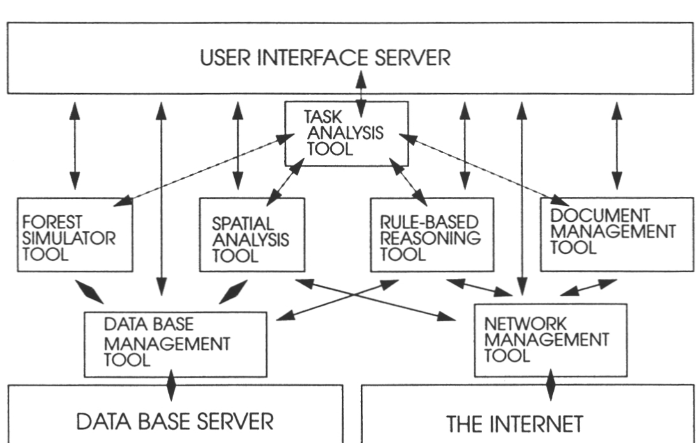
Ecosystem management requires more information than traditional forest management or natural resource management. Expansion of our information base is required in the following areas:

- Networking (*sensu lato*): Communication has become more important.
- Information about ecosystem health? Disturbance modelling.
- Biodiversity information: genetic, species, landscape elements.
- Landscape and stand heterogeneity: small scale spatial information.
- Increased need for integration.

Decision Support Systems

A decision support system, by definition (Sprague 1983), is capable of solving unstructured problems. To achieve this, unstructured tasks have to be turned into structured ones with a task analysis and by decomposing large, unwieldy tasks into smaller tasks. DSSs are ideal for ecosystem management because they can be used to integrate information from many sources.

Enabling Technologies for DSS include 1) Database Management Systems, 2) GIS, 3) Remote Sensing and Multispectral Imaging, 4) Object-oriented Modelling, 5) Artificial Intelligence and Expert Systems, 6) Network-Aware Hypermedia, and 7) Internet and the future *Information Superhighway*. Structure of a Decision Support System can be seen in the figure.



Functions of a DSS for Ecosystem Management can be found through modelling its activities. Object-Oriented Information Engineering is the leading methodology for such work. Preliminary analyses indicate that the DSS should include functions for 1) Biodiversity, 2) Health and resilience, 3) Forest regeneration, 4) Harvest schedule optimization, and 5) Multiple-use of forests.

DSS Functions for Biodiversity include access to basic species information such as 1) Naming and recognition, 2) Distribution, 3) References, 4) Rules for habitat suitability, 5) Biophysical modelling of occurrence and phenology, 6) Food web information. Aggregation of this species information is also important, and includes 1) Estimation of biodiversity from stand variables or by remote sensing, and 2) Modelling of biodiversity in individual landscape elements.

DSS Functions for Forest Ecosystem Health and Resilience have so far been managed in the context of Integrated Forest Pest Management. Its functions include 1) Monitoring of problems, 2) Reporting to national databases, 3) Modelling of population dynamics of harmful organisms, 4) Diagnosis of problems, 5) Estimation of ecological impacts, 6) Prescriptions of treatment tactics, and 7) Inclusion of treatments into forest planning.

DSS Functions for Regeneration and Progressive Forestry mean application of opportunistic rules rigorously in every treatment. As Finnish forestry schools educate: *"All activities in the forest are done for the forest."* A critical information need for this is an ecological classification of sites. A treatment priority must be established in the rule base: 1) Seed-trees over established seedlings; 2) Stands of retarded yield (incl. stands which are too sparse or result of devastation, over-aged stands, stands of wrong tree species for the site): 3) Scheduled thinnings and mature stands. Other policies that have also been implemented in Finland include expansion of the land base through 1) Ditching of peatland, and 2) Silviculture on former agricultural land.

Joint Finnish-Canadian Work in DSS

Below is an overview of the current joint work in DSS between Petawawa National Forestry Institute, the Finnish Forest Research Institute, and the Academy of Finland. All the projects include scientist visits in the other country. So far this exchange has meant 2.5 man-years of Finnish visits in Canada and 0.8 man-years of Canadian visits in Finland.

White Pine Expert System

This is work of Liisa Saarenmaa, University of Helsinki, Darwin Burgess, PNFI, and Fred Pinto, Ministry on Natural Resources, Ontario. It is an expert system for white pine (*Pinus strobus*) management, especially regeneration alternatives.

The system was necessary, because white pine is one of the most valuable tree species in eastern North America, but problems with its regeneration have made its management difficult. A large knowledge-base of white pine's ecology, silvics, and management practises is available consisting of research reports, textbooks, and expert opinions. An expert system was build to use all this knowledge for decision making.

The expert system was implemented as a KAPPA-PC (IntelliCorp, Inc.) application using an object-oriented approach. Knowledge acquisition was based on a dependency network that was designed before starting to write the rules. Currently, there are 163 rules and 20 functions. The system predicts regeneration result and gives silvicultural prescriptions at stand level. Currently, the system is just a prototype. Calibration and validation is planned for summer 1994 by Ari Hannila who will be working at PNFI.

FOKIS Finland

is joint work by Tom Gillis of PNFI, and Kirsi Valanne, Ari Nikula, Jouni Väkevä, Heikki Eeronheimo, and Hannu Saarenmaa of FFRI. Goal of the project is to introduce an ARC/INFO-based integrated forest DSS framework designed and built in Canada to Finnish users.

Finnish data sets that have so far been imported to FOKIS include 1) a forest planning area in south-west Lapland, 2) Pallas-Ounastunturi National Park, and 3) the National Forest Damage Database. Also the MELA timber management planning system has been installed under FOKIS. The framework is now being offered to various Finnish organisations for a basis of their integrated natural resource management systems.

Object-Oriented DSS Architectures

have been studied by Mike Power of PNFI and Jari Perttunen, and Hannu Saarenmaa of FFRI. Goal of this work is to find a modelling and programming framework for creating reusable, integrated DSS that can actually be delivered, and to find ways for avoiding technological pitfalls, costs and delays. Activities include joint work on DSS architectures with GIS and object-oriented modelling and sharing of technological know-how. The results have been published in several refereed journals and conferences. Future work includes creating an integrated object-oriented toolset for ecosystem management DSS.

Biodiversity Information Networks

BIN21 (Biodiversity Information Network / Agenda 21) is an international consortium that collects and organizes global biodiversity information into the Internet. BIN21 is a distributed network of open public-domain databases, and it is based on World Wide Web and HTML (e.g. Mosaic) as front-ends to databases. FinBIN is an implementation of BIN21 in Finland just being started, and it is coordinated in Finland by Hannu Saarenmaa and the FFRI information technology laboratory.

Joint work between PNFI and FFRI, as well as USDA Forest Service and the All-Russian Forest Resources Information Centre, includes implementing an international Forest Pest Information Network as part of the BIN21 effort. This work has been started in 1994.

Urpo Nikunen
M.Sc.(For.), Head of Department
Forestry Centre TAPIO
Maistraatinportti 4 A
FIN-00240 Helsinki, Finland
Tel. +358-0-156 2401
Fax +358-0-156 2232

FOREST REGENERATION IN NON-INDUSTRIAL PRIVATE FORESTS - DECISION SUPPORT SYSTEM AND PRACTICE

The total area of private forests is about 13.6 million hectares and amount of forest owners more than 330 000. Regeneration area in private forests has been near 140 000 ha/Y. The share of natural regeneration is more than 25%, the share of planting 60% and sowing near 15% of the total regeneration area.

Private forest law and forest regeneration

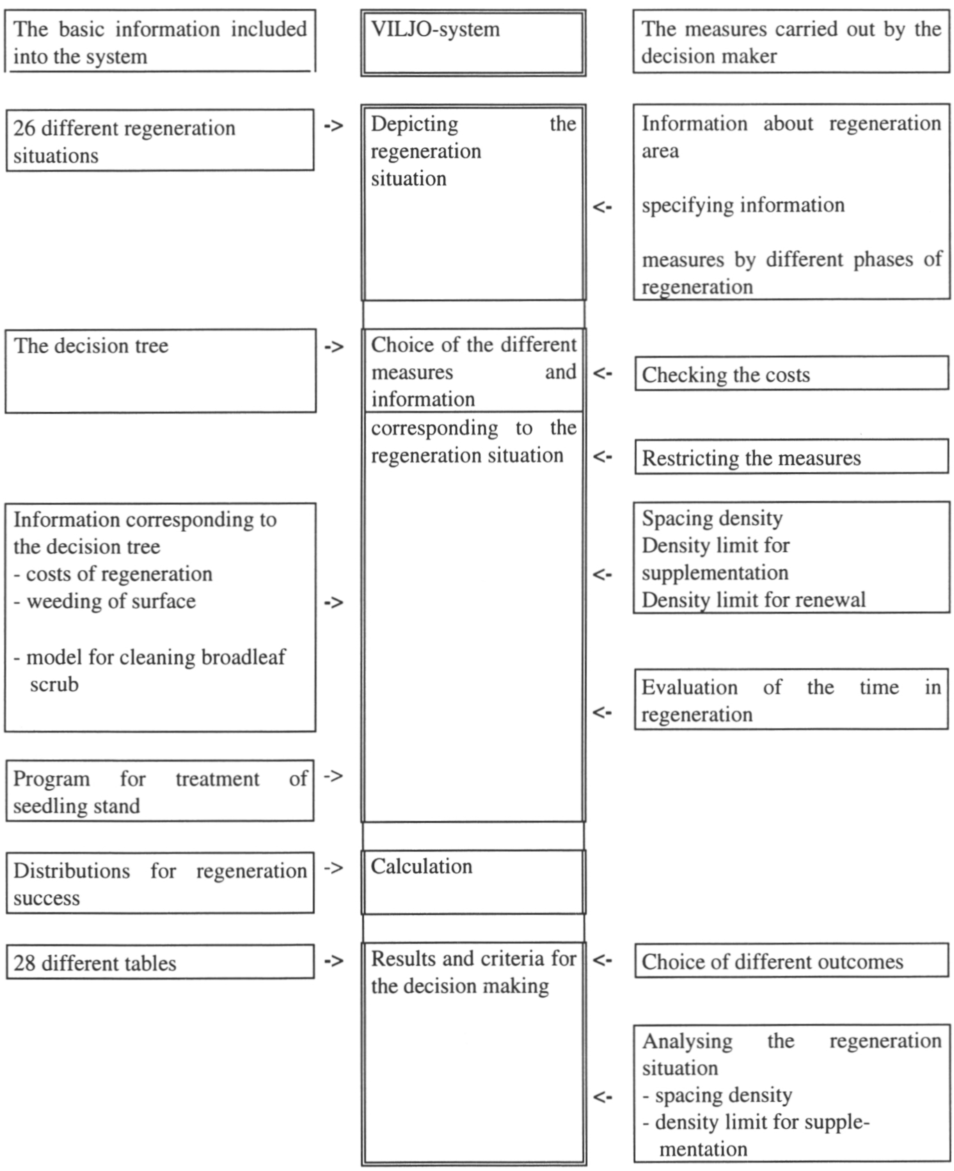
Forest owner must present to the local forest district before the regeneration cutting a plan for regeneration methods that he intends to use. The regeneration plan may be based on the forest management plan or it can also be based on separate regeneration plan. The regeneration method, soil preparation method and time schedule for the measures is determined in the regeneration plan. Normal maximum time to complete the regeneration tasks is five years.

DSS and practical experiences

Forest districts have used five years DSS called VILJO. The principle of VILJO is shown in the picture next page. The system contains simulation models, which uses a lot of details from each individual regeneration stand to be studied. Actual economical information as well as practical advises concerning risks in certain regeneration methods can be fed into the model. The VILJO-system produces normally numerous combinations of regeneration chains. Each combination; forecasts the stand at five meters dominant height including all the required measures, total costs and losses caused by the longer regeneration time and the number of the stems of the dominant tree species.

VILJO-system is good for teaching and studying the regeneration alternatives. VILJO-system is not used widely to study each individual regeneration stand in real practical use. Why not? - I see two reasons. First, knowledge of some important factors is too poor, for instance the peatlands and some geographical areas. Therefore the results especially in difficult stands are not very sufficient. Second, decisions for regeneration methods are not only economical - there is also human factor inside.

STRUCTURE OF THE CALCULATION SYSTEM



Simo Kaila
Senior Research Officer
Metsäteho, R & D Department of
Finnish Forest Industries Federation
P.O. Box 194, FIN-00131 Helsinki, Finland
Tel. +358-0-132 521
Fax +358-0-659 202

DETERMINING THE OUTCOME OF FOREST REGENERATION

Introduction

The amount of success in dealing with problems about cost effectiveness in forest regeneration depends on both general knowledge and special in formation - on facilities of alternative methods, natural processes and circumstances. Especially survival and growth of different seedlings, with planting success and natural restocking as main elements, should be known rather thoroughly. Costs as themselves are much easier to be predicted as soon as the need of after-planting operations is decided. The keys for this are a working notion on unit costs - or time studies on the time consumption of operations - but, first of all, a good research-based knowledge on regeneration progresses and a substantial information on the circumstances and actual outcomes of practical regeneration.

In spite of comprehensive research work done, forest regeneration success cannot be predicted with such an exactness as practical foresters demand. One fundamental reason to this is that nature is far too complex to be predicted with a good accuracy with any kind of a modelling technique. It may not be a reasonable aim, either. Though natural processes and human activity are involved, neither have such research approaches been common that regard the entity as a whole system.

Because predictability of regeneration through knowledge gained by research leaves many scruples, practical regeneration results in the organisation are paramount as an information source. Information requirements depend on tasks, which can be classified as follows: deciding the need and character of next operation, follow-up of regeneration in an individual plantation, management and supervision of operations, development purposes and special problems in regeneration.

It has showed out that different purposes set different demands to the material handled, and that they cannot duly be served through just one general information system. The outcome of regeneration is not any definite data set that can be quickly and easily determined in a plantation. Problems arise whenever measuring parameters for determining the production value of plantations is tried, instead of more practical, but less objective, visual estimates.

Modelling Efficiency of Forest Regeneration

Efforts for modelling forest regeneration have been going on during a couple of decades at least in North America (some more recent examples: Payandeh 1988, Belli & Ek 1988, Haas 1991) and in Finland. In the latter the systems approach, different from what was being developed elsewhere, was adopted (Räsänen 1988).

In the beginning of 1980s, a decision tree -structured forest regeneration decision and calculation model was introduced (Parviainen & Lappi 1983). It was developed further to handle more circumstances and regeneration alternatives, and has seen use in private forestry organisations. A few years later another type system model for evaluating site preparation and planting options and for handling a variety of site factors, with after-planting development and operations included, was made primarily for forest industry companies. It is briefly described in a IUFRO symposium report (Kaila 1989).

A hierarchical aggregated structure using results from field studies and knowledge of a few researchers and specialists, was defined as a conceptual scheme and information basis. The technique of aggregation has been described and discussed by Simon (1981 and 1990). A design thus built can handle a variety of sites and cultivation / planting material -alternatives. The model gives costs to be expected for site preparation, planting, repair planting and brush saw work. It also evaluates planting success, natural restocking, timing and amount of trees to be removed in cleaning and thinning operations and finally the time required to reach a height of 5 metres for the plantation. It uses a PC with the KnowledgeMan (Micro Data Base Systems Inc. TM.) work station system.

The model was meant to assist field personnel to evaluate options for site preparation and planting material under various site conditions. It has been used as an analysis tool when pursuing for more site specific use of reforestation methods. Although still in use as a demonstration device in training, the model has not showed to be any major achievement towards better practices in silvicultural operations.

It seems that no system idealising practical choices can produce operational solutions; very often these are strategic by nature, like choosing tree-species or use of natural instead of artificial regeneration. Due to uncertainties and because of the subjective nature in preferences of goal setting, these choices cannot definitely be solved through calculations that would depict the true process of wood production and its economy in a meaningful way. They are thus seen in practical forestry as "qualitative". Any kind of "hard systems modelling" (as defined in Checkland 1984), using but general knowledge as basis, lacks the ability for strategic formulations.

A Systems for Regeneration Inventory Studies

In the late 1980s, silviculturists in companies and state forestry included enhanced cost-effectiveness of forest regeneration as a key area in the general development of forest management practices. Management of general research information was not considered sufficient. The improvement of knowledge as to own results in regeneration was seen essential for development work. With this as the basis, a project aimed at defining information needs and developing the collection of data on field performance was started.

First, a technique based on the inventory study of young stands in the height phase of more than one metre was introduced (summary in: Kaila 1994). Traditionally, regeneration inventories for different aims have been done in several ways. The purpose was to create a data collecting system for combining material provided by the various forest management organisations, to make possible both general and organisation-specific analyses with each one's own definitions and concepts. The technique is based on samples composed of five plots, each of 10 m^2 in area. Seedling viability is not directly decided when collecting the material. This is done in data processing by seedling parameters and decision rules in the analysis program. Both the plots and the five plot groups are allocated with maximum stem densities per hectare based on site parameters.

The measurement data and results are saved into a data storage for further use, e.g., when comparing new material to be collected in years to come. So far the inventory study system has been used for analysing field performance of Scots pine regeneration methods from the Southeast to Lapland. This year it will be tried for evaluating differently established Norway spruce plantations.

This kind of an information system is expected to give comparable results from different regeneration methods on a given site condition combination fairly regardless of the preferences of the personnel collecting data. Another feature of the system is that it gives the description of conditions and results not as an average in each plantation, but by samples of the area regenerated. Thus, conditions and results can be matched more closely for the search of dependencies. However, the system gives just a cross section of regeneration methods, which - though sorted by climatic area and site conditions - does not correspond to results from field tests, e.g., when plotted against the time after establishment.

Early Development Plantation Inventory System

The second technique introduced in the project was a new method for figuring out the early development of plantations, at the age of a few years (brief summary in: Hämäläinen & Räsänen 1993). The data collection is more straightforward with fewer parameters and analysis facilities than in the technique for older plantations. It is meant for use in practical organisations, for feedback purposes on the quality of work and success of new site preparation equipment or new types of planting stock.

The starting point for this method were current inventory systems in use for assessing the need for repair planting, but they were altogether done away with since they did not prove to give essential help for work planning. So the data contents of the system were derived from a new information analysis.

During a couple of last years, the inventory system has been tested in most major forest industry companies' organisations for their own forests. The system has gained a use for management and follow-up purposes of establishment results as intended. Another use for it is observing the emerge of natural seedlings. A drawback is the subjectivity of data collection. It limits the system's use for research and development -type problems.

Future Considerations

There are methods for estimating costs on beforehand - against for instance planting success and height development to be expected - and methods for evaluating practical field performance of forest regeneration. However, these are not adequate to "solve" the problems related to cost effectiveness.

There is much to be done in research to gain a good understanding on cause and effect relationships essential for better modelling. More should be known about the natural processes, even if progress in that is slow and laborious. The state of a plantation is only an intermediate phase toward a stand producing quality timber. Especially the problems in variations of seedling height, spacing and tree-species, with site quality included, are not clear. Only when we can predict the development to first thinning through parameters describing the plantation, we are far on the way to that aim.

Also, there is much that can be learned through good control of each organisation's own practices. To arrange the mix of information sources properly, one should start with defining one's information needs. Goals and policies as to results to be achieved should be defined. There is a big difference in information quality needed if regeneration is measured for development purposes or just to see if the cultivation and the planting are properly done and seedlings are alive. There is no single answer about how to measure forest regeneration. It all depends on what we need it for.

References

Belli, K. L., Ek, A. R. 1988. Growth and survival modelling for planted conifers in the Great Lakes Region. Forest Science 34 (2): 458-473.

Checkland, P. B. 1984. Systems Thinking, Systems Practice. John Wiley & Sons Ltd. Chichester, New York, Brisbane, Toronto. Reprinted with corrections Feb. 1984, reprinted Aug. 1990. 330 s.

Haas, T. C. 1991. A Bayesian belief network advisory system for aspen regeneration. Forest Science 37 (2): 627-654.

Hämäläinen, J. & Räsänen, T. 1993. Menetelmä metsänuudistamisen varhaistuloksen mittaukseen. Summary: Method for measuring forest regeneration results. Metsäteho Review 6/1993. 6 s.

Kaila, S. 1991. Use of a system model in estimating the cost effectiveness of methods of forest regeneration. Efficiency of stand establishment operations; proceedings of a IUFRO symposium held at Rotorua, New Zealand, 11-15 Sept. 1989. New Zealand Ministry of Forestry, FRI Bulletin 156: 333-340.

Kaila, S. 1994. Metsänuudistamisen tuloksen määrittäminen ja männyn uudistamisen tuloksia. Summary: Determining the outcome of forest regeneration; results from Scots pine reforestation practices. Metsäteho Report 409. 47 s.

Parviainen, J. & Lappi, J. 1983. Laskentamalli metsänviljelyketjujen vertailemiseksi. Summary: A calculation model for the comparison of artificial forest regeneration chains. Folia Forestalia 549: 1-24.

Payandeh, P. 1988. Plant: A model for artificial forest regeneration in Ontario. Forest growth modelling and prediction; proceedings of the IUFRO conference August 23-27, 1987, Minneapolis, Minnesota. United States Forest Service, General Technical Report NC-120 (1): 386-393

Räsänen, P. K. 1988. Regeneration modelling and its management applications. Forest growth modelling and prediction; proceedings of the IUFRO conference August 23-27, 1987, Minneapolis, Minnesota. United States Forest Service, General Technical Report NC-120 (1): 394-401

Simon, H. A. 1981. The Sciences of the Artificial. Second edition. The MIT Press, Cambridge, Mass.; London, England. Third printing, 1984. 247 s.

Simon, H. A. 1990. Prediction and prescription in system modelling. Operations Research 38 (1): 7-14.

Veikko Koski
Professor
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 490
Fax +358-0-857 05 711

SPECIES AND PROVENANCE TRIALS IN RUOTSINKYLÄ RESEARCH AREA

The Finnish Forest Research Institute has an own network of research areas and protected areas, with a total area of ca 140 000 hectares. These areas are located in various parts of the country, the largest units are in northern Finland. Ruotsinkylä is one of the oldest research areas, established 1923. The total land area is to day 950 ha, and in addition there are close to 300 ha of water bodies. Because of its vicinity to the central unit of FRI and the city of Helsinki Ruotsinkylä is a very important site of experimental studies.

The first tree breeding station in Finland was built at Ruotsinkylä 1949. Grafting of plus trees for seed orchards and clonal archives was the first activity. Controlled crossings, handling of seed, raising of seedlings for progeny tests and operating the country wide field test activity were done in large volumes. Later on those practical phases were gradually moved elsewhere, and Ruotsinkylä was mainly devoted to research on forest genetics. Recently the field of the station has been widened to other kinds of ecological studies as well. In particular, experiments and observations on the response of trees to environmental changes are going on.

Trials of exotic tree species and provenance's are characteristic of Ruotsinkylä research area, as well as of other old research areas of FRI. The number of native tree species in Finland is quite low, about 20 only. Out of these *Pinus sylvestris, Picea abies, Betula pendula* and B. *pubescens* are commercially important. It has been supposed that this scarcity is still a consequence of the latest glaciation, after which the time has been too short to the return of species. Since the 18th century foreign species and origins have been transferred to Finland. The most comprehensive efforts were carried out during the former part of this century. From that period we also have a large number of trials in Ruotsinkylä research area. There are some 50 conifer species and around 30 broad leaved ones. Most of those experiments were planted around 1930 so that the trees are now close to 70 years old. The experimental design of that time did not include blocks and randomization within each plot, but fortunately most trials have replications at several sites.

The main result from species trials is quite obvious. There are very few exotic species that compete with the native ones in productivity. *Larix sibirica, Pinus contorta latifolia* and *Pseudotsuga menziesii perform* well on suitable sites. Even in these cases the origin (seed source) must be adequate. Several other species are suitable for ornamental purposes. It is also very apparent that the differences among species are large. some species tolerate long transfers some others do not.

Provenance trials were originally established in order to find out the most productive seed origin for commercial plantations. As regards native species a local, broad sense, for *Pinus sylvestris* and somewhat more southern for *Picea abies* is recommended in South Finland (Heikinheimo 1949). For lodgepole pine and Douglas fir the continental parts of British Columbia are most suitable.

Ten, fifteen years ago it looked like the old species and provenance trials had done their duty and they would stay only as monuments of initial stages of forest research. In recent years, however, they have got a new purpose. As soon as predictions of climate change were published, many people, even scientists postulated that climate warming would cause large scale damage and death in boreal coniferous forests. Numerous transplantation experiments with forest trees undeniably display considerable tolerance to climate change, especially if the transfer is towards milder climate. The Finnish provenance trials of Scots pine and Norway spruce have been reanalyzed in order to quantify the response of trees to climate change. The method is based on the fact that the same entries have been planted at several test sites with various climates. When plotting the performance values against the difference between the original site and test sites we get response curves and with pooled data response surfaces (Beuker and Koski 1992, Beuker 1994).

The longest transfers from North Finland to the southern coast mean 4 - 5 degrees difference in the annual mean temperature, which equals the most probable temperature rise in 50 years. The northernmost origins of spruce responded quite strongly. Their total production in 60 years has been roughly two times higher. Still their growth rate is lower than that of southern origins at the same site. Southern origins seem to respond more slightly to warmer climate. It is necessary to point out that also the light climate in South Finland, the photoperiodic pattern above all, is very different from that in Lapland. Thus, the production figures must not be applied as such to all cases. The main message, however, is that trees are flexible and able to acclimatize to slight climate change.

The acclimatization studies are a nice example of the irreplaceable value of old, properly managed field trials. Computer simulations and short time experiments in manipulated environments may lead to pessimistic forecasts. Vigorous trees are, however, a strong argument of the adaptability within certain limits.

References:

Heikinheimo, O. 1949. Results of experiments of the geographical races of spruce and pine. Commun. Inst. For. Fenn. 37.2:1-44.

Beuker, E. and Koski, V. 1992. Physiological and genetical adaptation of forest trees to climatic changes. In: Kanninen, M. and Anttila, P. (Ed.) The Finnish Research Programme on Climate Change, Progress Report, Publications of the Academy of Finland 3/92

Beuker, E. 1994. Long-term effects of temperature on wood production of Pinus sylvestris L. and Picea abies (L.) Karst. in old provenance experiments. Scand. J. For. Res. 9:34-45.

Ilari Lumme
Research Scientist
Finnish Forest Research Institute,
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 564
Fax +358-0-857 05 569

DEPOSITION LOAD OF AIR POLLUTANTS AND FOREST VITALITY IN SCOTS PINE (*PINUS SYLVESTRIS* L.) STANDS IN S.-E. FINLAND AND THE KARELIAN ISTHMUS, RUSSIA

Air pollutants, such as sulphur and nitrogen are a risk to forest vitality. In recent years, as progress is made in reducing emissions in Central Europe, Scandinavia and Finland, emissions from urban and rural areas of North-western Russia and of Estonia have gai-ned importance in terms of air quality in South-eastern and Eastern Finland. In 1991, the Finnish Forest Research Institute and the North-western Forestry Enterprise "Lesprojekt" based in the city of St. Petersburg initiated a joint Finnish-Russian project in order to determine the deposition load of air pollutants as well as to assess forest vitality in Scots pine (*Pinus sylvestris* L.) stands in the Karelian Isthmus, (Leningrad region) Russia, and S.-E. Finland. The project is carried out during 1991-1996.

The aim of this project is to determine an air pollution gradient between S.-E. Finland and the considerable emission sources located in St. Petersburg, in the Leningrad region and in Estonia and to study the effects of air pollution on forests. A total of 15 experimental plots were established in Scots pine stands (age 50-90 years) in semi-dry or dry heath forests with a podzolized soil profile. The experimental plots are located according to a gradient line approach, i.e. the Scots pine stands are situated along the assumed air pollution gradients.

Air pollution load in the monitoring area is studied by measuring and analysing bulk precipitation, stand throughfall as well as soil water using rainwater collectors and percolation lysimeters. Furthermore, forest vitality is assessed by several indicators, such as Scots pine needle element content, condition of needle surface waxes, occurrence of cell and tissue injuries in the needles, carbon isotope (^{12}C and ^{13}C) content in the trunk wood and fine root dynamics. In addition, needle loss as well as entomological and pathological assessments are carried out in the project.

The research is carried out in cooperation with the University of Joensuu, the Kymi Board of Waters and the Environment, the Finnish Meteorological Institute, the Komarov Botanical Institute of the Russian Academy of

Science (St. Petersburg) and the North Central Experiment Station, USDA Forest Service (Michigan, USA).

Bulk precipitation and throughfall studies revealed relatively high sulphur, ammonium-N and nitrate-N loads near St. Petersburg and in the southern part of S.-E. Finland. However, the high Ca and Mg concentrations detected in the deposition alleviate the acidifying effect of sulphur and nitrogen. The Scots pine canopies acted as a sink for ammonium and nitrate, while they increased the sulphur, calcium, magnesium and hydrogen ion deposition in the stand. The soil buffer system obviously neutralized a large proportion of the acidifying load entering the soil at depths of 5 and 20 cm. However, Ca and S were lost from the top soil via leaching.

Foliar S, N and Ca concentrations in the two youngest needle age classes correlated positively with the corresponding deposition load. However, low magnesium concentrations were detected in the foliage of the Scots pine stands in the vicinity of St. Petersburg. According to the preliminary results there was a positive correlation between the deposition load and the amount of damaged or altered surface wax structure in the Scots pine needles.

Needle loss and entomological assessments showed that the Scots pine stands were more damaged in the Karelian Isthmus, Russia, than in S.-E. Finland. However, the effect of air pollutants on forest vitality still remains uncertain at this phase of the study as there is a considerable difference in the stand structure between Russia and Finland; in contrast to the Finnish area no silvicultural measures have been applied in Russia. Thus, the Scots pine stands in the Russian area contain a large number of dying or severely damaged trees due to intraspecies competition.

Annex 1

FINNISH-CANADIAN FORESTRY SEMINAR, MAY 16-18, 1994
GUSTAVELUND, TUUSULA, FINLAND

MEETING PROTOCOL

As a formal basis for cooperation between Canada and Finland, a Memorandum of Understanding was signed on May 29, 1992. The Memorandum of Understanding lists a number of areas of cooperation of special interest to both countries but cooperation need not be limited to those. Also mechanisms of cooperation are mentioned in the Memorandum, among them joint seminars.

As a part of the above mentioned cooperation, a Seminar dealing with forest science and technology matters was organised in Tuusula, Finland, on May 16-18, 1994. The head of the Canadian delegation was Mr. Lorne Riley from Canadian Forest Service Headquarters. Mr. Jan Heino from the Ministry of Agriculture and Forestry of Finland acted as head of the Finnish delegation and opened the Seminar.

It was decided to divide the chairmanship of the Seminar between the two countries. Prof. Eero Paavilainen from Finland was the chairman for the first day of the Seminar, Mr. Lorne Riley from Canada for the second day, and Mr. Jan Heino for the closing session on the third day.

The attached Programme was accepted as the Agenda and timetable of the Seminar. In total 13 persons from Canada and 24 persons from Finland participated in the meeting. The list of participants is also attached as Annex II.

In each of the Special Discussion Topics Canadian and Finnish viewpoints were exchanged and updates were given on current program activities in each country, to aid in identifying areas of common interest for future collaboration.

In keeping with the spirit and intent of the aforementioned MoU and with the views arising from the seminar discussions, the heads of the Finnish and Canadian delegations have jointly agreed that their respective parent agencies should:

1. further develop and promote the following special areas of future collaboration between Finland and Canada:

- exchange of information and development of new methods for measuring forest resources and biodiversity; monitoring forest health; and planning for sustainable forest development
- cooperation in developing decision support systems for forestry
- cooperation in research on carbon and nutrient cycles and on climatic change impacts
- exchange of specialists on practical forestry and research

2. establish a small Steering Group to facilitate cooperation in forest science and technology between the two countries, the Steering Group to be limited to a maximum of three persons from each country.

3. establish a regular mechanism for financing bilateral cooperation between the two countries, providing special funding amounting to CAD 11 000 / FIM 40 000 annually for a minimum period of 3 years.

4. convene a further meeting, to be held in Canada before the end of 1994, to continue the current dialogue. The purpose of the meeting would be to elaborate further the topics proposed with a view to developing firm proposals for collaboration in forest science and technology.

In addition to the foregoing, it was agreed that, to promote potential collaboration in the fields of small-scale forestry and forestry / wildlife interactions, each country would identify initial contact persons for the two named areas, and that the individuals so named should explore such potential collaboration as may be appropriate.

Finally, the Finnish delegation noted the invitation extended by the Canadian delegation for Finland to join the growing international network of Model Forests based on the Canadian model and thanked the Canadian delegation for its consideration of potential Finnish interests in this area.

Additionally to the discussions, a visit to the Finnish Forest and Park Service, organised especially for the Canadian guests, took place on Tuesday, May 17. The Seminar ended with an excursion to the Field Station of the Finnish Forest Research Institute in Ruotsinkylä.

In Gustavelund, Tuusula, Finland, on May 18, 1994

Lorne Riley Head of the Canadian Delegation	Jan Heino Head of the Finnish Delegation

Annex 2

MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENT OF FORESTRY OF CANADA AND THE MINISTRY OF AGRICULTURE AND FORESTRY OF FINLAND ON COOPERATION IN FORESTRY

1. PARTIES

This Memorandum of Understanding is entered into between the Department of Forestry of Canada and the Ministry of Agriculture and Forestry of Finland.

2. Purpose

Whereas the Government of Canada and the Government of Finland have agreed to strengthen science and technology cooperation between Canada and Finland by an exchange of letters of intent on the 28th day of May in 1990, the purpose of this memorandum of Understanding is to foster cooperative efforts in the field of forestry, and to promote certain mechanisms further identified in paragraph 5 to enhance such coopertion.

3. Background

Canada and Finland derive significant economic, social and environmental benefits from their forests which are situated in geographic areas with similar ecological conditions. Consequently, many of the technological challenges and opportunities related to the management and utilization of the forest resource are common to both countries.

This Memorandum of Understanding recognizes and fully supports the ongoing informal forestry cooperation already existing between the two countries, both in the public and private sector.

4. Areas of Cooperation

Areas of cooperation of specific interest to both countries may include but need not be limited to:

(a) forest inventory, yield and remote sensing;
(b) forest management planning and planning systems;
(c) silviculture methods;
(d) seed improvement and nursery production;
(e) forest tree breeding and biotechnology;

(f) mechanical site preparation, planting, thinning, and harvesting;
(g) soil drainage and peatland management;
(h) environmental influences on the forest and forest protection;
(i) multiple uses and sustainable development of forests;
(j) joint ownership of forest lands;
(k) wood utilization;
(l) economics of forestry, the forest industry and the forest products market; and,
(m) taxation.

5. Mechanisms of cooperation

To further improve the already existing cooperation, both PARTIES will give special attention and support to a number of specific mechanisms of cooperation, including;

(a) study tours;
(b) seminars; and,
(c) professional exchanges.

Furthermore, both PARTIES will identify mutually essential problems within areas enumerated under paragraph 4 above and establish joint project teams to study such problems.

6. Implementation

In order to commence cooperation under this Memorandum of Understanding, an executing agency may be designated by each PARTY to take care of the practical management of the cooperation. One or more meetings of executing agencies experts from both countries may be organized by mutual agreement to better define areas of common interest, to develop a mechanism by which this Memorandum of Understanding will be managed and to prepare a program of implementation.

The PARTIES may discuss and decide upon the mutual exhange of study groups, the organization of seminars the selection of individuals for professional exchanges and the estavlishment of project teams.

The executing agencies will assist each other in the communication and sharing of information. The PARTIES will attend to, that appropriate funds and personnel are available each year to support the scientific and technological exhanges provided for under the mutually agreed program of implementation. A report will be prepared from time to time by the two PARTIES in order to report on work carried out pursuant to this Memorandum of Understanding.

7. Expenses

Unless otherwise provided, delegations and individuals visiting either country in accordance with this Memorandum of Understanding will be responsible for their own expenses. However, efforts will be made by both PARTIES to support professional exchanges by providing work facilities, allowances and other financial support where applicable.

8. Intellectual Property Rights

Should joint research project arrangements be established under this Memorandum of Understanding, then such arrangements will provide for the disposition of any intellectual property that might arise from such arrangements.

9. Effective Date

This Memorandum of Understanding will enter into effect upon signature by both parties and will remain in effect unless terminated by either PARTY upon nimety (90) days written notice to the other PARTY. Both PARTIES agree to review this Memorandum of Understanding five (5) years after its coming into effect. It may be modified at any time by mutual written agreement.

Done in Vancouver this 29th day of May 1992 in duplicate. The English, Finnish and French language versions being equally authentic.

For the Department of Forestry of Canada	For the Ministry of Agriculture and Forestry of Finland
________________________	________________________
The Honourable Frank Oberle Minister of Forestry	His Excellency Martti Pura Minister of Agriculture and Forestry

Annex 3

FINNISH CANADIAN FORESTRY SEMINAR, MAY 16-18. 1994
GUSTAVELUND, TUUSULA, FINLAND

LIST OF PARTICIPANTS

CANADA

Lorne F. Riley
Coordinator Criteria & Indicators
Canadian Forest Service (CFS)
Ottawa, Canada K1A 1G5
Tel. (819) 997-1107
Fax (819) 997-7022

Ian D. Thompson
Research Scientist
CFS, Petawawa National Forestry Institute
P.O. Box 2000, Chalk River, Ontario
Canada, K0J 1J0
Tel. (613) 589-3046
Fax (613) 589-2275

Ariane Plourde
Research Project Leader
Canadian Forest Service, Quebec Region
P.O. Box 3800, Ste-Foy, Quebec
Canada G1V 4C7
Tel. (418) 648-7616
Fax (418) 648-5849

Kevin E. Percy
Research Scientist
CFS, Maritimes Forestry Centre
P.O. Box 4000, Fredericton, N.B.
Canada E3B 5P7
Tel. (506) 452-3524
Fax (506) 452-3525

Denis Lachance
Research Project Leader
Canadian Forest Service, Quebec Region
P.O. Box 3800, Ste-Foy, Quebec
Canada G1V 4C7
Tel. (418) 648-3932
Fax (418) 648-5849

Stephen C. Zoltai
Research Scientist
CFS, Northern Forestry Center
5320 - 122nd Street, Edmonton, Alberta
Canada T6H 3S5
Tel. (403) 435-7210
Fax (403) 435-7359

Neil Foster
Research Scientist
CFS, Great Lakes Forestry Centre
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700

Richard Fleming
Research Scientist
CFS, Forest Pest Management Institute
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700

Edgar Robichaud
Associate Professor, Soils and Ecology
École de Sciences Forestières
Centre Universitaire St-Louis Maillet
165, Boul. Hébert, Edmundston, N.B.
Canada E3V 2S8
Tel. (506) 737-5249
Fax (506) 737-5373

Richard A. Sims
Research Scientist
CFS, Great Lakes Forestry Centre
P.O. Box 490, Sault Ste Marie, Ontario
Canada P6A 5M7
Tel. (705) 949-9461
Fax (705) 759-5700
email: rsims@fcor.glfc.forest

John Nelson
Associate Professor, Forest Operations
Univ. of British Columbia, Fac. of Forestry
Vancouver, B.C., Canada V6T 1Z4
Tel. (604) 822-3902
Fax (604) 822-9106

Ted Needham
University of New Brunswick
Faculty of Forestry and Env. Management
P.O. Box 4400, Fredericton, N.B.
Canada E3B 5A3
Tel. (506) 453-4506
Fax (506) 453-3538

Michael Power
Project Leader, Pest Management Systems
CFS, Petawawa National Forestry Institute
P.O. Box 2000, Chalk River, Ontario
Canada K0J 1J0
Tel. (613) 589-3008
Fax (613) 589-2275

FINLAND

Jan Heino
Deputy Director General
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki, Finland
Tel. +358-0-160 2418
Fax +358-0-160 5078

Eero Paavilainen
Research Director
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa
Tel. +358-0-857 05 470
Fax +358-0-857 05 569

Erkki Tomppo
Professor, Head of National For. Inven.
Finnish Forest Research Institute
Unioninkatu 40 A
FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 340
Fax +358-0-625 308

Antti Reinikainen
Research Scientist
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 423
Fax +358-0-857 05 569

Risto Päivinen
Deputy Director
European Forest Institute
P.O. Box 333, FIN-80101 Joensuu, Finland
Tel. +358-73-124 395
Fax +358-73-124 393

Rauno Väisänen
Head of Research Unit
Nat. Board of Waters and the Environment
Nature Conservation Research Unit
P.O. Box 250, FIN-00101 Helsinki, Finland
Tel. +358-0-695 1705
Fax +358-0-695 1733

Jari Parviainen
Research Director
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 220
Fax +358-0-857 05 361

Raimo Koskinen
United Paper Mills Ltd, Forest Department
P.O. Box 32
FIN-37601 Valkeakoski, Finland
Tel. +358-37-713 810
Fax +358-37-571 3839

Pekka Patosaari
Director
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki, Finland
Tel. +358-0-160 3353
Fax +358-0-160 2400

Henry Schneider
Helsingfors Skogsnämnd
Österviksgatan 22 A
FIN-00210 Helsingfors, Finland
Tel. +358-0-672 011
Fax +358-0-672 265

Hannu Saarenmaa
Chief Scientist
Finnish Forest Research Institute
Unioninkatu 40 A
FIN-00170 Helsinki, Finland
Tel. +358-0-857 051
Fax +358-0-625 308
email: hannu.saarenmaa@metla.fi

Urpo Nikunen
M.Sc (For.), Head of Department
Forestry Centre TAPIO
Maistraatinportti 4 A
FIN-00240 Helsinki, Finland
Tel. +358-0-156 2401
Fax +358-0-156 2232

Simo Kaila
Senior Research Officer
Metsäteho, R & D Department of
Finnish Forest Industries Federation
P.O. Box 194, FIN-00131 Helsinki, Finland
Tel. +358-0-132 521
Fax +358-0-659 202

Eljas Pohtila
Director General
Finnish Forest Research Institute
Unioninkatu 40 A
FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 210
Fax +358-0-625 308

Anne Ahti
Secretary of International Affairs
Finnish Forest Research Institute
Unioninkatu 40 A
FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 207
Fax +358-0-625 308

Erkki Alalammi
Metsäteho, R & D Department of Finnish
Forest Industries Federation
P.O. Box 194, FIN-00131 Helsinki, Finland
Tel. +358-0-132 5220
Fax +358-0-659 202

Erkki Länsisyrjä
Deputy Director
Lännen Tehtaat Oy
PL 170, FIN-27821 Iso-Vimma, Finland
Tel. +358-38-3974730
Fax +358-38-397422

Juhani Päivänen
Professor, Peatland Forestry
University of Helsinki
P.O. Box 24
FIN-00014 Helsinki University, Finland
Tel. +358-0-191 7680
Fax +358-0-191 7605

Lauri Valsta
Dr. For., Research Specialist
Finnish Forest Research Institute
Unioninkatu 40 A
FIN-00170 Helsinki, Finland
Tel. +358-0-857 05 242
Fax +358-0-625 308

Ari Nikula
Research Scientist
Finnish Forest Research Institute
Rovaniemi Research Station
P.O. Box 16, FIN-96301 Rovaniemi,
Finland
Tel. +358-60-336 411
Fax +358-60-33 64 640

Leena Halko
Forest Officer, Secretary of the Seminar
Ministry of Agriculture and Forestry
Department of Forest Policy
P.O. Box 232, FIN-00171 Helsinki, Finland
Tel. +358-0-160 2431
Fax +358-0-160 2400

Marja-Liisa Henritius
Secretary
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa
Tel. +358-0-857 05 471
Fax +358-0-857 05 569

Finnish Forest and Park Service

Eero Tilli
Director, Forestry
Finnish Forest and Park Service
P.O. Box 94, FIN-01301 Vantaa, Finland
Tel. +358-0-857 84 462
Fax +358-0-857 84 500

Kirsi-Marja Korhonen
Chief Inspector, Forestry
Finnish Forest and Park Service
P.O. Box 94, FIN-01301 Vantaa, Finland
Tel. +358-0-857 841
Fax +358-0-857 84 500

Matti Määttä
Project Coordinator
Finnish Forest and Park Service
P.O. Box 94, FIN-01301 Vantaa, Finland
Tel. +358-0-857 84 235
Fax +358-0-857 84 401

Liisa Nikula
Secretary of InternationalAffairs
Finnish Forest and Park Service
Corporate Communications Unit
P.O. Box 94, FIN-01301 Vantaa, Finland
Tel. +358-0-857 84 213
Fax +358-0-857 84 200

Ruotsinkylä Field Excursion

Veikko Koski
Professor
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 490
Fax +358-0-857 2575

Ilari Lumme
Research Scientist
Finnish Forest Research Institute
P.O. Box 18, FIN-01301 Vantaa, Finland
Tel. +358-0-857 05 564
Fax +358-0-857 2575

CONTENTS

3. DECISION SUPPORT SYSTEMS FOR FOREST MANAGEMENT - FOREST REGENERATION SYSTEMS

EXCURSION TO RUOTSINKYLÄ FIELD STATION

ANNEXES

Cover photograph: Jukka Lehtonen

ISBN 951-40-1378-6
ISSN 0358-4283