Northern Ontario Development Agreement (NODA) Northern Forestry Program: Status Report on Projects

D. Callaghan
Compiler

Natural Resources Canada
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ABSTRACT

This document reports on the status of over 140 projects funded under the Northern Ontario Development Agreement, Northern Forestry Program, and is a companion document to *Northern Ontario Development Agreement, Northern Forestry Program: Compendium of Projects* (NODA/NFP Technical Report TR-1) and *Compendium II* (NODA/NFP Technical Report TR-5). Information includes plot locations, plot layouts, sampling, design information, preliminary results, and an update on projected results. Projects cover a broad spectrum of sustainable forestry, including integrated management, silvicultural practices, forest protection, environmental impacts, planning and forest resource management, socioeconomic analysis, integrated resource management demonstration areas, and aboriginal forstry programming. Given the often lengthy time period (i.e., 4 to 5 years) between project start-up and the availability of results and reporting, these project descriptions will provide an update on progress and "premarket" anticipated results.

RÉSUMÉ

Le présent document rend compte de l'état de plus de 140 projets financés en vertu du Programme de foresterie du Nord découlant de l'Entente de développement du nord de l'Ontario et il complète les documents *Entente de développement du nord de l'Ontario, Programme de foresterie du Nord : Recueil des projets* (EDNO/PFN Rapport technique TR-1) et *Recueil II* (EDNO/PFN Rapport technique TR-5). L'information suivante y est présentée : lieu des parcelles, disposition des parcelles, échantillonnage, renseignements descriptifs, résultats préliminaires et mise à jour des résultats prévus. Les projets portent sur de nombreux domaines de la foresterie durable, notamment la gestion intégrée, les pratiques sylvicoles, la protection des forêts, les impacts environnementaux, la planification et la gestion des ressources forestières, l'analyse socio-économique, les zones de démonstration de la gestion intégrée des ressources et la programmation forestière sur les terres autochtones. Étant donné qu'il s'écoule souvent beaucoup de temps (de 4 à 5 ans) entre le démarrage d'un projet et la présentation des résultats, ces descriptions permettront de faire le point sur l'évolution des projets et sur les résultats prévus avant la publication.

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ACKNOWLEDGMENTS

An undertaking of the scope and magnitude of this publication is rarely the product of a sole, unassisted author. Contributions to this report have been made by a great number of people.

The initial draft of this report was prepared under contract by Ms. P. Dunning and coordinated by G. Richir. Editing was carried out and assistance provided by the NODA/NFP staff: namely, S. Alanen, C. Bell, D. Elliot, J.P. Gladu, R. Greet, H. Jääskeläinen, R. Macnaughton, R. Spadafora, and B. Sykes. Appreciation also goes out to the principal investigators, scientific authorities, and collaborators on the projects for providing project information and illustrations, and for answering numerous questions.

D. Callaghan
Development Officer

INTRODUCTION

OVERVIEW OF NODA/NFP

The Canada–Ontario Northern Ontario Development Agreement (NODA) is a 4-year, $95 million initiative funded equally by the Government of Canada and the Government of Ontario. This agreement, which includes forestry, tourism, and mining, has allocated $50 million to the Northern Forestry Program (NFP) to promote sustainable forestry.

The forests of northern Ontario support one of the largest forest products sectors in Canada, with production valued at $10 billion. The industry provides direct employment for over 80 000 workers and sustains the economy of more than 30 resource-based communities. The forest also provides the backdrop for a growing multimillion dollar tourist industry.

This agreement was implemented against a backdrop of shared environmental interest from both Canada and Ontario, and was designed to address the eight principles of federal–provincial programs accepted by the Canadian Council of Forest Ministers: namely,

- Long-term Planning
- Improved Forestry Data
- Responsibilities for Silviculture
- Integrated Resource Management
- Research, Development, and Technology Transfer
- Incrementality
- Public Awareness
- Human Resource Development.

More specifically, the objective of the NODA/NFP is to promote sustainable forestry development in northern Ontario by:

- undertaking programs of applied research and technology transfer that provide information in support of sustainable forestry in Ontario;
- providing improved capability to forest managers through improved decision-support systems, advanced silvicultural training, development of alternative forest management techniques, collection and publication of forestry information, and expanded economic analysis of the forest sector;
- supporting the economic development of aboriginal people through on-reserve forest management programs, access to off-reserve resources, and enhanced forestry training; and
- promoting broader understanding of the forest, the values it generates, and the contributions of Canada and Ontario to its sustainable use.

Projects have been funded in four program areas:

Sustainable Forestry Development ($32 million)

Aboriginal Forestry ($12 million)

Communications, Awareness and Education ($4 million)

Management and Evaluation ($2 million)

The Canadian Forest Service (CFS) and the Ontario Ministry of Natural Resources (OMNR) each deliver programs in the following areas.

Sustainable Forest Development

- Applied Research (CFS and OMNR)
- Technology Development and Transfer (CFS and OMNR)
- Decision Support (CFS)
- Socioeconomic Analysis (CFS)
- Integrated Resource Management Demonstration Areas (CFS)

Aboriginal Forestry

- Reserve Lands Forestry (CFS)
- Provincial and Agreement Lands Forestry (OMNR)
- Training and Education (OMNR)

Communications, Awareness, and Education

- Communications (CFS)
- Awareness (CFS and OMNR)
- Education (CFS and OMNR)

Management and Evaluation

- Management (CFS and OMNR)
- Evaluation (CFS and OMNR)

Almost 64 percent of the NFP funding has been allocated to research and technology transfer, and the CFS provides an opportunity for forest partners to submit proposals addressing sustainable forestry issues and research projects aimed at resolving them. The OMNR has utilized existing steering committees within the Science and Technology Units to identify research and development priorities and to develop, submit, and approve projects.

Joint working committees were established to coordinate CFS and OMNR research initiatives and to ensure consistency with the overall provincial strategy. This report provides updates on CFS-delivered projects. It is important to recognize that while these projects are funded by the CFS, networking at the project level ensures that the project builds upon the latest science and meets the needs of the forest manager.

While the NODA/NFP expired on March 31, 1995, two follow-up years will ensure that results are published, distributed, and transferred to users.

Purpose of the Status Report

This status report will provide an advance glimpse at the projects funded under the NODA/NFP agreement. Some of the projects that appear in this publication have been completed, many more have provided preliminary results, and all have made significant progress. It is hoped that the information provided on each project will create a sense of anticipation in the target audience for the final product delivery and also provide a basis for planning future initiatives, such that they build on the current state of research.

These project deliverables represent, in total, over $16 million worth of research and on-the-ground activity, which is designed to improve the sustainability of the forests of northern Ontario, and increase the stability of the communities that the resource supports. They cover a broad range of topics, including integrated management, silvicultural practices, forest protection, environmental impacts, planning and resource management, and socioeconomic analysis. They also provide resources and technical support to the First Nations across northern Ontario to enhance the sustainability of their forest lands.

This status report will give potential users information on what can be expected from the projects, what implications these results may have for their particular area of interest, and how appropriate they might be from an operational perspective. Readers seeking more project details than are presented in this document are encouraged to contact the CFS Publications Section for those technical notes, reports, et cetera that have been published to date. The address is located on the cataloguing page of this publication.

The use or mention of trade names or proprietary products does not imply endorsements by Natural Resources Canada or the Ontario Ministry of Natural Resources.

Integrated Management

Techniques for Sustaining Wildlife Populations in Managed Forest Land

Principal Investigator: D. Welsh, Canadian Wildlife Service, Ontario Region, Nepean, ON.
Scientific Authority: R.A. Lautenschlager, Ontario Forest Research Institute, OMNR, Sault Ste. Marie, ON.

The objective of this project is to model the relationship between habitat type and wildlife productivity. By measuring productivity in habitats of low, medium, and high abundance, the principal investigator is attempting to relate per capita productivity and survivorship to species abundance. Productivity data will be incorporated into a mathematical modeling approach (Population Viability Analysis) to predict the probability of a population surviving when it is subject to different habitat management options. The model will allow managers to evaluate management approaches, and assist them in predicting how, where, and when to harvest timber while still maintaining essential wildlife habitat.

Eight sites with different vegetation characteristics were chosen in June 1992 in the Rinker Lake study area to represent potential avian productivity gradients in areas not scheduled for harvest within the next 5 years (*see* NODA/NFP Project 4212, Page 109). Eight netting stations were established in each site to provide census data, and Forest Ecosystem Classification (FEC) types were determined for each station.

Two hunderd and ninety-three birds were banded in 1992, 348 new birds were banded in 1993, and a further 332 birds were banded in 1994. Thirty-one of the birds banded in 1992 returned to within 300 meters of the banding point, and 431 returned again in 1994. Similarly, 43 of the birds banded in 1993 returned in 1994.

Initial associations between FEC vegetation attributes and breeding success and abundance have been identified. Additional vegetation measurements surrounding each net site have allowed researchers to more accurately evaluate plant species and structural attributes that explain variation in bird species abundance and breeding success. These characteristics are being directly related to both FEC and Forest Resource Inventory (FRI) measures.

Although all 64 stations are distributed among the eight stands, each station is considered an independent measure of breeding success and abundance. Stations will be grouped depending on similarity of vegetation characteristics correlating with bird numbers. Tests of spatial autocorrelation between stations show less than 1 percent significant autocorrelation (Partial Mantels Test).

Results have been integrated into a Digital Elevation Model (DEM), being developed by the CFS–Sault Ste. Marie, of forest vegetation in the Rinker Lake area of northwestern Ontario (*see* NODA/NFP Project No. 4208, Page 107).

This GIS-based landscape model, using bird number indices and the landscape terrain model, is being developed to predict the amount and distribution of potential breeding habitat for forest birds in northwestern Ontario.

The principal investigator presented a paper based on this NODA/NFP project, entitled "*Density and productivity measures for evaluating habitat quality: Implications for forest wildlife management*", at the GIS '93 symposium in Vancouver.

Figure 4005.1. Researcher with a sharp shinned hawk. (Photo courtesy of Dr. Daniel A. Welsh.)

4045

Integrated Modelling of Moose Habitat and Population

Principal Investigator: P. Duinker, Lakehead University, Thunder Bayy, ON.
Scientific Authority: A. Rodgers, Centre for Northern Forest Ecosystem Research, OMNR, Thunder Bay, ON.

The objective of this project is to develop and test a preliminary set of integrated simulation models that will forecast potential effects of forest and moose population management. It will attempt to translate simulated effects on habitat to effects on populations. By building on past modeling efforts and making use of expertise and advice from Ontario biologists, the project will produce first-approximation models linking these effects.

The first phase of the project, a review of relevant literature, has been completed. This review will continue throughout the project to ensure that new, pertinent literature is also included.

Work is under way on model development and programming. Basic structure and linkages between a habitat model and population model have been developed by research teams. Reconstruction of the habitat model began in April 1994. Specifications and programming of the population model by ESSA Technologies Ltd., Richmond Hill, Ontario, is well under way. The population model will follow principles of life-table modeling, and the key link between the two models will be energetics.

A final report and two seminars on the development of the model and its potential use and one training session will be completed in spring/summer 1995. The models will be useful for guiding applied research and in preliminary exploration of the effects of long-term forest management plans on moose populations.

Figure 4045.1. This project is developing a set of models that will forecast the effects of forest and moose population management. (Photo courtesy of J-P. Gladu.)

Trade-off Analysis in Protecting Caribou in Multiple-use Forestry in Northwestern Ontario

Principal Investigator: G. Fox, University of Guelph, Guelph, ON.
Scientific Authority: H. Cumming, Lakehead University, Thunder Bay, ON.

This project is designed to address conflicts between timber management and caribou/moose habitat maintenance in northwestern Ontario through a case-study approach, and to provide an economic analysis of the various incentives created by alternative institutional frameworks.

Phase I of the study is nearing completion. Stakeholder interviews have been completed. An ongoing assessment of the various timber management guidelines has also been completed, and work has begun on Phase 2.

A paper entitled *Property rights in the development of Ontario forest tenures* was completed in June 1994. It provided an analysis of Ontario forest tenures based on their incentives for stewardship and efficiency in use. It also provides a history of the rules and regulations governing forest tenure from preconfederation times to the present.

The first section discusses the function and purpose of property rights. The essential characteristics are identified as exclusiveness, comprehensiveness, duration, and transferability. Each of these characteristics is found to be important in the creation of incentives for stewardship and efficiency.

The second and third sections provide an assessment of how well Ontario forest tenures have created incentives for stewardship and efficiency by granting or withholding property rights.

A second report, *Alternative models and methods for valuation of the caribou resource in northern Ontario*, has also been completed. A summary follows:

"Caribou are an unpriced resource. The economic analysis of the tradeoffs in protecting woodland caribou habitat requires that the value people place on caribou be estimated. Several synthetic approaches are available to estimate the value of unpriced resources. The travel–cost method uses the expenditure on travel to reach a recreational site as a type of proxy for the value placed on the site. Hedonic pricing models express market prices as a function of the characteristics of a good. Contingent valuation is an approach which uses polling methods to estimate willingness to pay. Shadow pricing uses the imputed opportunity cost of a resource decision as a measure of value.

There are difficulties in using these approaches with woodland caribou in northwestern Ontario. Since caribou are not currently a major tourist attraction, the travel–cost method is not an appropriate technique. Since there are not aspects of the caribou resource which are traded, hedonic pricing cannot be used. Contingent valuation requires that a representative sample of the population be familiar with the resource. This condition is not satisfied in the case of woodland caribou in northwestern Ontario. Shadow pricing can be used as a measure of the implicit value of woodland caribou. This is taken as the value of the benefits foregone under caribou management".

In addition to these two papers, in May 1995, this project resulted in a technical report summarizing procedures, findings, and recommendations. Workshops are also planned for resource managers in industry and government. Results will facilitate decision making in multiple use and integrated resource management in northwestern Ontario.

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A Market Segmentation Analysis of Desired Ecotourism Opportunities

Principal Investigators: D. Twynam and D. Robinson, Lakehead University, Thunder Bay, ON.

This project is intended to identify desired ecotourism opportunities of the latent ecotourism market for northern Ontario. It will also develop a visitor segmentation profile for marketing purposes.

A literature search was completed and information related to ecotourism and survey instrumentation was gathered. The survey instrument was developed, and membership lists have been acquired for Phase 1.

Phase 1 involves sampling 2 000 potential visitors who are associated with nature-oriented recreation organizations/groups, developing a questionnaire that specifically addresses desired ecotourism opportunities, and using multivariate analysis to generate socioeconomic segmentation.

The survey was pilot tested in February 1994, and mailed in March. It included questions about preferred activities, accommodation, time of year, sources of information, setting characteristics, experiences, and outcomes.

Phase 2 is designed to profile the desired opportunities of ecotourists who already visit northern Ontario by interviewing travelers coming into the region from U.S. border crossing points. Data analysis was completed by December 1994.

Researchers are looking at the possibility of combining results of the Butler/Boyd GIS database on ecotourism opportunities (*see* NODA/NFP Project No. 4053, page 9) with the results of this project, to see if the motivational preferences identified in this study can be linked to the physical attributes identified in the GIS study.

A report highlighting the U.S.A.–Canada intercept study, a workshop on project results, and a final report will be produced. A technical note, *A market analysis of desired ecotourism opportunities in northern Ontario,* (NODA Note No. 14) has already been completed and will be published.

Figure 4052.1. This project is identifying ecotourism opportunities in northern Ontario and developing a profile of potential visitors. (Photo courtesy of Dr. R. Sutton.)

Identifying Sites/Opportunities for Forest-based Ecotourism in Northern Ontario

Principal Investigators: R. Butler, S. Boyd, Butler and Boyd Associates, Strathroy, ON.

Phases I and II of this project have been completed. These included selecting criteria and developing a geographic information system (GIS)-based methodology for identifying northern Ontario sites suitable for forest-based ecotourism by using an existing Landsat forest cover classification. The study area covers 125 000 km^2 between Sault Ste. Marie and North Bay in northeastern Ontario.

A literature search and past experience revealed the following seven key attributes for successful ecotourism development.

- environmentally and socially responsible
- focused on elements of the natural environment
- managed in such a way as to have minimal environmental and social impacts
- nonconsumptive
- capable of providing desired economic benefits to local residents
- compatible with other resource uses in the area
- appropriate in scale for conditions and environment

The key criterion used for identifying potential ecotourism sites in northern Ontario was "naturalness". Other criteria considered were: wildlife attributes, cultural heritage sites, landscape features, and community characteristics.

A methodology was developed from features of each criteria that could be recorded using a GIS. Elements within a region were recorded as points (e.g., mills, mines), polygons (e.g., areas of clear-cut), or lines (e.g., rivers, logging roads.) Distance components involved with criteria were accommodated by placing buffers of a certain magnitude around features. For example, where noise might be a deterrent to ecotourism, a buffer of specific radius was placed around current activities with a noise component.

Naturalness was expressed in terms of seven attributes: namely, presence or absence of permanent settlement, biophysical (vegetation) characteristics, extent of resource-related activity, type of access, presence of wildlife, nature of recreational activity, and landscape characteristics. A value was assigned to the various aspects of each attribute, and an overall score and the type of naturalness was determined.

Phase III was completed in July 1994. Twenty-seven maps of the study area were examined to identify potential ecotourism sites. Preliminary data suggest that six potential Type I (high scoring) sites and 12 potential Type II (moderate scoring) sites exist in the study area.

During the summer of 1994, field interviews were undertaken in those areas identified as prime candidate sites to encourage community input about the potential for ecotourism development, and to gain information about criteria that could not be measured using GIS.

The final phases of the project will involve detailed site selection and field examination, and the development of guidelines for a comprehensive planning process for forest-based ecotourism in northern Ontario. This will be used by tourist operators, community leaders, and policy makers.

The project was presented to the annual meeting of the Canadian Association of Geographers in Waterloo, Ontario, and a paper summarizing the results of Phases I and II was presented to the Northeastern Recreation Research (NERR) Symposium in Saratoga Springs, NY.

Three NODA/NFP file reports have been completed: *Report 1: Review of the development of ecotourism with respect to identifying criteria for northern Ontario* (File Report 5); *Report 2: Geographic information systems: A tool for establishing parameters for ecotourism criteria* (File Report 6); and, *Report 3: GIS mapping of potential areas for ecotourism in northern Ontario* (File Report 7).

In addition, several NODA/NFP technical notes based upon the file reports will be published under the following titles:

Identifying criteria and establishing parameters for forest-based ecotourism in northern Ontario, Canada (NODA Note No. 7); *Mapping areas of suitability for forest-based ecotourism in northern Ontario using geographical information systems (GIS)* NODA Note No. 9; and *Building a sustainable world through tourism* (NODA Note No. 11, a report on the conference with the same name).

A technical report, *Development of an ecotourism opportunity spectrum for sites identified using GIS in northern Ontario* (NODA/NFP Technical Report TR-11), will also be published.

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Forest-based Ecotourism in Small Northwestern Ontario Communities—Panacea or Placebo

Principal Investigator: M. Wanlin, Boreal Ecosystems Associates Ltd., Thunder Bay, ON.

The objectives of this project are to identify opportunities for successful forest-based ecotourism by looking at three northwestern Ontario communities and their surrounding areas; to develop criteria for establishing successful ecotourism initiatives in northwestern Ontario; to identify the economic impact of ecotourism in existing or potential parks on the selected communities; and to illustrate how forest and park planning systems can support the development of ecotourism opportunities.

Opportunities, successes, and key ingredients in ecotourism were examined in three Ontario communities: Armstrong, Atikokan, and Rossport; and two U.S. communities: Bayfield, Wisconsin and Ely, Minnesota. Key general ingredients for success were identified as:

- positive community attitude
- strong community leadership and direction
- significant natural features managed for sustainable tourism use
- good marketing and promotion
- availability of a range of desirable tourism products
- adequate infrastructure to provide a combination of natural experiences and creature comforts
- assistance and support from government and non-government partners.

The following ingredients were identified as specific to ecotourism:

- an openness and readiness for tourism of this type
- understanding the ecotourism market
- ecotourism offerings
- interpretative material and experiences
- education
- combining outdoor adventures with creature comforts
- economic contribution by ecotourists to protection and sustainability
- standards of protection from users
- quality of the natural experience.

The project identified a number of actions that communities can take to support the planning and development of ecotourism. These included:

1. Establish a broad cross section of interests to lead the planning and development process.
2. Use community self-assessment to determine where government investment will yield the highest benefit.
3. The development of multistakeholder processes will be important to the development of ecotourism on crown and park lands.
4. Diversified communities require diversified planning, in keeping with the Ontario government's Policy Framework for Sustainable Forests.
5. The development of an information base about the economic impact of tourism is an area where government support and initiative is needed.
6. Unorganized communities, like Armstrong and Rossport, have no effective means of planning or acting in concert. Tourism development zones could be beneficial in such communities, as well as in areas adjacent to national or provincial parks.
7. A nongovernment wilderness tourism industry association would be a valuable support for ecotourism development.
8. Senior government research support would contribute to maximize benefits from ecotourism.

In its simplest form, a community is ready to develop ecotourism:

1. when the community has the desire to move in that direction, and
2. when the natural, historical, or cultural features are significant enough to attract people from a considerable distance.

The project has been completed and the results are presented in NODA/NFP File Report No. 1, *Forest-based ecotourism in small NWO communities: Panacea or placebo*, and in NODA Note No. 2, *Ecotourism: A community-based approach to the challenge*. The results of this project were also presented in community workshops in each of the participating communities.

Table 4054.1. Comparison of tourism employment with other important industrial sectors in some northern Ontario communities.

Community	Population	Labor force	Accommodation, food, and beverage service (%)	Forestry/ mining (%)	Manufacturing (%)
Atikokan	4 047	2 045	12.0	9.4	16.5
Blind River	3 355	1 490	8.4	15.4	6.4
Bruce Mines	684	305	8.2	14.8	16.4
Fort Frances	8 891	4 570	7.5	5.7	15.8
Gore Bay	916	400	15.0	-	7.5
Huntsville	14 997	7 640	13.8	> 1	11.5
Kearney	734	280	10.7	-	21.0
Kenora	9 782	5 130	10.6	1.7	10.6
Mattawa	2 454	1 105	11.8	7.7	17.2
Ontario	10 048 885	5 511 235	5.9	> 1	17.1
Parry Sound	6 125	3 015	9.3	> 1	4.5
Red Lake	2 268	1 255	10.4	18.7	1.1
Temagami	939	450	6.7	8.8	3.3

4055

Innovative Ecotourism at the Boreal Edge

Principal Investigator: A. Salmoni, Laurentian University, Sudbury, ON.

The objective of this project is to develop innovative ecotourism techniques that will encourage active learning about forest ecosystems and about the impact of forest management practices on those ecosystems.

Information, gathered by personal and telephone interviews and by written questionnaires, revealed perceived barriers to full participation in forest-based active learning experiences, particularly among older adults and families with young children. Sites were identified along the existing Deer Trail tour route, between Iron Bridge and Elliot Lake, that demonstrate a range of forest management techniques, are of interest from an ecology/wildlife point of view, and are easily accessible to the target groups.

Interim project reports, *Innovative ecotourism at the boreal edge: Ecological assessment report* and *Innovative ecotourism at the boreal edge: Ecotourist survey*, have been completed. As well, the final report, *Ecotourism at the boreal edge* (NODA/NFP Technical Report TR-9), will be published.

Ecological Assessment

Each site was evaluated on the basis of:

1. visual appeal, taking into account forest, dome peaks, hills, color contrasts, rocks, water, road, bare areas, and clear-cuts;
2. general attributes, including wildness, learning potential, rest and comfort capabilities, nature trails, interpreataive aspects, overall interest, and parking area;
3. fitness/recreation potential for picnic area, short and long hiking trails, beach area, Nordic skiing, and canoeing; and,
4. educational potential, as gauged by presence of old growth, selective harvesting, clear-cuts, artificial regeneration, interesting geology, botanical features, and ornithological aspects.

Based on accessibility and ecological interest, 18 sites were ranked. Six of these were determined to merit further development as active learning locations.

Ecotourist Survey

The survey was designed to discover the needs of ecotourists at the forest management sites and to determine what would attract them to such sites. For example, it was found that individuals were often attracted to old growth. Therefore, the first in a series of educational sites should offer such characteristics. Second, once at the site, certain educational, recreational, and general needs must be met. Therefore, the site must do more than simply possess a diversity of management characteristics. It must also have certain biological, physical, and topological potentials. The ideal site is one that matches educational potential with tourist needs.

In addition to the report on selected sites, and a report on forest-based active learning techniques for seniors and families with young children, the researchers will present findings at a related conference or workshop.

Developing Analytical Procedures for Establishing the Level of Protection for Forest Fire Management to Support Sustainable Forestry in Ontario

Principal Investigator: David L. Martell, Faculty of Forestry, University of Toronto, Toronto, ON.
Scientific Authority: F.M. Dunn, Aviation, Flood, and Fire Management, OMNR, Sault Ste. Marie, ON.

The objectives of this project are to: improve the degree of understanding of the relationship between forest and fire management within the forestry community; develop a widely understood and acceptable means of selecting the level of protection for fire and forest management programs; develop the means to integrate decisions on the required level of protection in forest management planning; and develop analytical procedures that facilitate the allocation of resources between components of the fire management program, and that are compatible with forest management objectives.

In 1993, a discussion paper describing some of these issues, and outlining some approaches for determining level of fire protection, was prepared to serve as a basis for discussion by fire and forest management experts. Issues included fire and forest management, values that are subject to impact by fire, timber production, spatial features, biodiversity and disturbances, objectives and constraints, aboriginal communities, and forest management information systems.

A modeling framework for a Level of Protection Decision Support System was developed. Project investigators conducted a Level of Fire Protection Workshop for OMNR staff in Sault Ste. Marie, 21–22 September 1993.

The development of the LANIK Level of Protection Decision Support System was completed during 1994. LANIK, a computer-based decision support system, is designed to help resolve fire protection decisions. Its major components include a database management system designed to handle both historical data, data that describes the predicted performance of new strategies, and other model management software that make it relatively easy for fire managers and planners to develop and evaluate strategies.

This project was completed in June 1994 and the resulting discussion paper will be published.

4220

Predicting Canopy Closure for Habitat Modelling

Principal Investigator: A. Aldred, Dendron Resource Surveys Inc., Ottawa, ON.
Scientific Authority: T.J. Lynham, NRCan, Sault Ste. Marie, ON.

The purpose of this project is to develop quantitative models that estimate crown cover density of forest stands from available data in the Ontario Ministry of Natural Resources Forest Resource Inventory (FRI) information system. Models were developed and tested on two areas: six townships in Algonquin Provincial Park and the Shining Tree Crown Management Unit in the Gogoma District. The Algonquin test area consisted of a total of 4 540 stands; 300 stands made up the data set for Gogoma.

The testing included the potential role of FRI working group and stand variables, such as stocking, height, volume, site class, and age. The possible influence of geographic location and the photo interpreter who carried out the original FRI classification were also analyzed.

Models have been developed that utilize FRI stocking, and optionally, age, stand height, and site class to estimate crown cover density. Separate models are needed for each working group, geographic area, and photo interpreter who carried out the original FRI classification. The models tested estimated crown cover density with a reliability of approximately ± 10 percent two-thirds of the time.

Stocking by working group provided the strongest estimates of crown cover density; age, stand height, and site class added slightly to the predictive power of some of the equations. Both the geographic location and the original interpreter were found to have an important bearing on the equation coefficients.

This project has been completed and the final report entitled, *Predicting canopy closure for habitat modelling* (NODA/NFP Technical Report TR-13), will be published. This report includes a set of equations for predicting canopy closure (expressed by crown-cover density) by working group, for the two test areas. It also includes statistics on the accuracy of the models and recommendations on how to apply them in habitat supply projections. The models will enable forest managers to better evaluate habitat supply and predict the impacts of forest management practices and interventions.

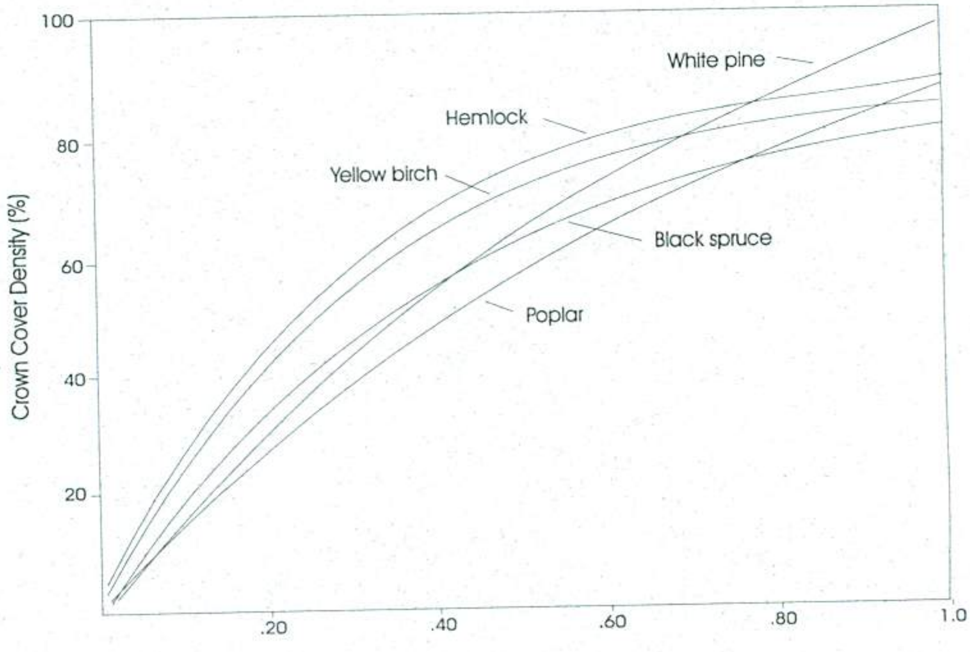

Figure 4220.1. Crown-cover density on stocking equations for five working groups in the Algonquin Provincial Park test area. (Figure courtesy of Dendron Resource Surveys Ltd.)

Integration of New Technologies for Deer Yard Assessment

Principal Investigator: A. Aldred, Dendron Resource Surveys Inc., Ottawa, ON.
Scientific Authority: D. Voigt, OMNR, Maple, ON.

This project will develop a decision support system for deer yards that integrates dynamic habitat supply and population simulation models. The project consists of two activities:

1) mapping conifer cover to identify suitable candidate deer yards using a Landsat 5 thematic mapper or Système Probatoire d'Observation de la Terre (SPOT) panchromatic imagery in conjunction with digitized Forest Resource Inventory (FRI) maps and data; and
2) collecting detailed data on tree species, crown cover density, crown spacing (cover, browse area, accessible area), carrying capacity, and current deer population.

A test area, which covered part of the Loring Deer Yard, was used to develop a geographically based, multistage design for the collection and analysis of habitat data. The FRI digital map data was used to provide a geographic foundation for the project, and a base on which to register the satellite image data and detailed data from the large-scale photos and field observatons. The FRI stand data and available deer population data were used to select areas for more detailed photo and field sampling. This detailed data will be used to both "train" the satellite image data classifier and, later, to test their effectiveness. The field data will be used to support the large-scale photo analysis and provide browse concentrations and additional deer population data.

During 1994, work maps were prepared for the selection of stands for detailed analysis. A method developed earlier was used to map the density of deer tracks in the snow using a ground-based global positioning system (GPS). The GPS-generated data can be linked directly to the digital FRI spatial database and associated stand attribute database.

A large satellite image data classification system was acquired and installed, image data has been successfully registered to the digital FRI map base, and sites were selected for detailed analysis. Large-scale photo coverage of these sites was obtained and linked to the digital database. The selected FRI stands were transferred to and analyzed on large-scale photos to produce data on coniferous trees species, tree location, position of tree crowns, and spaces among the crowns. This information will be used to classify suitability of the stands for cover and browse and to assess the carrying capacity.

The report to be produced by this project will include a description of the methodology developed during the project, results of the tests, and recommendations for future user application. Maps, a database and analyzed statistics on suitable conifer cover for deer yards, and estimates of accessible area, browse area, and carrying capacity will be included.

Figure 4224.1. This project is developing a decision support system for deer yards that integrates dynamic habitat supply and population simulation models.

Silvicultural Practices

Competitiveness of Nutrient-loaded Seedlings on Vegetation-rich Boreal Mixedwood Sites

Principal Investigator: V. Timmer, Faculty of Forestry, University of Toronto, Toronto, ON.
Scientific Authority: I.K. Morrison, NRCan, Sault Ste Marie, ON.

Work to develop fertilization regimes for inducing steady-state nutrient loading in container seedlings, at North Gro Development near Kirkland Lake, has shown that exponentially based models are most appropriate. Six times the conventional dose of fertilizer resulted in relatively stable internal nutrient concentrations during the growing season, and confirmed that steady-state, nutrient loaded seedlings have higher nutrient reserves and greater resistance to cold stress and hardening treatment than do conventional seedlings.

Full scale trials were initiated near Iroquois Falls in 1992 to test mathematical models that would ensure exponential fertilizer delivery while incorporating some of the technical limitations common in nursery production. Programs were designed to facilitate calculation of fertilizer amounts, prevent toxicity development, and schedule application frequencies.

First-season (1992) results from the outplanting trial and in-the-pot bioassays from the same mixedwood site near Iroquois Falls confirmed that nutrient loaded seedlings outperformed conventional seedlings of similar preplant size under both weed and weed-free (herbicided) conditions. In terms of height increment, the loading response was equal to the herbicide response, suggesting that nutrient loading may compensate for the lack of vegetation control in early seedling performance on weedy sites. Chemical analysis of sample trees indicated that the response was associated with greater nutrient reserves in loaded seedlings. Tree biomass was significantly and negatively related to weed biomass, inferring that the loaded trees were better competitors on vegetation-rich sites.

Data compilation and statistical analysis of growth and nutritional responses revealed that loaded seedlings at the time of outplanting contained 28 percent more nitrogen, 40 percent more phosphorous, and 18 percent more potassium than conventionally fertilized seedlings. Comparisons of nutrient reserves in older tissues of loaded and conventionally fertilized seedlings after 18 weeks of growth in an outplanted environment showed that depletion was less in conventional seedlings despite their lower reserves at the time of planting. Researchers presume this reflects a nutrient conservation response. Since immediate productivity is reduced through storage, the loss in competitive advantage from short-term resource accumulation must be balanced by long-term persistence on infertile sites.

In comparison, loaded seedlings showed typical opportunistic traits of competitive plants where growth resources are directed toward current growth to capitalize on the environment at later stages. Nitrogen allocation to the current shoot among loaded seedlings was increased by 68 percent, phosphorous by 100 percent, and potassium by 74 percent over conventional seedlings in a weedy environment. Researchers believe that retranslocation of nitrogen to actively growing parts may increase nutrient-use efficiency by recycling protein nitrogen to supply the strong sink of new growth under conditions of limiting nutrient availability.

Second-season (1993) growth response indicated even larger responses from loading, thereby suggesting a possible compounding effect.

The project has now been completed and funding has been secured from Abitibi-Price Inc. and the OMNR's Vegetation Management Alternatives Program (VMAP) for support to continue monitoring the field trials.

A paper based on this research has been submitted to the Canadian Journal of Forestry, and the principal investigator was invited to present preliminary results at the National Integrated Forest Management Research Workshop, Sault Ste. Marie, 23–25 March 1994. This work also has been presented at the International Symposium on Planting Stock Performance and Quality Assessment "Making the Grade" held in Sault Ste. Marie in September 1994. A report, entitled *Manual for exponential nutrient loading of seedlings to improve outplanting performance on competitive forest sites*, has been submitted for publication.

4006

Regeneration of Black Spruce Cutovers Using Miniplugs

Principal Investigator: R. Booth, Domtar Inc., Red Rock, ON.
Scientific Authority: G. Hogan, NRCan, Sault Ste. Marie, ON.

This project is designed to determine the suitability of Techni-Culture® brand miniplugs for plantation establishment on a range of site types in northwestern Ontario. Comparative field trials and ecophysiological studies are being used.

Two stock types (miniplug and vent block container) are being compared through field trials on a range of upland site conditions commonly found in northwestern Ontario. The physiological condition of the stock types is being investigated at the time of outplanting, and changes in physiological response over the growing season in relation to soil water availability and light levels are being examined.

Site Suitability

Initial plot selection and establishment took place during the 1992 growing season. Collection of site data included: surface soil sample collection, vegetation index measurements, forest ecosystem classification (FEC) soil and vegetation type determination, LFH depth/forest humus form, site photos, and original stand species composition. Forty plots were established in the Lake Nipigon Forest in 1992; 49 were created in 1993.

For analytical purposes, certain FEC soil types have been combined to form four "soil groups" that represent the most common upland site conditions in northwestern Ontario. These groups are:

SS3	Very Shallow
SS5-SS6	Shallow Sandy and Coarse Loamy
S2-S3	Deep Sandy or Coarse Loamy
S4-S6	Deep Fine Loamy, Silty, or Clayey

Three levels of competition (nil to light, moderate, and heavy) are being analyzed for each soil group.

Fall assessments include total seedling height and root collar diameter for each tree in the experimental plots. Plots previously established by Domtar (40) between 1988 and 1991 are also being assessed annually.

Ecophysiological Characterization

Concurrent with the planting on the Lake Nipigon Forest, representative samples from the different stock types were planted in the greenhouse at the Great Lakes Forestry Centre and at a field site near Sault Ste. Marie. Measurements of seedling gas exchange; water potential, its pressure, and osmotic components; hydraulic conductance; root egress; leaf area; and stem development were made during the 1992 and 1993 growing seasons.

Physiological and growth response information is also being collected from selected Lake Nipigon Forest sites to provide a basis for interpreting first year growth and survival results, and to provide a link with more detailed physiological and growth responses measured under controlled conditions at Sault Ste. Marie.

A series of reports on the feasibility of using Techni-Culture® brand miniplugs will be prepared by June 1995, along with management guidelines for various northwestern Ontario Forest Ecosystem Classification soil and vegetation types. These will enable forest managers to determine the suitability of miniplugs for their particular areas.

Efficacy of Release Treatments on Regeneration Strategies of Major Competing Species of Northwestern Ontario

Principal Investigator: A. Mallik, Department of Biology, Lakehead University, Thunder Bay, ON.
Scientific Authority: W. Bell, Ontario Forest Research Institute, OMNR, Sault Ste. Marie, ON.

This project is designed to study the efficacy of three release treatments (the herbicide Vision®, the use of brush saws, and complete removal of competing vegetation) in relation to the regeneration strategies of the major competing (noncrop) species of northwestern Ontario, and to predict vegetational changes following release treatments based on the regeneration strategies of competing species. An understanding of the regeneration strategies of the competing species is a prerequisite to properly evaluate the responses of crop species to release treatments.

The study site is located in Block 164 of the Seine River Forest. The site was prepared with heavy drags in the fall of 1987, and jack pine (*Pinus banksiana* Lamb.) container stock was planted in 1988. The site was 81 percent stocked with jack pine and had heavy trembling aspen (*Populus tremuloides* Michx), pin cherry (*Prunus pennsylvanica* L.f.), beaked hazel (*Corylus cornuta* Marsh), green alder (*Alnus viridis* spp. *crispa* [Aiton] Turrill), and willow (*Salix* spp.) competition.

The regeneration study was carried out by collecting and analyzing data on species regeneration behavior through nondestructive and destructive sampling. In the nondestructive sampling, six 1-m transects were studied around each of five randomly selected jack pine seedlings. All plant species touching the transects at 10-cm intervals were recorded. Destructive sampling was employed by excavating plants to study vegetative regeneration strategies of the four competing species for pre- and first-year posttreatment.

Three conifer release treatments were applied in 1992 and 1993: brushsawing, aerial treatment of Vision® herbicide, complete removal treatment using aerial treatment of herbicide plus backpack application of Vision®. A control was also maintained. Treatment dates for Vision®, complete removal, and brushsaw treatments were August 1992, August 1993, and July 1993, respectively. Data collection was conducted in August 1992 and May–September 1993.

Preliminary Conclusions

All of the major competing species in northwestern Ontario (trembling aspen, green alder, beaked hazel, pin cherry, and red raspberry [*Rubus idaeus* L.]) regenerate mainly through vegetative methods, although they have different competitive strategies. Two types of competition strategies have been recognized: a horizontal competition strategy (HCS) and a vertical competition strategy (VCS). Green alder and beaked hazel compete vigorously with jack pine seedlings through HCS, while trembling aspen and pin cherry compete mainly for light with jack pine trees through VCS. With all the competing species present in the study site, the jack pine plantation encounters both types of competition before entering into a free-growing stage. Since vertical and horizontal competition are severe, there is a strong need to control hardwood competition and thereby release jack pine seedlings.

The sprouting ability of competing species was reduced markedly after herbicide application, but enhanced after manual cutting. The majority of competing species were very susceptible to herbicide; however, alder was quite resistant to glyphosate. High above- and below-ground biomass production of this plant has diluted the herbicide effects. Crop tree growth was enhanced notably after brushsaw cutting, but it is possible that high sprouting may cause a problem in the following years if all the sprouts are able to sustain their growth. It is likely that the jack pine in the herbicide-treated plots will be taller in the coming years as a result of the competition control.

At the conclusion of the project in December 1995, a field guide highlighting major findings and their implications for competition control will be produced.

4011

Low Cost, Antistress Antioxidants for Enhanced Growth and Stress Tolerance in Conifer Transplants

Principal Investigator: T.J. Blake, Faculty of Forestry, University of Toronto, Toronto, ON.
Scientific Authority: I.K. Morrison, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop techniques suitable for use by nurseries and greenhouses to harden seedlings and make them more competitive on harsh, northern boreal microsites. To meet this objective, the survival, vigor, and competitiveness of Ambiol®-treated coniferous seedlings is being compared to untreated seedlings, and the nature of the stress response induced by Ambiol® is being studied.

Work in Toronto analyzed growth of the genotypes under simulated drought using computer-controlled chambers.

Work is also continuing to define genetic markers for Ambiol® responsiveness by means of starch gel electrophoresis. The data on isozyme variability within 15 enzyme systems and the structure of genotypes of four black spruce families has already been analyzed. The enzyme systems are: alcohol dehydrogenase, aldolase, aspartataminotransferase, catalase, esterase, fumarase, glucose-6-phosphate-dehydrogenase, glutamate dehydrogenase, isocitrate dehydrogenase, inalate dehydrogenase, malic enzymes, phosphoglucometase, 6-phosphogluconate dehydrogenase, phosphoglucose isomerase, and shikimic acid dehydrogenase. The analysis of heterozygosity as an index of early selection and as a marker for Ambiol® response has still to be accomplished.

In Sault Ste. Marie, work has focused on three major experiments: maintenance and measurement of a field experiment established in 1993 at the Ontario Forest Research Institute (OFRI) arboretum site; testing drought response of Ambiol®-treated seedlings in rain shelters at the arboretum; and a growth-chamber study to simulate dormancy induction and release and the effect of Ambiol® on the acquisition and loss of frost and heat tolerance. Initial trials in 1992/93 showed that certain seed sources of black spruce and jack pine showed increased heat tolerance after treatment with Ambiol®. However, there appeared to be little effect on frost tolerance and it was felt that differences due to Ambiol® treatment may be more evident during the acquisition and loss of frost tolerance (i.e., during fall and early spring). Additional information was also required on the growth effects of Ambiol® treatment and the persistence of these effects. Three experiments in the field and growth chamber were carried out to address these questions.

This research project was completed in July 1995, and a final report, on the use of antistress antioxidants to enhance growth and stress tolerance in conifer transplants, has been submitted.

Natural Regeneration of Softwood and Hardwood Tree Species After Full-tree Harvesting in Northwestern Ontario

Principal Investigator: E. Symons, Earthworks, Thunder Bay, ON.
Scientific Authority: J.B. Scarratt, NRCan, Sault Ste. Marie, ON.

Data from the Ontario Ministry of Natural Resources (OMNR) Survey of Artificially Regenerated Sites (SOARS) clearly showed that plantations in northwestern Ontario often become overstocked from ingress of natural regeneration. These results demonstrated the need for a tool to help predict the rate and abundance of natural regeneration.

The objective of this project is to determine whether full-tree harvesting results in different rates of ingress of natural regeneration, species composition, and stand structures for selected sites in northwestern Ontario. The study is taking place within the framework of ecological site types and seedbed conditions for hardwood and softwood tree species that occur in northwestern Ontario cutovers. The project will review results with respect to current OMNR requirements for timing of postharvest regeneration surveys.

During the spring of 1993, the records for plantations suitable for sampling were located in district and industry offices across northwestern Ontario, and sites were selected using the following criteria:

1. 10- to 15-year-old full-tree harvested areas, planted to jack pine (*Pinus banksiana* Lamb.), red pine (*Pinus resinosa* Ait.), white spruce (*Picea glauca* [Moench] Voss), or black spruce (*Picea mariana* [Mill.] B.S.P.), without replant, fill plant, or aerial seeding;
2. four levels of seedbed condition (undisturbed forest floor, scalped soil, slash, and prescribed burn); and
3. Northwestern Ontario Forest Ecosystem Classification (NWOFEC) vegetation and soil types.

Presampling site inspections were carried out in July 1993. These were followed by sampling in September 1993. During 1994, Tree Ring Increment Measurement (TRIM) data files were used to create rate graphs for each FEC soil and vegetation group; a statistical software package was obtained to analyze collected data; background information for sampled plantations was collected; additional plantations were selected for sampling; stand structure/composition for 1994 samples was described and combined with 1993 data; and rate graphs were produced for 1994 TRIM data.

A report describing the ingress of natural regeneration on selected NWOFEC site types after full-tree logging has been completed, along with a FEC interpretation for ingress of natural regeneration by site type.

4022

Yellow Birch and Sugar Maple Thinning: Effects on Diameter and Height Increment, Crown Size, and Stem Form

Principal Investigator: J.E. Wood, NRCan, Sault Ste. Marie, ON.

The objective of this project is to determine the effects of different intensities of thinning on diameter and height increment, crown size, stem form, and epicormic branching of yellow birch (*Betula alleghaniensis* Britton) and sugar maple (*Acer saccharum* Marsh.) crop trees.

The study was carried out near Thessalon, Ontario, in the Blind River Area of the Ontario Ministry of Natural Resources. Twenty-year-old yellow birch and sugar maple saplings were released by a Canada Works Job Development crew.

Treatments consisted of a control, or the removal of all competing trees at 1, 2 or 3 meters around the boles of sugar maple crop trees or 1, 2, 3, or 4 meters around the boles of yellow birch crop trees.

Results showed that the greater the release, the larger the increase in the 5-year diameter increment and crown width of both species. Height increment in the yellow birch crop trees decreased with the intensity of release, while height increment of the sugar maple crop trees was higher in all thinning treatments than in the control. Figure 1 shows the diameter and height increment of yellow birch and sugar maple crop trees by thinning intensity.

Few epicormic sprouts developed on the stems of both species released at 1 to 3 meters. However, release of yellow birch at 4 meters increased both the number and size of epicormic sprouts.

Five years after release at 1 or 2 meters, the space available for yellow birch crown expansion had nearly been filled. However, release at 3 meters provided a good balance between diameter increment and stem quality.

Release at 1 meter was inadequate for crown expansion of sugar maple crop trees, while release at 2 and 3 meters increased diameter increment by 114 percent and 171 percent, respectively, and allowed adequate space for crown expansion for a further 5 years.

The final report, entitled *Effects of different intensities of yellow birch and sugar maple crop tree release* (NODA/NFP Technical Report TR-4), makes the following recommendations, and will assist foresters in the Great Lakes-St. Lawrence Forest Region to maximize the value of timber resources earlier in the rotation.

1. Apply the first crop tree release in sapling stands 15 to 25 years old.
2. Release 200 to 250 yellow birch crop trees or 175 to 200 sugar maple crop trees per hectare.
3. Have crop trees selected by well trained, knowledgable workers capable of exercising good judgement under variable stand conditions.
4. For yellow birch release, apply the crown-touching method in which all trees are removed that touch the crown of a crop tree, or remove all trees to create an opening 1.5 m to 2.0 m wide around the circumference of the crop tree crown.
5. For sugar maple release, apply the crown-touching method or remove all trees to create an opening 1.2 m to 1.5 m wide around the circumference of the crop tree crown.
6. Plan to repeat the release at 10-year intervals.

Figure 4022.1. Yellow birch crop trees shortly after release at 30 percent density. (Photo courtesy of F.W. von Althen.)

Black Spruce Outplantings on Boreal Mixedwood Sites: Effect of Vegetation Management and Stock Size

Principal Investigator: J. E. Wood, NRCan, Sault Ste. Marie, ON.

The objective of this project is to evaluate the effects of postplanting vegetation management and the effects of stock type and grade on black spruce establishment on upland boreal mixedwood sites.

To help fill current information gaps about the long-term effects of vegetation management, researchers are carrying out an eleventh-year remeasurement of four black spruce vegetation management and comparative planting experiments in northeastern Ontario.

Four field experiments were established in 1981 to assess the performance of black spruce outplants in relation to: weed control, stock type, planting season, and planting position. A total of 1 800 seedlings were planted in each experiment and assessed after five and eleven growing seasons in the field.

All experiments are located in the northeastern Ontario boreal forest region; three are within the Lake Abitibi Model Forest and one is near Timmins, Ontario.

The total height of black spruce outplants was not significantly improved by weed control 2 to 4 years after treatment. However, 8 to 10 years after release, weed control significantly improved black spruce height growth (*see* Figure 4023.1). Stem diameter was significantly improved by weed control after only 2 to 4 years. The benefits of weed control increased over the experimental period. The effects of weed control with glyphosate on deciduous trees and brushy plant species was still evident 8 to 10 years after treatment. The application of herbicides in narrow bands over the top of crop trees was shown to be a silviculturally effective alternative to conventional broadcast herbicide applications.

Eleven growing seasons after outplanting, bareroot stock remained significantly taller and had larger stems than did paperpot stock. However, the relative differences in size tended to decrease over the experimental period. In two of the four plantings, height growth of the bareroot stock was significantly greater than paperpot stock 11 years after outplanting. In general, the initial size advantage of the spring-planted compared to the summer-planted seedlings was maintained.

This project will provide forest managers with information needed to develop sound regeneration programs and plantation performance standards on boreal mixedwood sites. It should be possible to determine the best planting season, the most resilient stock type, and the best vegetation control treatment for producing hardy black spruce trees from seedlings.

A technical report, entitled *Silvicultural treatments for black spruce establishment in boreal Ontario: Effect of weed control, stock type and planting season*, has been submitted and will be published (NODA/NFP Technical Report TR-10). Data from this project are being used to develop quantitative, time-dependant predictive models describing the effects of weeds on crop growth in black spruce plantations (*see* NODA/NFP Project 4214, page 112).

Figure 4023.1. Black spruce plantation, June 1992, Kenning Township. (Photo courtesy of J.E. Wood.)

4026

Low-cost Regeneration Methods for Black Spruce on Peatlands

Principal Investigator: A. Groot, NRCan, Sault Ste. Marie, ON.

This project is comparing 10-year development of black spruce advance growth following harvesting by three different methods, and examining 10-year development of broadcast-seeded black spruce on peatlands.

Follow-up measurements and analyses of two experiments established between 1982 and 1984 are being conducted. The first examined the survival and growth of black spruce advance growth following chainsaw felling with narrow-tire skidder forwarding in summer; feller-buncher felling with wide-tire skidder forwarding in summer; and feller-buncher felling with narrow-tire skidder forwarding in winter. The second examined the interrelationships of seeding rate, seedbed amount, and seedbed receptivity with stocking and density in black spruce broadcast seeding.

Field measurements of both advance growth plots and seeding experiments were taken in the summers of 1992 and 1993. Data collection was completed during the summer of 1994, and analysis will take place during the winter of 1994–95.

This project is scheduled for completion in June 1995. Two reports on project results, *Direct seeding black spruce on peatlands: Tenth-year results*, and *Regeneration and surface condition trends following forest harvesting on peatlands*, have been submitted and are under review. This information will assist forest managers and silviculturalists in the planning and implementing of harvesting and regeneration treatments for black spruce dominated peatlands.

Black Spruce Stand Development in Naturally Regenerated Strip Cuts at 15 Years

Principal Investigator: J.K. Jeglum, NRCan, Sault Ste. Marie, ON.

The objective of this project is to assess stand development after 15 years in naturally regenerated black spruce strip cuts on shallow upland soils in the Nipigon District. Figure 4030.1 illustrates the concept of strip clear-cutting. The Nipigon strip cut study was initiated in 1974 to study stand and vegetation development following strip clear-cutting in boreal black spruce. Fifth-year regeneration response was recorded in 1979, and stocking levels were reported as fully acceptable. This project reassessed three study areas for regeneration, vegetation, and quality of seedbed at 16 to 18 years after cutting, and will provide a temporal sequence of structural and floristic diversity changes.

1. Regeneration of Existing Permanent Quadrats

Regeneration and vegetation were assessed in three areas using the original data criteria. Data was entered on a DAP hand held data logger, and transferred to a personal computer (PC). The data was analyzed using Fortran programs and a QUATTRO PRO spread sheet.

2. Characterization of Stand Structure and Development

Twenty plots were established and, when possible, all tree and shrub species stems above 10 cm diameter at breast height (DBH) were mapped and measured for canopy diameter, height, and DBH.

3. Temporal Changes in Vegetation and Flora

Vegetational data was collected and species identifications were made. Preliminary results indicate that after 16–18 years for the first-cut strips and 14–16 years for the second-cut strips, the overall ratio of conifers to hardwoods was 74:26. The ratio of conifers to hardwoods, based on density, in the first-cut strips was 70:30. In the second-cut strips it was 65:35. Additionally, the overall density of conifer seedlings and saplings was 4.14 stems/quadrat in the first-cut strips, 3.30 stems/quadrat in the second-cut strips, and 3.83 stems/quadrat overall.

Stocking of the plots in general is above that required for satisfactory regeneration. The distribution of ages in the sampled trees tends to support the hypothesis that this type of harvesting system leads to an even-aged stand. Some potential defects in stem form were identified. These are difficult to extrapolate to rotation-age trees. It cannot be stated if the quality of the next stand will be higher than the original stand. The growth of the naturally regenerated new stems appears to be as rapid as the original stand, with Site Class 1 growth rates in general. However the residual stems (greater than 20 years), although showing release after harvest, do not achieve as great height growth increments as do the younger, seed-origin trees.

Receptive seedbed, strip width, leave period, and site type, individually, all had a significant effect on the density of black spruce. A predictor for stocking and density has been developed based on receptive seedbed, strip width, and seeding period.

A manual, *Strip clearcutting in black spruce: A guide for the practicing forester*, by J.K. Jeglum and D.J. Kennington, has been published. Additional manuscripts are being prepared.

A demonstration area featuring the results of regeneration in strip cuts will be established.

This project provides reliable information to foresters on the probability of regeneration success after strip clear-cutting in black spruce.

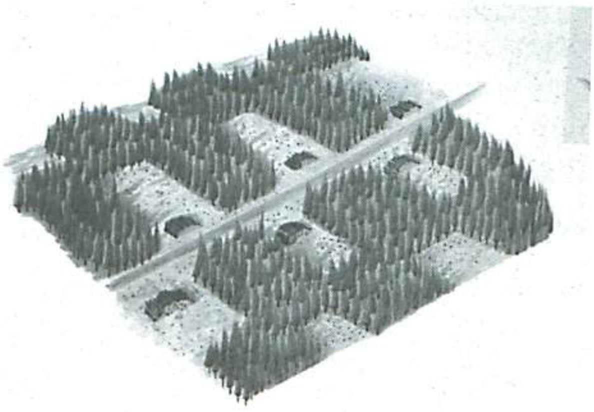

Figure 4030.1. Alternate-strip clear-cutting, showing first cuts alternating with leave strips. (Illustration by D.J. Kennington.)

4031

Seedbed and Microsite Effects on the Growth of Seeded Upland Black Spruce

Principal Investigator: R.L. Fleming, NRCan, Sault Ste. Marie, ON.

The objective of this project is to enhance the establishment, growth, and productivity of seed-regenerated stands of black spruce by identifying optimal seedbed and microsite conditions on different upland site types in northwestern Ontario.

Although specific seedbed requirements for black spruce establishment on coarse-textured soils have been identified, there has been little information on the effects of different seedbed and microsite conditions on subsequent growth. This project measured seedlings that were established as part of a series of black spruce scarification and seedbed microsite trials in 1982. Figure 4031.1 shows the layout of seedspots across the scarified furrow within a seeding plot and illustrates five microsite positions. Growth response was related to the seedling's particular seedbed and microsite conditions.

Researchers report the following conclusions:

1. Successful direct seeding of black spruce requires adequate quantities of receptive seedbeds, which are primarily located just above and below the mineral soil–humus interface. Very little establishment can be expected on undisturbed surfaces or thick organic horizons. In these trials, seedling establishment was often better on shallow-mineral than on thin-F seedbeds, but seedling growth was as good or better on thin-F than on shallow-mineral seedbeds.
2. Better seedling establishment can usually be expected on sites with Moist Soil Regimes than on sites with Dry or Fresh Soil Regimes.
3. Seeding within 1 year of scarification resulted in greater seedling establishment and growth than did seeding 2 or 3 years after scarification.
4. Microsite position across 2.5m-wide scarified furrows had no consistent effect on either seedling establishment or growth.
5. Black spruce seedling growth is slow, and common woody competitors will grow much more rapidly. Twelve years after seeding, mean black spruce seedling heights ranged from 90 to 110 cm. In comparison, mean heights of dominant competing jack pine and trembling aspen, which were of similar age and established primarily from seed, ranged from 250 to 400 cm.
6. Tending of seeded stands is recommended within 3 to 5 years of establishment to prevent growth reductions from competition.
7. Large size inequalities and positively skewed seedling size hierarchies quickly developed within populations of seeded black spruce. There appears to be sufficient variation in growth rates among individuals so that dense, regenerating stands will not stagnate from interspecific competition.

The results of these and similar trials support the conjecture that the poor record of success with direct seeding black spruce can largely be attributed to (a) poor site selection, (b) inadequate seedbed preparation, and (c) inappropriate seeding regimes. With careful attention to site selection and preparation, direct seeding does afford a reasonably reliable, low-cost method of successfully establishing black spruce.

On most upland sites, tending will be necessary if seeded black spruce are to attain free-to-grow status within 10 to 15 years of sowing.

The results of this research were presented at the "Black Spruce Direct Seeding Workshop" in Cochrane, Ontario, in January 1994. As well, a technical report, entitled *Establishment and growth of seeded upland black spruce: 7–12 year response* (NODA/NFP Technical Report TR-8), will be published.

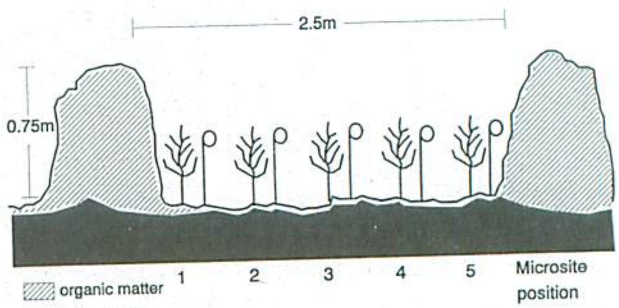

Figure 4031.1. Layout of seedspots across the scarified furrow within a seeding plot, showing the five microsite positions.

Partial Cutting in Boreal Mixedwoods: Evaluation of Harvesting Operations, Site Disturbance, and Damage to Residual Trees and Advance Growth

Principal Investigator: J.B. Scarratt, NRCan, Sault Ste. Marie, ON.

This harvesting project is the core element of a suite of projects that collectively form the Black Sturgeon Boreal Mixedwood Research Project (hereafter referred to as the Black Sturgeon Project). The Back Sturgeon Project, located 100 km northeast of Thunder Bay in the Black Sturgeon Forest, is conceived as a long-term multidisciplinary program of studies aimed at a better understanding of ecosystem dynamics and function in boreal mixedwoods. A thorough understanding of the response of these forests to disturbance, at all ecosystem levels, is an essential prerequisite to developing appropriate management strategies to meet different resource-use goals.

The multiagency Black Sturgeon Project currently comprises three principal elements:

1. A harvesting component, established under NODA/NFP Project 4038 and comprising the umbrella for several other NODA/NFP projects (4040 [*see* page 99], 4049 [*see* page 38], 4050 [*see* page 87]).
2. A fire ecology component (funded principally by OMNR, but with inputs from NODA/NFP Projects 4038, 4049 [*see* page 38], 4050 [*see* page 87]).
3. A site preparation component (Green Plan/NODA/NFP Project 4025 [*see* page 83]).

A research technical committee, made up of active study leaders, helps to coordinate the Black Sturgeon Project.

NODA/NFP Project 4038 – Partial Cutting in Boreal Mixedwoods

This multidisciplinary NODA/NFP project investigates the short-term impacts of alternative harvesting methods on harvesting productivities and site disturbance, logging damage and pathological colonization of residual trees, logging damage to advance growth, forest regeneration, and early vegetation succession.

Harvesting commenced in September 1993 and was completed in February 1994. A description of the harvesting treatments as outlined in the April/May 1995 issue of *Canadian Forest Industries* follows:

More than 35 000 m^3 were harvested using four different systems:

1. Standard feller-buncher (John Deere 690 with Harricana sawhead) and grapple skidding full-tree to roadside.
2. Ultimate 4500 tree-length harvesting head on a Cat 227 carrier and grapple skidding tree-length to roadside.
3. Cut-to-length (Timberjack FMG 1270 single-grip harvester and 1010 forwarder) producing 16-ft spruce and 8-ft poplar at roadside.
4. Manually felling trees and cable skidding full-tree (conifer) and tree-length (hardwoods) to roadside.

All cut blocks, either clear-cut or partial cut, were 10 ha. These were separated by 100-m buffers. The partial cuts were designed to remove about two-thirds of the merchantable volume, including all harvestable balsam fir (*Abies balsamea* [L.] Mill.). A uniform canopy of aspen with a scattering of potential spruce seed trees was retained. All but the single-grip treatments were carried out by Sturgeon Timber Ltd., Avenor's full-phase contractor on the Black Sturgeon Forest.

Prior to the harvest, assessments were taken to collect baseline data on stand characteristics, vegetation, and bird and small mammal populations. Within weeks of the timber operations, teams of researchers descended on the patchwork of cuts to study a broad range of harvesting effects. These studies examined, among other things: harvest productivity, logging damage, growth and yield, vegetation succession, small mammals, amphibians, birds, disease infection, and soil productivity.

The second phase of this harvesting component, site preparation and forest renewal investigations on designated portions of the harvest blocks, will commence in the summer of 1995.

A summary of progress (to the end of 1994) by project element is as follows:

1. Harvesting Treatments

In 1994, following harvest, a substantial amount of work was carried out to clean up access to the treatment blocks and to reestablish block boundaries and markers before researchers began using the sites. Interpretative signs and displays were erected under the NODA/NFP Demonstration Forests Program, Project 4411 (*see* page 135).

Aerial photography of all project areas was completed for record purposes in February 1994 (black and white), immediately after harvesting, and again in June (infrared). These photographs are being used to prepare definitive maps of the treatment areas, and will ultimately be useful for GIS mapping of the entire Black Sturgeon Project area.

Baseline data information needs were addressed as follows:

- postharvest assessments of the amounts and distribution of logging debris were conducted by the CFS–Sault Ste. Marie fire research group;
- chemical and physical analyses of preharvest soil samples were completed;
- block description summaries (vegetation/inventory/soils), based upon the network of permanent sample points, were prepared from the preharvest surveys conducted in 1993;
- postharvest stand inventories, based upon the network of permanent sample plots, were completed;
- scanning and analysis of the preharvest hemispherical canopy photographs (to estimate canopy closure) were completed with the assistance of the Centre for Northern Forest Ecosystem Research; postharvest photographs were repeated at the same positions during the summer of 1994, to obtain a measure of canopy reduction in the partial-cut blocks;
- permanent photo points were established in front of each treatment block, and a first series of recorded (focal length and compass bearing) photographs were taken with the aim of characterizing stand development over the long term;
- two automatic weather stations were installed – one on a clear-cut block, the other in one of the partially cut blocks; and
- an Excel database was initiated to consolidate general baseline data collections for use by all project participants; all participants are encouraged to contribute data summaries and other information to this database.

2. Evaluation of Harvesting Operations

Productivity assessments were completed by the end of February 1994. Because of snow conditions, postharvest assessments of ground disturbance and logging damage had to be delayed until the early spring of 1994. Because of harvesting delays, frozen soil conditions and snow cover may have reduced site disturbance on the later-harvested treatment blocks, thereby reducing the validity of comparisons between harvesting equipment. Similarly, the productivity assessments may have been compromised by operational problems experienced during harvesting. A final report on the harvesting evaluation was submitted in October 1994 and published (1995) in abbreviated form as FERIC Field Note No. 4, *Partial cutting in boreal mixedwoods: A comparison of productivity and site impacts with different harvesting systems.*

3. Pathological Investigations

Two hundred wounds (stem, butt, and root) identified in 1993 on conifer trees were sampled three times, in April, June, and November 1994, for wound-infecting organisms. Identification of the organisms is under way.

The area of all wounds has been measured and the proportion of stem girdled by the wounds has been determined for 44 of the 100 trees being monitored. Measurement of callus formation and rate of wound closure, scheduled for 1994, could not be accomplished because of the insignificant amount of growth.

Stem analysis based on wood cores taken by increment borer in November 1994 from 57 wounds on 44 trees, showed that growth rates have been declining over the past 10–20 years in approximately 90 percent of the trees with stem wounds. A sharp decline, evident over the past 4–5 years, is perhaps associated with the current spruce budworm infestation.

A survey of decay fungi naturally present in the project area was carried out in the fall of 1994.

Identification of wound-inhabiting microorganisms will continue in 1995. As early as possible, a number of wounded trees in the portion of the blocks assigned for site preparation treatment will be felled, dissected, and examined for signs and symptoms of fungal colonization and/or decay. Decay organisms will be isolated from the dissected trees and identified. Data will be analyzed to determine whether successional pathways of wound microorganisms can be detected.

4. Advance Growth/Regeneration Investigations

Following harvest, a total of 80 assessment plots (10 m x 20 m) were reestablished and remeasured in the spring of 1994. Within each plot, 50 quadrats (2 m x 2 m) were permanently marked.

In the harvest blocks, the same information as in the 1993 assessment was collected for comparison with preharvest conditions, *viz*: (i) numbers and heights, by diameter class, of coniferous regeneration and advance growth, and of aspen and white birch (*Betula papyrifera* Marsh); and (ii) numbers and heights of mountain maple (*Acer spicatum* Lam.) and hazel seedlings and saplings. Information on ground disturbance, logging tracks, and slash distribution within the assessment plot was also recorded. In the control plots, only trees <1.37 m tall and <1.0 cm DSHob were remeasured.

Sorting and summarization of first-season preharvest data and preparation for analysis will commence in January 1995. This is expected to guide the focus of remeasurements planned for the late summer of 1995. In the fall, incorporation and analysis of the second-year data should help to define trends and draw short-term conclusions.

5. Seed Bank/Seedfall Investigations

Preharvest core samples, taken from the forest floor in 1993 in the planned harvest blocks, completed cold stratification in January 1994. These were transferred to a greenhouse where the contained seeds were germinated. This gave a preliminary indication of stored seed species diversity and incidence in the seed bank, and pointed to a number of refinements that were needed in the sampling and treatment of future sample cores. Subsequently, a custom core sampling device was designed and constructed.

In 1994, four permanent seed bank/seed rain sampling locations were selected in each of 17 harvest treatment blocks and three uncut control blocks, in association with designated permanent sample plots. Seed traps were emptied monthly until November, and 103 seed samples were collected for identification and viability testing. In late September, three soil cores (10-cm diameter) were taken at each sampling location. This gave a total of 12 cores per treatment block (204 samples in total).

In early 1995, after three months of cold stratification, the core samples will be divided into organic and mineral layers, and each layer will be subdivided into 2 cm-deep subunits. Each subunit will be mixed with an extender and transferred to a heated greenhouse to germinate any contained seeds and to identify emergent seedlings.

Commencing with snow melt in 1995, seed traps will be emptied monthly until November. Additional soil cores will be collected and germinated in early June 1995 to compare with the fall core sample germination results. Above-ground vegetation on the monitoring quadrats will be reassessed in summer.

Two additional related projects have been undertaken to review current literature on the use of alternative harvesting silviculture systems in boreal mixedwoods (Project No. 4111, *see* page 43) and the effects of alternate silvicultural practices on wildlife (Project No. 4124, *see* page 49).

Information generated from this project will benefit sustainable forestry development in northern Ontario by helping to define the feasibility of alternative management strategies in boreal mixedwood sites. In the longer term, project results will contribute to a better understanding of ecosystem response to disturbance and manipulation.

4039

Small Forest Openings to Promote the Establishment and Growth of White Spruce in Boreal Mixedwood Stands

Principal Investigator: A. Groot, NRCan, Sault Ste. Marie, ON.

The objective of this project is to determine how small forest openings can be used to improve the establishment of white spruce (*Picea glauca* [Moench] Voss) from seed, reduce planting check in white spruce, reduce frost damage to white spruce, and inhibit the development of broadleaved competition.

Site selection took place in 1992, approximately 30 km southeast of Chapleau.

In the spring of 1993, three treatments were applied. These consisted of 12 circular openings, 6 narrow strips, and one block cut. Radiation, air temperature, and soil temperature sensors (20, 70, and 40 sensors, respectively) were installed within the treatment areas and in the uncut forest adjacent to the treatment blocks.

About 2 800 trees were planted, and first-year survival was very high. Nearly 2 400 seed spots were established.

In the fall of 1993, a program of measurement was undertaken, including: survey of frost damage to planted seedlings; survey of initial seed spot establishment; survey of initial aspen regeneration; comprehensive environment measurements (radiation, air temperature, soil temperature, humidity, soil moisture); and seedling physiological measurements. In 1994, the treatment areas were remeasured and a weather station was installed.

Ongoing data analysis should indicate which openings are most favorable for white spruce establishment. These measurements will be complemented by physiological measurements on the planted and seeded stock. Preliminary indications are that the size and shape of forest openings have an important effect on aspen regeneration.

Later in 1995, this project will result in two reports on white spruce regeneration: plant responses to environmental variables and the effects of forest opening configuration.

Prediction of Residual Crown Cover for White Pine in Central Ontario

Principal Investigator: C. Bentley, Consultant, Churchill, ON.
Scientific Authority: S. Reid, OMNR, Huntsville, ON.

This project was designed to determine the natural crown cover and produce stocking guides for white pine (*Pinus strobus* L.) stands of different diameter at breast height (DBH) classes in the White Pine Working Group.

Uncut stands with more than 30 percent of the basal area as white pine were selected in the North Bay and Temagami districts of the Ontario Ministry of Natural Resources' Central Region. Stands with the following characteristics were selected from the Forest Resource Inventory (FRI) database:

Stocking:	range from 30 to 80%
Species composition:	30–100% white pine
Age:	20–141+ years

The data covered a wide range (10–94 cm DBH) of diameters. The following data were collected from 628 trees: DBH; total tree height; base of live crown; average live crown diameter; age at DBH; and canopy closure. The tree data was used to explore various relationships between tree growth and stand parameters associated with canopy cover.

Basal area was found to be a poor indicator of percent canopy cover; diameter was the most consistent indicator of crown area in this study, and the model developed for each species group was used to produce tables of percent canopy cover for field use.

A final report for this project has been completed. It contains stocking guides and tables of percentage crown cover for white pine in the White Pine Working Group. A technical note will be published.

4042

Uneven-aged Silviculture for Peatland Second Growth Black Spruce

Principal Investigator: J.R. Gemmell, Abitibi-Price Inc., Iroquois Falls, ON.
Scientific Authority: P.A. Addison, NRCan, Sault Ste. Marie, ON.

The objective of this project is to provide information on the aspects of uneven-aged silviculture for second growth black spruce swamps, including: harvesting costs; productivity and equipment suitability; damage to residuals and advance growth; forecasts of stand structure and growth; and analysis of wood supply implications. The project is also designed to transfer technology relating to harvesting equipment and techniques required to implement uneven-aged silviculture.

A second-growth black spruce forest originally harvested in 1929–1930 in the Lake Abitibi Model Forest, and immediately adjacent to the Wade Lake Interpretative Centre, was chosen as the experimental harvest area. In the summer of 1993, the experimental area was divided into harvest blocks, and a preliminary Forest Ecosystem Classification and mensurational survey were carried out in each block. In the fall of 1993, permanent sample plots were established by the CFS in blocks scheduled for winter harvesting to collect baseline mensurational data, including height–diameter relationships, density and diameter, measurements for trees > 1.3 m in height, density and height measurements for trees < 1.3 m tall, and percentage of alder cover.

The experimental partial cuttings were carried out using a cut-to-length single-grip processor and a forwarder during the winter in a corridor selection system. Three replications of each harvesting treatment (35 percent basal area removal, 50 percent basal area removal, and removal of all merchantable trees) were carried out in the winter of 1993. In the following summer (1994), postharvest assessment of the winter harvest was carried out. This included all preharvest measurements, plus the percentage of slash cover, shallow ruts, and deep ruts. As well, preharvest assessment and cutting was carried out for summer harvest blocks.

The Forest Engineering Research Institute of Canada (FERIC) conducted studies of the machines working in one replication of each of the three different treatment types and has prepared a report on the productivity and cost of a cut-to-length system in different stand removal intensities.

Supervisor and operator training workshops were held in March and August 1994.

Data analysis and reporting will be completed by July 1995. A combined field tour/workshop will be held at Wade Lake to transfer information on a number of aspects of uneven-aged silviculture of black spruce.

Methodologies for Maintaining the Softwood Component in Boreal Mixedwoods

Principal Investigator: R.M. Edmonds, McChesney Lumber Division, E.B. Eddy Forest Products Ltd., Timmins, ON.
Scientific Authority: J.E. Wood, NRCan, Sault Ste. Marie, ON.

This project is designed to demonstrate and transfer methodology for establishing white spruce on competitive mixedwood sites using three different establishment methods and two stock types.

The main part of the study will provide comparisons between three establishment treatments: corridored mechanical site preparation and manual planting (control), Power Pellets® herbicide pellets applied at 1-m x 1-m spacing and manual planting, and excavator mounding and manual planting. As well, a second experiment will establish the effectiveness of Power Pellets® relative to Gridballs® (two pelleted herbicides containing the active ingredient Hexazinone) in controlling weed vegetation and in promoting white spruce establishment.

The trials were successfully established during May and June 1993 with four randomized blocks. Each of these had three 50-m x 100-m plots (site preparation method), longitudinally divided into two subplots to accomodate the two different types of stock. In each subplot, five row subplots of 20 trees per row were located symmetrically from a random start and individually labeled (2,400 trees sampled).

Two 40-m x 40-m areas adjacent to the main experimentation were selected for comparison study of the effects of Gridballs® vs. Power Pellets®. These areas were planted with bareroot and containerized white spruce in alternating lines, but without site preparation other than the placement of the pelleted hexazinone on the forest floor. In each of the two areas, two replicate 10-m x 10-m plots were established for each of three treatments: control (no treatment), Gridballs,® and Power Pellets®.

To quantify the dynamics of weed regrowth after site preparation, and to assess the effect of such regrowth on the establishment of white spruce, the photosynthetic photon flux density (the preferred measurement for photosynthetically active radiation "PAR") is being measured using a Li-Cor Quantum Sensor.

Initial measurement of the trees (total height, diameter, and condition) for both parts of the project was undertaken in June 1993. This was followed by a fall assessment in September 1993 of total height, annual growth, diameter, and condition. PAR readings were observed and recorded on three separate days during August, September, and October 1993. Assessment trees were remeasured during the fall of 1994 and PAR readings were taken each month between May and October 1994. Third year field data will be collected during the summer of 1995.

A final report including all data and findings from the project, will be prepared by November 1995, as will a technical brochure on the pelleted herbicide technique. The information obtained on establishment costs and performance over the first two seasons of growth will indicate the relative biological and economic effectiveness of the three establishment methods for introducing white spruce onto fertile mixedwood sites dominated by shrubs and/or hardwoods. The data collected within subplots will provide information on the relative performance of the two different stock types.

Figure 4043.1. Inspecting the mounding site treatment following preparation, but prior to planting. (Photo courtesy of Dr. R. Sutton.)

4044

Reforestation Using Timber Harvesting Wastes

Principal Investigator: J.G. Marshall, University of Waterloo, Waterloo, ON.
Scientific Authority: B.A. Nicks, E.B. Eddy Forest Products Ltd., Espanola, ON.

The objective of this project is to examine natural regeneration using the cone-bearing logging debris left at the roadside of jack pine and black spruce cutovers. The project has three phases: laboratory analysis to compare the release of viable seed from harvesting residues using a combination chipper/shredder to that of standard heat extraction protocols; field testing the biological effect of mechanically produced seed mulches of jack pine and black spruce on a range of different site types and seed beds; and economic and policy analyses.

To optimize the rapid mechanical extraction of live seed from timber harvesting waste in the field, a machine was developed that will turn logging slash into a readily available source of seed for biodiverse direct seeding from the ground.

It was found that a Farm King hammer mill equipped with blunt hammers and operating at high or low speeds will adequately extract black spruce seed. About 0.6 free-live-seeds per gram of cones are produced with optimal production from 0.5- to 0.8-inch screens. Somewhat less than 1/6 of the cones survived undamaged. This amount of live seed is sufficient to achieve reforestation. The presence of residual undamaged cones is not likely to provide additional stocking and is not of interest in black spruce.

In contrast, a high-speed mill (3 500 rpm) equipped with blunt hammers will demolish jack pine cones and destroy all the seed. After considerable modification (875 rpm, knives), the mill will produce 0.03 free-live-seeds per gram of cone. Free-live-seed production is not strongly dependent on retention screen size. However, the proportion of undamaged, full cones increases dramatically at screen sizes of 1.0 inch and greater. Preliminary evidence suggests that reducing hammer length will not increase the production of free-live-seed but will increase the proportion of undamaged cones. It seems probable that reducing mill speed below 875 rpm will result in additional amounts of live seed and/or a greater proportion of full cones.

Mechanical seed extraction has far exceeded expectations in black spruce. Jack pine, however, presented difficult technical challenges. The limited success of modifications made to equipment to extract jack pine seeds suggest that additional technical advancement is still probable.

Field trials for black spruce and jack pine commenced in April 1994 and will be remeasured in 1995.

This project will result in a report containing a set of management guidelines outlining the site, season, seedbed, and dose rate to encourage effective, natural regeneration from a mechanically produced mulch of seed-containing logging residues. An economic and policy analysis of direct seeding using harvesting wastes will be prepared. Demonstrations will be made in one or two locations, in cooperation with industry.

Management of Black Spruce on Highly Productive Sites

Principal Investigator: R.L. Fleming, NRCan, Sault Ste. Marie, ON.

The objective of this project is to enhance smaller-scale black spruce silvicultural systems and techniques on highly productive coarse-textured sites by determining growth response of black spruce plantations to various levels of basal area removal. The development and growth rates of pure black spruce and interplanted black spruce (*Picea mariana* [Mill.] B.S.P.)–jack pine (*Pinus banksiana* Lamb.) plantations will also be compared.

Two experiments established in 1985 near Tyrol Lake in the Beardmore area were remeasured in 1994. One is a dense, pure black spruce plantation established in the spring of 1962; the other is an interplanted jack pine–black spruce plantation at the same site. Diameter, height, and a variety of other parameters, including foliage analysis and feathermoss abundance, will be measured. First year field work has been completed with only sampling of foliage from black spruce and jack pine being deferred to 1995 as the tree heights prevented the samples from being gathered using pole pruners.

Two reports will be produced in 1995: one will document the 10-year growth response of planted black spruce on highly productive, coarse-textured sites based on the effects of different site types and thinning regimes; the second will provide stand and site-specific guidelines for the management of mixed black spruce–jack pine stands on similar sites. Two technical notes will summarize the reports. Workshops are planned to transfer this knowledge to the forest managers.

4049

Influence of Environmentally Considerate Silviculture on Bird and Mammal Populations in Boreal Mixedwoods

Principal Investigators: K.F. Abraham, Southern Terrestrial Ecosystem Section, OMNR, Maple, ON and A.R. Rodgers, Centre for Northern Forest Ecosystem Research, OMNR, Thunder Bay, ON.

Scientific Authority: S. Holmes, NRCan, Sault Ste. Marie, ON.

This project is monitoring changes in density and species diversity of bird and mammal populations in boreal mixedwoods before and after the application of environmentally considerate silvicultural techniques and harvesting. It is part of a broad-based, multidisciplinary research program in the Black Sturgeon Lake area (*see* NODA/NFP Project No. 4038, page 29).

In the mammal component of the project, during the first 2 years, trapping grids and sampling sites were established; pre- and postharvest inventories were taken of mammal populations, and evaluation of habitat characteristics was undertaken. Evaluation and quantification of logging damage, soil disturbance and postharvest debris, and postharvest inventories of mammal populations were completed in 1994.

Activities conducted during the winter of 1993 included recording of mammal tracks in snow and evidence of browsing along grid lines.

Structural elements of small mammal habitats (210 sample points) were surveyed. Between late July and early October of each year, small mammal trapping was conducted on all grids. Traps were prebaited for three nights prior to each trapping session. Trapping was then conducted on each grid until a recapture rate of approximately 70 percent was achieved (3–5 nights). More than 2,000 small mammals were marked on all grids during the preharvest trapping. Analysis of the first postharvest surveys will be completed in the winter of 1994–95.

Two protocols were written during the initial phase of the project: a protocol for sampling small mammals in boreal mixedwoods and a protocol for sampling structural elements of small mammal habitats in boreal mixedwoods. These will be combined to form the basis for a technical note. A paper, provisionally entitled *Habitat associations of small mammals in boreal mixedwoods*, will be prepared for submission to a primary scientific journal.

Based on previous experience, the principal investigator concluded that one of the major effects of forestry on small mammal populations is a change in movement patterns of individual animals. Therefore, spooling and radio telemetry were added to live-trapping data as means of tracking movement patterns more precisely.

In the bird component of the project, the principal activity has been song bird monitoring on the two stands scheduled for harvest treatment and on a control stand west of the Black Sturgeon Road. This control stand has historical data from previous forest research projects. A fourth stand, part of the OMNR prescribed burn project, was monitored in an ad hoc manner.

Between 14 June and 23 July 1993, 61 bird species were recorded on the Black Sturgeon Lake study plots. The most common and abundant species were: ovenbird, red-eyed vireo, Swainson's thrush, bay-breasted warbler, and yellow-bellied flycatcher, although several other species were wide-spread in occupancy but of lower relative abundance. Nests of six species were located and documented: namely, yellow-rumped warbler, black-backed woodpecker, three-toed woodpecker, Swainson's thrush, northern flicker, and spotted sandpiper.

Monitoring of postharvest population changes will continue. Together with other studies at the same location, this will provide a valuable case study of the technical aspects, environmental impacts, and silvicultural benefits and constraints of partial cutting in boreal mixedwoods. The major results of the mammal and bird components of this study will be published, thereby giving short-term impacts of alternative harvesting methods on wildlife populations.

4102

Development and Transfer of Methods for Predicting the Abundance and Distribution of Advance Growth in Black Spruce Ecosystems in Northeastern Ontario

Principal Investigator: R.W. Arnup, Ecological Services for Planning Ltd., Timmins, ON.
Scientific Authority: D. Archibald, Northern Forest Development Group, OMNR, Timmins, ON.

The objective of this project is to transfer knowledge related to the management of coniferous advance growth in black spruce ecosystems to forest managers in northeastern Ontario. Such knowledge includes:

- stand and site conditions associated with the abundance of advance growth;
- tools and techniques for predicting the abundance and distribution of advance growth in black spruce ecosystems for inventory and planning purposes; and
- experience regarding utilization of the advance growth component in harvesting and regeneration prescriptions.

To evaluate stand and site conditions associated with the abundance and distribution of advance growth, 85 stands located throughout northeastern Ontario were surveyed using replicated, fixed-area plots. These data were combined with information from the Clay Belt Forest Ecosystem Classification (FEC) database, the Northeast Region FEC database, relevant data from the northwestern Ontario FEC program, and the Advance Growth Survey database collected by A. Groot of the Canadian Forest Service–Sault Ste. Marie for an additional 320 stands. Stand and site factors associated with black spruce (*Picea mariana* [Mill.] B.S.P.) and balsam fir (*Abies balsamea* [L.] Mill.) advance growth, and relationships of advance growth abundance to FEC site types, were explored using multiple regression and other analytical techniques.

This project is nearly complete and the results in the final report show that stand and site conditions related to the abundance of black spruce advance growth included the total basal area of the stand, stand productivity, percent black spruce in the stand, stand age, the abundance of tall woody shrubs in the understorey, the abundance of *Sphagnum* spp. mosses, and the abundance of materials on the forest floor that inhibit or reduce layering. Black spruce advance growth was most abundant in nutrient-poor, black spruce-dominated stands, with low basal area, few tall woody shrubs in the understorey, and abundant *Sphagnum* spp. mosses on the forest floor.

Stand and site conditions that were related to the abundance of balsam fir advance growth included stand productivity, stand age, species composition, soil moisture regime, and the nature of materials on the forest floor. Balsam fir advance growth was most abundant in medium to rich, fresh to moist, conifer-dominated mixedwoods, especially stands with balsam fir, white spruce, and/or hardwood components. Mixtures of materials on the forest floor, including mosses, debris, decomposed logs, needle litter, leaf litter, and exposed mineral soil were also associated with balsam fir advance growth.

The FEC site types provided a useful framework for understanding the distribution of black spruce and balsam fir advance growth in forested ecosystems in northeastern Ontario. Nutrient-poor, black spruce-dominated peatlands, including Site Types 11, 12, and 14, had the highest stocking and density levels of black spruce advance growth. Mesic, mixed coniferous upland spruce–fir sites, including Site Types 6a, 6b, and 6c, had the highest stocking and density levels of balsam fir advance growth.

Keys are provided in the final report to assist forest managers in recognizing stands with the capability to support abundant black spruce advance growth. These keys are intended for use mainly as forest-level planning aids.

As well, a manual is being prepared to provide information to forest managers on the most effective methods of predicting and mapping the abundance of advance regeneration prior to harvest planning. Workshops will be held to train forest planners and field staff in the Northeast Region in the use of the predictive tools and aids to mapping advance growth.

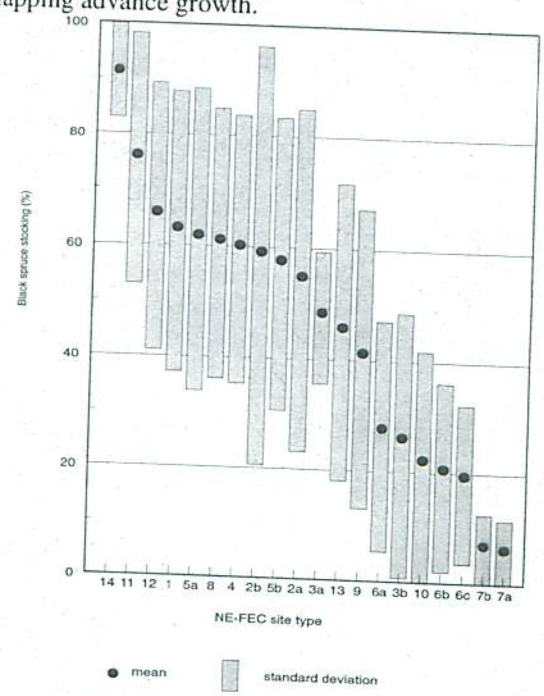

Figure 4102.1. Percentage stocking to black spruce advance growth, by FEC site types.

4103

A New Approach to Training Trainers in Spacing and Thinning

Principal Investigator: H.J. Kelly, BGLN Economic Development Centre Inc., Geraldton, ON.
Scientific Authority: H.L. Jääskeläinen, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a core of qualified trainers, knowledgeable in all aspects of motor and manual spacing and thinning, including proper equipment use, equipment maintenance, and safe work practices. The project is completed, and NODA Note No. 6, *A new approach to training silviculture trainers in spacing and thinning*, will soon be available.

The Geraldton Community Forest Project is one of four pilot projects funded under the Sustainable Forestry Initiative of the OMNR. A specific objective of the Geraldton project is to demonstrate the practicality of intensive forest management in a boreal forest setting. The Geraldton Community Forest Project anticipates that it will precommercially thin approximately 1 000 ha of young forests within the next year. To develop a competent workforce, the Geraldton Community Forest initiated a 3-week "Train the Trainers" Program in August 1993. It was sponsored by the NODA/NFP and designed to develop instructors who would be used to train a local workforce. Training expertise was contracted from Nordfor Training and Consulting, Huskvarna, Sweden.

A total of eight students participated in the program, representing seven community forest groups and organizations: 6/70 Community Forest, Kapuskasing; Elk Lake Community Forest, Elk Lake; Geraldton Community Forest, Geraldton; Ginoogaming First Nation, Longlac; Kimberly-Clark Forest Products Inc., Longlac; Ministry of Natural Resources, Geraldton; and Wikwemikong Community Forest, Manitoulin Island.

The majority of the training focused on using brush saws in relatively young dense stands of softwood and hardwood. A portion of the course was also dedicated to using chainsaws in larger precommercial/commercial thinning operations.

The course was designed to show the participants various precommercial thinning techniques and allow them to practise those techniques until they became proficient. A key component of the course was to give the participants in-depth training into the biology and reasons behind precommercial thinning practices. It also focused on the dynamics of instructing people.

Of the seven organizations that participated in the program, 6/70, Elk Lake, and Wikwemikong community forests trained 6 workers each and the Geraldton Community Forest trained 17 people. After their training was completed, the trained workers were employed in the field during the fall and early winter of 1993.

The Geraldton Community Forest used the trained personnel to precommercially thin approximately 300 ha of forest land. Productivity rates varied greatly between individuals and the various job sites.

Several variables appear to have a direct affect on productivity: namely, stand density, brush density, tree species, stem diameter, ground slope, rockiness, slash levels, stand height, air temperature, precipitation, and snow depth. Since the majority of workers had not used a brush saw in the past, this project was not able to make comparisons between productivity levels before and after training. However, production and quality increases realized during the training program were significant and directly noticeable after a short time. Table 4103.1 provides data on average productivity rates experienced under various stand conditions.

Table 4103.1. Various stand parameters and production rates for precommercial thinning operations within the Geraldton area.

Job site	Average height (m)	Pretreatment stand densities (#/ha)				Average productivity (ha/day)
		Conifer	Hardwood	Brush	Total	
A	5	8,200	1,500	2,250	11,950	.83
B	7	4,200	1,300	5,100	10,600	.34
C	7	5,400	800	4,100	10,300	.36
D	7	5,100	1,650	1,000	7,750	.29
E	8	5,500	1,250	2,200	8,950	.46

Autecology of Selected Competitive Species in the Boreal and Great Lakes-St. Lawrence Forest Regions of Ontario

Principal Investigator: H.M. Kershaw, Devlin Consulting Services, Sudbury, ON.
Scientific Authority: F.W. Bell, OFRI, Sault Ste. Marie, ON.

The objective of this project is to produce a comprehensive guide to the autecology of selected competitive vegetation for the Boreal and Great Lakes-St. Lawrence Forest Regions of Ontario through the expansion and updating of the report by Bell et al. (1991) entitled, *Critical silvics of conifer crop species and selected competitive vegetation in northwestern Ontario* (COFRDA Report 3310/ NWOFTDU Technical Report 19). The new guide will be entitled *Autecology of selected competitive plant species in northern and central Ontario.*

The summary for each species will include a general description and information on its habitat, natural reproduction, propagation, growth and development, phenology, response to disturbance, effects on other tree species, and implications for vertebrates, invertebrates, and diseases. This manual will be used by field personnel to reduce dependency on herbicides, and improve forest regeneration through better vegetation management.

Two technical notes resulting from this project have been published through Northwest Region Science and Technology: *Critical silvics of feathermoss as related to vegetation management*, TN-29; and *Critical silvics of sphagnum moss as related to vegetation management*, TN-30.

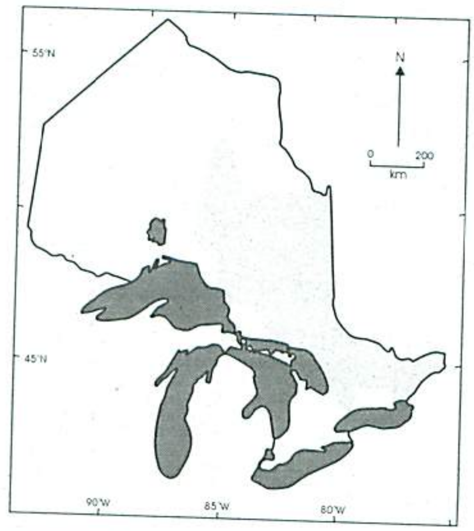

*Figure 4108.1. Distribution of sheep-laurel (*Kalmia angustifolia *L.).*

*Figure 4108.2. Sheep-laurel (*Kalmia angustifolia *L.).*

4109

Field Manual for Direct Seeding Black Spruce and Jack Pine in Northern Ontario

Principal Investigator: M.J. Adams, NRCan, Sault Ste. Marie, ON.

The objective of this project is to provide, in convenient form, the information and predictive models that foresters and technicians require to make and implement direct-seeding prescriptions. Predictive software will be developed, along with a manual that will incorporate and synthesize all published data on direct seeding of black spruce and jack pine. The draft manual and integrated software "PC-SEED" will be evaluated under field conditions and revised before the final printing.

The software has been completed and a preliminary version of the field manual is under review. It contains chapters on: orientation; planning; the seed; harvesting considerations; site preparation; seedbed suitability; seedbed assessment; seed application; seedling establishment; decision support tools; and economic considerations.

Training workshops will be held in the use of the software and manual.

The field manual will enable managers to carry out a statistically sound reconnaissance survey, identify more accurately all seedbed types present, and estimate their respective areas. The computer model, which relies on input generated by the field survey, will predict the likelihood of regeneration success in accordance with the course of action taken. Foresters will be able to identify and select candidate sites for direct seeding of black spruce and jack pine, and predict the resources required to treat these sites effectively.

Figure 4109.1. The field manual will enable managers to better identify seedbed types present and estimate their respective areas. (Courtesy of M.J. Adams; illustration designed by S. Kennington.)

The Use of Alternative Harvesting and Silvicultural Systems in Boreal Mixedwoods–Review and Synthesis of Information

Principal Investigator: J. B. Scarratt, NRCan, Sault Ste. Marie, ON.

The objectives of this project are: i) to assemble and review literature in the public domain that deals with the application of alternative (i.e., nonclear-cutting) harvesting and silvicultural systems in boreal mixedwoods, with emphasis upon the experience in Ontario; and ii) to synthesize the information into a report that summarizes the Ontario experience. This report would describe the short- and long-term results and impacts of the practices described in relation to resource management goals and concerns, and identify gaps in knowledge that must be filled in order to implement alternative harvesting and silvicultural systems successfully in boreal mixedwoods in Ontario. A companion report is being written on the *Effects of alternative silviculture on wildlife* (*see* NODA/NFP Project 4124, page 49).

The project was contracted to ESSA Technologies Ltd. of Richmond Hill, Ontario. The contractor conducted preliminary literature searches at the CFS–Sault Ste. Marie library, and consulted a number of bibliographic databases, both commercially and privately constructed, at a number of research institutions in Ontario. A scoping report, outlining the extent of relevant literature and proposing a format for the final literature review, was prepared from these preliminary searches.

The final report has been published. A computerized bibliographic database (ProCite) has been prepared. It is comprised of approximately 2 400 references, of which about two-thirds will have abstracts.

The final report, as well as the literature review and bibliographic database, will be of importance to managers of the boreal forest by emphasizing the applications of alternative practices and identifying areas in which research can be directed.

4113

Publication of "Guide to the Application of Mechanical Site Preparation Equipment in Northwestern Ontario"

Principal Investigators: B.J. Sutherland and F.F. Foreman, NRCan, Sault Ste. Marie, ON.

The objective of this project is to complete a publication on the application or use of mechanical site preparation equipment on sites in northwestern Ontario. Since its inception, this project has been expanded to include additional material suggested by reviewers and forest managers.

The *Guide to the application of mechanical site preparation equipment in northwestern Ontario* is divided into three sections: Section A looks at the biological requirements for and constraints to tree seedling growth and seed germination (*see* Figure 4113.1). It discusses six of the more important microclimatic variables and outlines the positive and negative aspects of mechanical site preparation on each of them. Section B discusses a variety of site preparation equipment and the soil disturbance patterns achievable by them. The most common of the soil disturbances are presented, incorporating silvicultural requirements for the four major coniferous crop species in northwestern Ontario. Recommended and nonrecommended planting and seeding locations are identified. Section C provides representative samples of postharvest site conditions and site preparation results achieved. This section is a photoseries of typical site preparation case studies and employs many of the conventions used in the Northwestern Ontario Forest Ecosystem Classification.

The guide is written such that a forest manager can immediately refer to the photoseries in Section C and identify situations in the field that approximate those on paper. This should then assist the manager in selecting the most appropriate piece of site preparation equipment for the site. Alternatively, it provides a useful, understandable review of biological requirements for regeneration and mechanical site preparation equipment in northwestern Ontario.

The principal investigators for this project have been invited by Northeast Science and Technology to assist in the development of a similar guide for the northeastern part of Ontario.

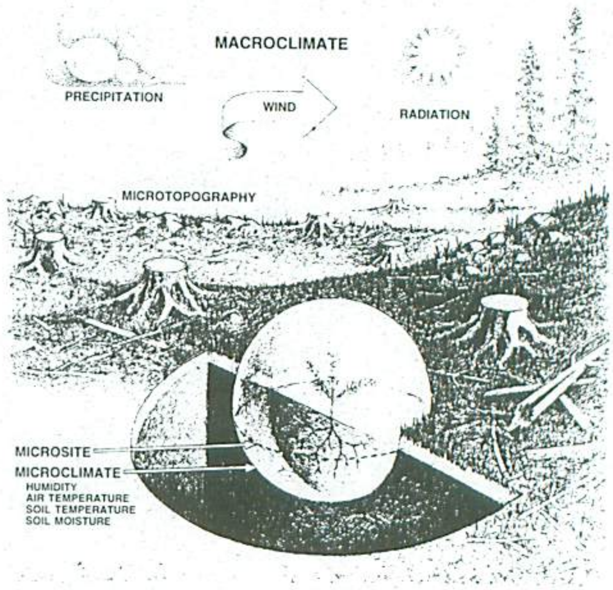

Figure 4113.1. The guide focuses on the four major coniferous crop trees in northwestern Ontario and summarizes microclimatic variables important to tree seed germination and seedling growth. (Courtesy of B.J. Sutherland; illustration designed by S. Kennington.)

Black Spruce Silviculture: A Compendium of Notes

Principal Investigators: A. Cameron and G. Crook, NRCan, Sault Ste. Marie, ON.
Scientific Authority: C.R. Smith, NRCan, Sault Ste. Marie, ON.

The objective of this project is to prepare and distribute to field practitioners user-oriented summaries of key, currently relevant research results from more than 25 years of black spruce silviculture carried out by the Canadian Forest Service–Sault Ste. Marie.

Numerous research results on black spruce silviculture have been published for a scientific audience. They have been reviewed and are presented as a series of technical notes in a format more readily understood by field personnel.

The complete compendium of technical notes has been released and is now being distributed. It will provide easy access to a wide variety of technical information that will broaden the knowledge base and improve decision making at the field level.

4115

Demonstrating Sustainable Integrated Resource Management to Private Landowners in Northern Ontario

Principal Investigator: C. R. Smith, NRCan, Sault Ste. Marie, ON.

The objectives of this project are to transfer to landowners information about the latest techniques and tools for small woodlot management, to promote the concept of sustainable forestry through integrated resource management, to increase awareness of the full range of values associated with small scale forestry, and to provide educators with forestry education resources and information.

More than 35 on-site displays and activities were developed and exhibited at the Copeland Forest, near Barrie, Ontario, as part of "Silvilog '93" in September 1993. The full range of traditional and nontraditional woodland values were covered, with the goal of promoting the concept of sustainable forestry through integrated resource management. Activities included a strong educational component for school groups.

General categories included: management practices; woodlands products and marketing; forest health; woodlands inventory; planning; history; and research and development.

NODA-funded activities, displays, exhibits, and demonstrations included:

- demonstration of use of aerial photographs
- tree interpretative signs
- wildlife habitat interpretative signs
- forest health interpretative signs
- insects and disease exhibit
- acid rain and forest health monitoring
- logging wounds
- red pine products
- "your woodlot as an environmental protection agency"
- "unseen forest" (biological and other soil processes)
- planning the cut
- total value production in a forest stand
- farm tractors in the woods
- cable logging in the woods
- horse logging
- noncommercial booths/exhibits for 30 nonprofit agencies/associations
- bookstore
- seminars
- Leading Edge—a "minimarketplace" on practical research
- educational programs—"Focus on Forests" workshop, and curriculum development workshops

"Silvilog '93" provided an opportunity for over 8,000 woodlot owners, families, students, educators, and the general public to see more than 130 exhibits on sustainable integrated resource management and small scale forestry.

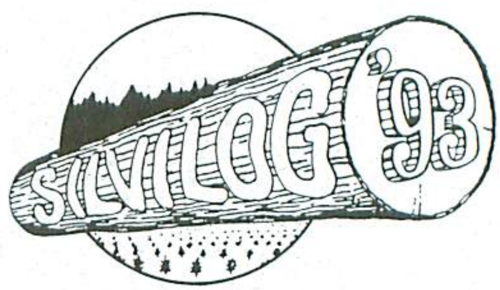

Figure 4115.1. More than 35 on-site displays and activities were developed and exhibited at the Copeland Forest during Silvilog '93.

Aerial Seeding of Prescribed Burns

Principal Investigator: F. F. Foreman, NRCan, Sault Ste. Marie, ON.

The objective of this project is to publish the manual entitled *The effect of rate of seed application and site conditions on subsequent stocking and density of jack pine stands from aerial broadcast seeding prescribed burns*. The manual will be available both as hard copy and as decision support software in DOS format for use by forest managers.

The results of three prescribed burn sites, which have been seeded, are being used to develop a computer model to measure postburn conditions and predict the stocking and density of a stand resulting from various rates of aerial seed application. The three sites were located southwest of Timmins in the Timmins District, southwest of Shining Tree in the Gogama District, and at the north end of Rousseau Lake in the Chapleau District.

A first draft was completed in March 1994, and the final version is expected in late 1995. The published manual and support software will enable forest managers to appraise postburn site data and estimate both the potential of aerial broadcast seeding and the required seeding rates.

4123

Standard Procedure for Testing Aerial Seeding Equipment

Principal Investigator: J.-D. Leblanc, NRCan, Sault Ste. Marie, ON.

This project will publish a manual, entitled *Standard assessment procedure for determining deposition and distribution of ultra low volumes of dry matter (seed) afforded by aircraft/spreader combinations*, both as hard copy and as decision support software. The project will use case studies completed over the past 18 years to develop a step-by-step standard assessment procedure covering preparation, testing, and data collection of aircraft–seeding equipment combinations in a recommended sequence that includes the on-site set-up, material, tally sheets, and calculations.

Both the manual and the computer program will enable forest managers to evaluate different aircraft/seeder combinations with respect to seed distribution, and allow them to choose the most efficient combination for the proposed aerial seeding activity.

Effects of Alternative Silvicultural Practices on Wildlife

Principal Investigator: C. Wedeles, ESSA Technologies Ltd., Richmond Hill, ON.
Scientific Authority: K.F. Abraham, Southern Terrestrial Ecosystem Section, OMNR, Maple, ON.

This project will complete and publish a comprehensive literature review and annotated bibliography on the effects of alternative silvicultural practices on mammal and bird habitat and populations in the boreal forest. Emphasis will focus on examining practices relevant to the boreal mixedwood forests of Ontario. It compliments the annotated bibliography produced under NODA/NFP Project 4111 (*see* page 43).

Initial results indicate that while there is considerable literature on the effects of forestry on wildlife, it will be difficult to determine how to interpret and use the available literature in the context of alternative silviculture practices. Researchers are also finding it a challenge to apply information about the effects of alternative silviculture to the spatial scale at which species-specific concerns exist.

The written report has been submitted and is presently being reviewed. The complete bibliography will also be produced in ProCite. Over 500 articles have been entered in the database. Two seminars describing the results of the project will also be delivered.

Forest managers will have access to a comprehensive review of the available scientific literature on wildlife-related issues, and this should allow them to address wildlife habitat and population concerns while planning and undertaking forestry operations.

4125

Risk Assessment of Residual Stands Following Forest Harvesting

Principal Investigator: R. L. Fleming, NRCan, Sault Ste. Marie, ON.

This project will develop site- and stand-specific guidelines to reduce the damage to residual mature stands during and following logging operations, and identify and assess salvage opportunities for damaged or windfall trees in residual stands.

It will produce a risk assessment manual for residual stands following forest harvesting; generate management guidelines for reducing damage and mortality in residual boreal conifer stands after harvesting; and provide a deterioration index for assessing the salvage potential of such material.

Two technical notes will be produced; one describing a stem deterioration index for windthrown or standing dead boreal conifers, and one presenting management guidelines for reducing tree damage from logging, windthrow, and insects and diseases in residual boreal conifer stands. A poster outlining the "do's and don'ts" of boundary location and harvesting practices will accompany the risk assessment manual. Field seminars and workshops will ensure that information is transferred to the forest manager. The information will permit managers to refine the selection criteria for sites, stands, and the layout of strips so as to reduce losses, and to plan operations to salvage material from residual stands with a knowledge of the rates of deterioration of downed material.

Figure 4125.1. Measurement of windthrow damage. (Photo courtesy of R.L. Fleming.)

Economic Analysis of White Pine Management

Principal Investigator: K. Rollins, University of Guelph, Guelph, ON.
Scientific Authority: H. Jääskeläinen, NRCan, Sault Ste. Marie, ON.

The objective of this project is to produce for forest managers a technical note and file report summarizing the results of unpublished economic studies based on data gathered over two decades from the Petawawa National Forest Institute Cartier Lake White Pine study.

Part I, Forestry Economics, discusses the basic intuition of forestry economics. The objective of an economically optimal rotation age is to maximize the present-value of benefits that flow from the stand. Discounting, which is crucially important to the economic evaluation, is the process by which economic values accruing in different years can be directly compared in present-valued terms. Indeed, the average rate at which an investment in the economy is expected to grow, given by the interest rate, is as important as the volume growth rate of the stand when determining the optimal economic harvest age. In general, as the interest rate increases, the present-value of net benefits from forest management decreases.

Part I derives and discusses the basic economic models of forestry, (the one-cycle Fisher formula and the infinite-cycle Faustmann formula), and discusses how they are different from the maximum sustained yield criterion. The models are used to analyze two types of price changes. A one-time increase in the price of timber will decrease the optimal rotation age, while a steady upward trend in price may cause a steady decrease in the rotation age, as long as the rate of price increase is less than the interest rate. If the price increase is very close to the interest rate, the optimal rotation age approaches the maximum sustained yield rotation age.

Part II applies these concepts empirically to the Cartier Lake white pine experiment. Standard tools of forestry economics have provided insight on the effects of an experimental improvement cut, designed to release understorey white pine and initiate a shelterwood system. The economic criterion for the selection of the optimal rotation age is to harvest when the present value of net benefits from the stands is highest. While the proper way of calculating these benefits is over the perpetual use of the same site for a series of rotations, this study first calculates present-valued net benefits, and optimal rotation ages for treated and control stands using one rotation only.

This study determines the optimal rotation ages for the single rotation in two ways, giving identical results. Optimal rotation ages and maximum net benefits are then simply read from the graphs. The Fisher formula is also used. These methods show that the treatment increases the net benefits flowing from the stands and also reduces the optimal rotation ages.

A technical note, *Economic analysis of forestry management practices with an application to a white pine improvement cut in Ontario*" (NODA Note No. 3), has been published. In addition, NODA File Report 2 of the same title, details the project activities and economic analyses.

4209

Cone Crop Monitoring Systems and Decision Support Systems for Jack Pine and Black Spruce Seed Orchards

Principal Investigator: P. de Groot, NRCan, FPMI, Sault Ste. Marie, ON.

This project is developing cone-crop monitoring and decision-support systems for jack pine and black spruce seed orchards so that managers can determine the causes of cone losses, predict seed yields, and decide on the most appropriate cone crop management option.

In 1990, a pilot cone crop monitoring system (CCMS) was established in several seed orchards in Ontario to enable seed orchard managers to:

- assess the impact of various cone and seed mortality factors during the development of the cone crop;
- estimate and predict cone and seed crop size;
- identify good and poor crop trees, families, or clones;
- determine where in the orchards pest management is required;
- provide a cost analysis of seed production and efficacy of insect control programs; and
- estimate the work loads and work requirements for pest management and cone collection.

This project has adapted the manual CCMS into a computerized decision support system for jack pine and black spruce seed orchards. The system features a database to store and archive assessment data, and program modules to collect, manage, retrieve, summarize, and analyze data. Several program modules will be employed to provide users with simple access to the data, and to automate CCMS and decision support system (DSS) calculations and predictions.

These modules will include:

- Data collection module for data loggers—a stand-alone, hand-held program to be used in the field for CCMS assessments;
- Data transfer module to—down-load data from the data logger into the database;
- Editing module—to modify data within the database directly;
- Report module—to provide printed reports of raw data and data summarized by tree and orchard;
- Graphics module—to permit temporal and spatial trend analysis via graphical display of current and historical data;
- Cone analysis module—to calculate cone and seed yield indices, predictions of seed yield, clone or family summaries, cone condition, and mortality factor summaries;
- ASCII interface module—to produce ASCII files of CCMS data, for subsequent processing or analyzing in commercial software packages; and
- Decision support module—to integrate cone analysis data with a decision support database to explore and identify optimal pest and crop management strategies.

Several workshops with seed orchard managers have been held during the project to discuss the use and implementation of the CCMS-DSS.

In 1992, a structure of the prototype CCMS and DSS was designed with the assistance of tree improvement specialists, jack pine and black spruce cones were collected for analysis, and development of the software for CCMS and DSS was contracted out.

A meeting with the zonal tree improvement specialists and seed orchard managers was held in September 1993. At this time minor changes were made to the data collection procedures and to editing and analysis functions in the CCMS software. Researchers also proceeded with the development of a graphic display of the data so that users could visually examine the results.

An ASCII interface module was developed to allow users to download the CCMS information into an ASCII file, which could then be used in peripheral data analysis software such as SAS.

During the winter of 1994, an Information Management System (IMS) was developed. It includes biological and pest management information on all the important cone and seed pests. In September 1994, the IMS was augmented with a database that included all the pertinent information on pest control products currently registered by Agriculture Canada for control of cone and seed insects. The IMS and CCMS has been used to develop a simple DSS that will allow the user to make important decisions about the utility of conducting a pest management program under specified conditions, such as the size of the cone crop, expected damage from pests, efficacy of the pest control product, and expected cost of treatment.

Cone analysis, completed in March 1994, provided information about the quality and quantity of seed from specific orchards. Such data are essential to the development of accurate forecasts of the size and condition of a cone crop.

A report of this project was published in Crosstalk, a national newsletter on tree improvement.

Following completion of the project, Frontline Technical Note No. 85, entitled *A cone crop monitoring and decision support system for jack pine and black spruce seed orchards,* was published.

In addition to the software itself, courses and manuals are being developed to ensure transfer of this technology to seed orchard managers. The monitoring and support system will provide tools for improving the predictability of jack pine and black spruce cone production from seed orchards.

4211

Seed Zone Delineation for Jack Pine in the Ontario Northwest Region by Short-term Testing and Geographic Information Systems

Principal Investigator: W. H. Parker, School of Forestry, Lakehead University, Thunder Bay, ON.
Scientific Authority: D. Joyce, Ontario Forest Research Institute, OMNR, Sault Ste. Marie, ON.

Short-term testing of jack pine using Geographic Information Systems (GIS) is being undertaken to: improve the knowledge of the adaptive variation of jack pine in the Northwest Region of Ontario; refine the existing pattern of seed zones for the region; and develop focal seed zones for this species using GIS techniques.

The first stage of the methodology, namely the intensive sampling of natural stands of jack pine from the Northwest Region, was completed in the fall of 1992. This included the collection of cones as well as form data from ten trees per stand, and Forest Ecosystem Classification (FEC) data from 103 jack pine stands. These constitute the seed sources or provenances being tested.

The second stage of the methodology involves the use of short-term common garden, greenhouse, and laboratory tests to comparatively assess growth potential, frost hardiness, and phenological characteristics for each of the seed sources. Trial sites for common garden tests were established at Kenora, Dryden, and Sioux Lookout. Seed was planted in leach tubes at the Lakehead University greenhouse in the spring of 1993, and seedlings were outplanted in three completely randomized blocks in late July and early August of that same year. Each block contained ten seedlings from each seed source at each trial site. Seedlings for the greenhouse trial were planted in May to coincide with the natural cycle; transplanted to 3-liter pots in September, and randomized into a single block of 25 seedlings from each seed source. To provide material for the freezing trials in the fall of 1994, additional seedlings were planted in the summer of 1993 at the Thunder Bay Forest Nursery.

Collection of phenological and growth potential data was completed at each trial throughout the spring and summer of 1994. Candle lengths of each seedling were measured regularly throughout the growing season, and total heights were recorded at the beginning and end of the growing season.

The third stage of determining focal point seed zones involves the summarization of growth, phenological, and frost hardiness data into a few major axes of variation using multivariate statistical methods. This was carried out in early 1995.

The fourth stage of the methodology is to regress the summary variables with climate variables to examine that portion of the variance that is adaptive, and to then construct three-dimensional models using GIS. The x and y axes are the geographic coordinates of the seed sources, and the z axis is the major axis of variation. Weather variables of interest are related to temperature, precipitation, and timing of the growing season.

The fifth and final stage of determining focal point seed zones involves the construction of contour maps using GIS techniques for each of the major axes of variation, followed by the intersection of contours to yeild a polygon or seed zone. Software has been developed for this purpose.

This project will result in an ARC/INFO data base that summarizes the adaptive variation in jack pine for the Northwest Region of Ontario and project results will be transferred to users through workshops. This information will be used in the development of improved guidelines for seed transfers within the region. Such guidelines should minimize the risk of using maladapted seed.

Figure 4211.1. Jack pine field measurements. (Photo courtesy of W.H. Parker.)

4223

Stand Dynamics of Boreal Mixedwood Forests of Ontario

Principal Investigator: D. J. Smith, Consultant, Sault Ste. Marie, ON.
Scientific Authority: R. A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop and transfer Stand Density Management Diagrams (SDMDs) for use in managing boreal mixedwood ecosystems.

A series of SDMDs for interpretation in mixedwood stands have been developed for six boreal mixedwood species compositions, utilizing models that were adapted for multispecies stands using species-averaged parameters. The SDMDs consist of a series of curves and models of height, volume, diameter at breast height (DBH), mortality, and density relationships superimposed onto one diagram. An instructional booklet will include SDMD derivation, model verification, and validation procedures, and will demonstrate interpretation utility. A final report will outline the methodology used to develop the SDMDs and will provide supporting information for the curve derivation, including suggestions for improvement of the curves. Three workshops will be conducted to acquaint forest managers with the methodology.

An interim report on Phase I of this project has been prepared. However, a change in methodology to move to three-dimensional models has been accepted. As a result of this change, the project has been extended to September 1995.

The information provided by this project will enable forest managers to determine the timing and extent of single or multiple thinning of fully stocked stands as a tool to maximize volume production and plan thinning prescriptions.

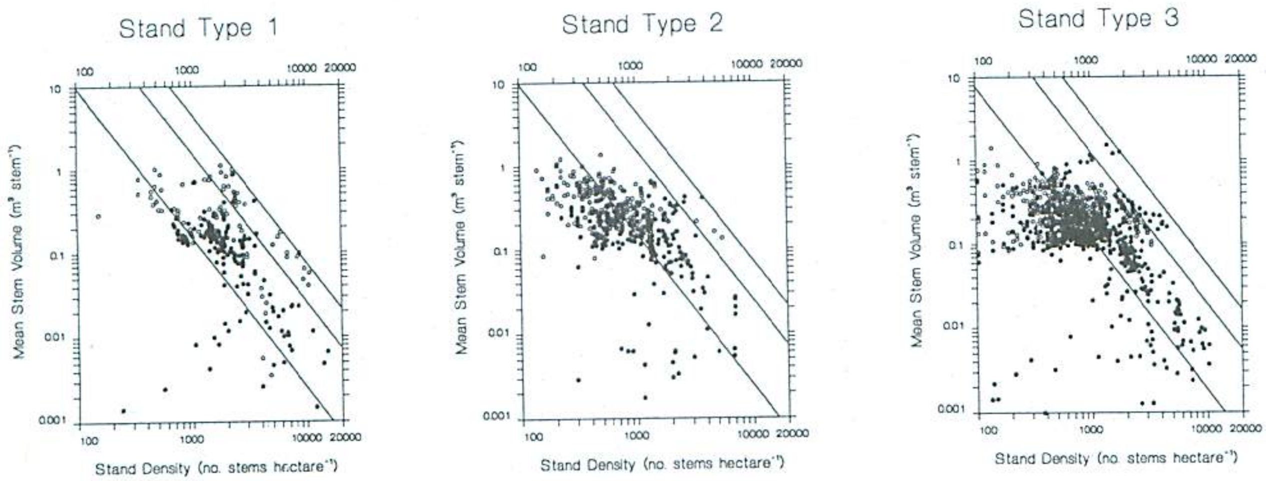

Figure 4223.1. Boreal mixedwood density dependent mortality model for black spruce and jack pine dominated stands. Stand types are identified by the percentage of the basal area for each species within a stand. Stand Type 1 (25 percent Pj; 75 percent Sb). (Figure courtesy of D. Smith.)

Forest Protection

4004

The Development of Bialaphos and Glufosinate-ammonium as Silvicultural Herbicides

Principal Investigator: G.R. Stephenson, University of Guelph, Guelph, ON.
Scientific Authority: R. Wagner, Ontario Forest Research Institute, OMNR, Sault Ste. Marie, ON.

This study will provide fundamental knowledge on differences in the translocation, mode of action, and behavior of glufosinate-ammonium and bialaphos in plants.

Bioassays for glufosinate activity on conifers and competing species were completed in August 1993.

Physiological and Morphological Factors that Influence Conifer Tolerance

During the fall and winter of 1993–94, an extensive growth room study indicated that white spruce (*Picea glauca* [Moench] Voss), jack pine (*Pinus banksiana* Lamb.), white pine (*Pinus strobus* L.), and red pine (*Pinus resinosa* Ait.) were initially very sensitive when sprayed with these chemicals at herbicidal rates near the time of bud break. However, the trees increased in tolerance to sprays of these herbicides at later stages in the growth period.

In May of 1994, white spruce, black spruce, and red pine seedlings were obtained from OMNR for a second growth room study. The goal of this study is to relate the previously observed increases in bialaphos or glufosinate tolerance to morphological or chemical changes in the conifer foliage at four different phenological stages of tree development during a season of growth. Samples have been taken and particular attention will be directed at the analysis of concentration changes in cuticular and epicuticular waxes.

Studies were also initiated with an additional chemical, paclobutrazol, which has been reported to increase epicuticular wax production in plants. For these studies, one-year-old conifer seedlings that had received various pretreatments with paclobutrazol, were treated at various stages of growth with radiolabelled glufosinate. Cuticular penetration and translocation of the radiolabelled glufosinate is being measured as well as any differences in cuticular development in response to the paclobutrazol treatments.

Fate and Impact of Glufosinate Ammonium and Bialaphos in an Aquatic Environment

During June 1994, a series of 30 limnocorrals were constructed and installed in an aquatic environment approximately 100 km northwest of Sault Ste. Marie, Ontario. The aquatic environment was a shallow pond (1 m deep), with a known history. The chemical application of Ignite® (glufosinate-ammonium) and Herbiace® (bialaphos) was accomplished on 2 August 1994. Each experimental unit was sampled for chemical residue (water and sediment), phytoplankton, periphyton, and zooplankton. As well, a visual macrophyte assessment was completed. Samples were taken from 13 to 77 days after application.

Field Evaluations of Bialaphos and Glufosinate for Efficacy and Selectivity as Site Preparation or Conifer Release Treatments

A. Conifer release evaluations

Two large scale plots were established near Thunder Bay in July 1993 to compare the efficacy of glufosinate-ammonium, bialaphos, and glufosinate for control of competing grasses (*Calamagrostis* spp.) and wild raspberry (*Rubus* spp.). It was not possible to find a single research site with sufficient quantities of raspberry and grass together, so separate sites were chosen. In late August, each herbicide was applied at four different rates to four replicate plots at each location. During September, each plot was assessed for herbicide injury by measuring the fresh and dry weights of either the grasses or wild raspberry in 1-m^2 quadrants. The data was used to predict and assess regrowth for the 1994 season.

B. Site preparation evaluations

To test the effectiveness of glufosinate and bialaphos as preplant chemical site preparation treatments, 20 black spruce and 20 jack pine containerized seedlings were planted in June 1994 in each of the 48 treatment plots at both the *Calamagrostis* and raspberry experimental sites. A total of 3,840 trees were planted and measured immediately after planting and at the end of the first growing season in September 1994. The trees planted both prior to and postherbicide treatment will be assessed again in September 1995.

Final reports on each aspect of the project, along with two technical notes, will be submitted when the project is completed in March 1996.

Data generated from this research project will be required for registration of the herbicide, and will aid in the delivery of a biorational herbicide with greater public acceptance and a suitable desiccant for use in prescribed fire programs in Ontario. These naturally produced phytotoxins may provide a cost-effective and efficient alternative to synthetic herbicides.

Alternative Biological and Biorational Control of *Botrytis* Gray Mold in Containerized Conifer Stock

Principal Investigator: J. Sutton, University of Guelph, Guelph, ON.
Scientific Authority: A. Hopkin, NRCan, Sault Ste. Marie, ON.

Gray mold, caused by *Botrytis cinerea* Pers.: Fr., is a major disease of black spruce seedlings and other conifers grown in containers in greenhouses in northern Ontario and elsewhere. This project is evaluating biological control organisms and biorational compounds as alternatives to fungicides for controlling gray mold in containerized conifers, and developing integrated pest management strategies for effective control.

During the initial stages of this project, biological control tests were undertaken on black spruce and red pine seedlings in greenhouse and growth-room environments. Several mycelial fungi, yeasts, and bacteria that effectively suppressed gray mold in preliminary screening tests were used. Various concentrations of sodium silicate and sodium bicarbonate were incorporated into the nutrient system as part of routine watering/feeding beginning 3 weeks after germination. Studies in population dynamics of a biocontrol agent on black spruce seedlings were also undertaken.

Papers on biocontrol in black spruce seedlings, population dynamics of a biocontrol agent on black spruce seedlings, and predisposition toward gray mold as a result of low light intensity have been completed.

A technical note, entitled *Environmental factors predispose container-grown conifer seedlings to gray mold* (NODA Note No. 5) has been published. It reports that 4-month-old seedlings, subjected to varying light, temperature, and moisture conditions, revealed that high temperature, low light intensity, and drought conditions, each and in combination, predispose black spruce seedlings to gray mold. Therefore, researchers suggest that the maintenance of air temperature below 30°C at the soil surface, spacing of seedlings to increase light intensity in lower portions of seedling canopies, and regular irrigation are potential measures for controlling gray mold.

Studies on population dynamics of gray mold on black spruce were completed in May 1994. Second-repetition tests of red pine seedlings, new experiments on biocontrol tests in black spruce seedlings, silicate and bicarbonate experiments in controlled environments, and Paclobutrazol experiments have also been completed.

The final report for this project has been submitted and is being reviewed. Two technical notes on the use of biological control methods to control gray mold and the effect planting densities have on the severity of gray mold are also being completed.

Figure 4010.1. Botrytis cinerea sporulating on killed spruce needles. (Photo courtesy of Dr. J.C. Sutton.)

4012

Silvicultural Prescriptions for Management of White Pine Weevil in Jack Pine

Principal Investigator: S.M. Smith, Faculty of Forestry, University of Toronto, Toronto, ON.
Scientific Authority: G.M. Howse, NRCan, Sault Ste. Marie, ON.

This project is designed to quantify the effects of stand manipulations on the survival of, and damage by, the white pine weevil (*Pissodes strobi* Peck) in young jack pine plantations and to provide predictive information to enable forest managers to reduce weevil populations through silvicultural prescriptions. It is examining innovative pest control practices in jack pine plantations that could lead to long-term management of the weevil.

The research on stand manipulation to increase mortality of weevils set out to demonstrate several techniques for reducing weevil damage on jack pine by reducing litter under trees, augmenting shrew and mice populations, and increasing herbaceous cover. Samples were collected by stratum in two weed and two weed-free plots in each of two stands.

Removal of Litter

Because of a demonstrated poor relationship between the depth of the duff and overwintering mortality of weevils, this component of the research was discontinued.

Increasing Shrew Predation: Effects of Herbaceous Cover on Weevils and Mammalian Predators

A. Vegetation biomass

The samples of vegetation per stratum taken in the summer of 1993 were analyzed in 1994. Total vegetation biomass was lower in the weed-free than in the weed patch.

B. Weevil damage

In Stand 1, the jack pine was taller in the weed-free than in the weed patch. Weevil damage to jack pine, based on the number of dead leaders, was similar in the two patches. Data in Stand 2 will be analyzed.

C. Overwintering mortality

The open and exclusion cages established in the fall of 1993 were assessed in the spring of 1994. No significant difference was found in the number of weevils surviving in the weed and weed-free patches, suggesting that overwintering mortality of weevils was not affected by the presence of competing vegetation. Mammalian predation was significant in the weed patch (where more small mammals were caught), but not in the weed-free patch.

D. Mammalian predators

Sampling of small mammals was conducted by live and dead trapping in weed and weed-free patches in two weevil infested stands during June–October 1993 and June–November 1994. Sample analyses were completed for 1993 and 1994. In the summer of 1993, population dynamics of shrews differed between weed and weed-free patches. The total number of captured shrews and mice was higher in the weed than in the weed-free patch in Stand 1, but it was similar in Stand 2. Data on microhabitat selection by mammalian predators were taken during the summer of 1994.

E. Other beetles

Arthropods were collected in pitfall traps during summer–fall 1993–94. In 1993, the number of arthropods in general and beetles in particular was higher in the weed than in the weed-free patch during June–July, and lower during August–September.

Forecast of Weevil Impact

A. Weevil activity and damage

Analysis of field data from 1993–94 showed a good correlation between number of oviposition holes/leader and the percentage of leaders dying in a stand. Progressively poorer regressions were observed for the percentage of leaders dying and the number of feeding holes/leader and the number of adult weevils observed/leader. This suggests that the number of oviposition holes/leader can be used to predict damage, but from a manager's perspective, this does not provide sufficient lead time to implement satisfactory control measures.

B. Year-to-year population prediction

During the fall of 1994, Forest Insect and Disease Survey (FIDS) Unit data on permanent sample plots were collected and preliminarily examined. This data provides for yearly infestation rates of 6,000 individual trees over 6 years of differing ages and stand density and will allow the determination of whether a relationship between percentage of leaders killed in one year and those killed in subsequent years exists.

C. Long-term Impact

Discussions with FIDS personnel and examination of their data suggests that there is sufficient information to combine it with the data from this project and produce a report addressing the long-term impact of leader loss on the merchantability of jack pine. This data provides perspectives from both the individual tree as well as the stand level and includes data for different stand ages and densities. The proportion of trees with repeated leader losses at different ages can be determined and then used to predict the impact of leader loss on tree survival at the stand level.

Based upon this work, an article, *Predation and overwintering mortality of the white pine weevil, Pissodes strobi Peck, in planted and seeded jack pine*, has been published in the Canadian Journal of Forest Research (24:1426–1433). The following additional journal articles are in various stages of publication.

Bellocq, M.I.; Smith, S.M. 1994. Arthropods preferred as food by *Sorex cinereus* (masked shrew) and *Peromyscus maniculatus* (deer mouse): An experimental approach. Mammalia 58:391–396.

Bellocq, M.I.; Smith, S.M. Management of *Pissodes strobi* (Coleoptera, Curculionidae) in jack pine forests in Ontario, Canada: Pest mortality factors and microhabitat selection by mammalian predators [in Spanish]. Ecologia Austral. (In press.)

Bellocq, M.I.; Smith, S.M. Influence of reforestation technique, slash, competing vegetation and duff depth on the overwintering mortality of *Pissodes strobi* (Coleoptera, Curculionidae), the white pine weevil. Forest Ecology and Management (submitted in November 1994).

A technical report linking all data to provide information for management of this pest, and two technical notes are expected in May 1995. Through collaboration with the FIDS program, results of this study will be directly available to field personnel for incorporation into the current sampling program.

Figure 4012.1. Overwintering cages to assess the effect of litter depth on weevil survival -- spring emergence 1992. (Photo courtesy of Dr. S.M. Smith.)

4024

Guidelines for Rating Root Rot Hazard Based on Ecological Site Character and Inoculum Level

Principal Investigator: M.T. Dumas, NRCan, Sault Ste. Marie, ON.

This project is investigating the relationship of root rot infection hazard to site character, as rated by the Forest Ecosystem Classification (FEC) system, and assessing the impact, distribution, and intensity of root rot infection in Ontario's Northwest Region. An interpretative manual will be produced with guidelines for rating root rot infection hazard on sites being regenerated to spruce, with a site-specific set of root rot control recommendations.

During the first year of the project (1992–1993), sites in northwestern Ontario were chosen from a list prepared jointly with personnel from the Ontario Ministry of Natural Resources (OMNR), OMNR Northwest Region Science and Technology (NWRS&T), Abitibi-Price Inc., and Avenor Inc. All sites on the list are being regenerated to black spruce and are in the stand age range of 5–15 years.

Researchers developed a list of characteristics, which provides 90 percent confidence that root rot is present, for determining healthy trees from those affected. Methods for sampling sites were tested, and a description of the parent population was prepared from the listing of candidate sites.

Early evidence confirmed that species of *Armillaria* are causing most of the damage. The initial plan was to isolate and identify species of *Armillaria* from a subsample of collections. The project was later modified to allow for identification of all collections (more than 300) to a species level. This will provide data about which species are present for each plantation. This additional information will be useful as species of *Armillaria* vary in virulence, and certain species may be associated with more heavily damaged plantations.

During the 1994 season, data on site, inoculum, and rot intensity variables was collected for input to ordination analysis. *Armillaria* trap logs were installed and foliar samples were collected in the fall. This was followed by laboratory analysis and initial data management and analysis.

A root rot impact report, detailing the influence on the black spruce population in the sample area and based on damage assessed during the survey of sample sites, is expected in mid-1995. A manual containing guidelines for rating root rot hazard, with emphasis on postcut appraisal and use of FEC classifications, inoculum level, and other characteristics identified by the project to rate hazard, is expected to be completed later in 1995. Also to be completed later is a report containing control recommendations relative to site character and root rot hazard.

The project will provide managers with site selection criteria to identify sites on which root rot damage can be expected to be substantial. A technology transfer workshop will be scheduled to present results and publications.

Development of Aerial Survey Methodology for the Evaluation of Balsam Fir and White Spruce in Stands Affected by the Eastern Spruce Budworm

Principal Investigator: J.H. Meating, NRCan, Sault Ste. Marie, ON.

This project is developing a relatively inexpensive aerial survey methodology for the evaluation of host condition in stands affected by the eastern spruce budworm (*Choristoneura fumiferana* [Clem.]). The methodology could be used to record and identify a number of phenomena that threaten forests, including insect outbreaks, disease, fires, and environmental damage.

Experimental flight lines were located in the Thunder Bay and Nipigon districts, and flown in July and August 1992. Ground surveys were then conducted to evaluate stands along the flight lines.

Some technical problems, encountered during the videography flights, were not detected until the tapes were being processed. Initial problems with the Geographic Information System (GIS) patch to the flight videotape made it difficult to relate video images to specific ground locations.

During the winter of 1992–93, aerial survey technicians viewed the videotapes, and researchers compared their interpretations with each other and with ground tests.

In 1993, the same blocks were reflown in an attempt to improve the quality of imagery. Flight altitudes, light conditions, and shutter speeds were varied from the 1992 flights.

Preliminary comparisons suggest that the 1992 videotapes, taken at 500 feet in early morning and late evening, provide the best imagery.

A draft report is now being reviewed. It concludes that aerial videography will provide a permanent record of forest conditions over a significantly larger area than can be evaluated by ground surveys, for a significantly lower cost per hectare. There are, however, difficulties with variation in interpretation of eastern spruce budworm damage to host trees in videoplots with the underestimation of host tree mortality.

4028

Evaluation of Site Preparation Methods on the Development and Progression of Root Decay Fungi with Emphasis on *Armillaria*

Principal Investigator: M.T. Dumas, NRCan, Sault Ste. Marie, ON.

The objective of this project is to determine the species of *Armillaria* and relative levels of inoculum present on sites that were treated with various scarifying techniques and then seeded, and to compare and correlate the infection rate by *Armillaria* spp. with seedling mortality and the method used to prepare the site.

During 1993, plots were established in the Northwestern Region near Madden Lake, and in the Wawa–Chapleau region. Sporophores and infected wood samples were collected, and mortality rates were determined in sample plots.

By late summer of 1994, researchers had determined the level of infected trees in each plot, cultured and identified the decay pathogens, and established trap logs in each plot. During the winter of 1994–95, they determined the species of *Armillaria* present.

Written project results will be submitted in December 1995. The results of this project will benefit foresters in the implementation of techniques to minimize or alleviate the establishment of decay fungi at an early stand age.

Monitoring Changes in Forest Fire Hazard using Satellite Remote Sensing Data

Principal Investigator: T. J. Lynham, NRCan, Sault Ste. Marie, ON.

This project investigates the use of the Normalized Difference Vegetation Index (NDVI) for monitoring changes in forest fire hazard. NDVI is a measure of "greenness", which is an indicator of forest fire hazard. NDVI values calculated from Advanced Very High Resolution Radiometer (AVHRR) data were used to assess vegetation greenness in 1993 for northern Ontario. LANDSAT Multi-Spectral Scanner (MSS) data were also used to calculate NDVI to monitor localized changes in greenness in the Sudbury basin over a 20-year period, starting in the early 1970s. AVHRR data have a resolution of about 1 km and are suitable for examining large land areas. LANDSAT MSS data, with a resolution of 50 km, are useful for studying smaller land areas in more detail.

AVHRR data were acquired from the Manitoba Remote Sensing Centre in Winnipeg, Manitoba. The data were processed using the GEOCOMP system that produces geocorrected, composited data. GEOCOMP produces 10-day composites, using cloud-free portions from a series of daily images. Twenty composites were produced for Ontario to cover a 200-day period from mid-April to mid-October 1993. LANDSAT data were acquired from Radarsat International in Vancouver, British Columbia. Geocorrected images of the Sudbury basin were acquired for the years 1974, 1976, 1980, and 1991.

NDVI data results from a calculation using infrared and visual (red) satellite data. NDVI is a single pseudo-band that is visually represented by gray tones. Bright areas represent higher chlorophyll response and hence a greater degree of vegetation development. By assigning colors to ranges of gray tones, it is possible to produce a color image that shows the levels of greenness in the image. A color assignment that was first developed by the United States Forest Service was modified for use in Ontario. A vector outline of the districts and regions of Ontario was acquired from the Ontario Ministry of Natural Resources to overlay on all greenness maps. In addition, a water mask of Ontario lakes was added to each image.

Twenty greenness maps were produced for 1993. A series of eight sample sites was chosen across the ecodistricts of Ontario to acquire statistics from the image data and to examine the trends in greenness from April to October. In general, southern sites have a higher peak greenness. This is probably due to the dominance of broadleaf tree types and the longer growing season. Beginning in April, all sites show a gradual increase in greenness that peaks in July or August and decreases rapidly in the late summer.

Researchers have started to receive GEOCOMP data for 1994 and will compare this with data from 1993. Because 1993 was so cloudy, it was not possible to acquire cloud-free imagery during the spring, which is the most important time for monitoring fuel hazards. The data show that 1994 was more cloud-free than 1993.

The LANDSAT MSS data that were acquired for the Sudbury basin match the National Topographic Series map sheet for the Sudbury area. The greenness maps reveal a general lack of vegetation in 1974. By 1991 the area has a normal appearance with respect to greenness, indicating a significant reduction of the hazard in the fuels surrounding Sudbury.

Data were also acquired on sulphur dioxide emissions in the Sudbury basin from 1960–1993 (Fig. 4029.1). The reduction in sulphur dioxide emissions around Sudbury has permitted some re-vegetation of the area. This increase in greenness is partly responsible for the reduction in the number of forest fires in the Sudbury district. Figure 4029.2 shows the high expected number of fires that might have occurred (since 1982) based on the trends of the 1960s and 1970s. It also shows the lower number of fires that actually occurred since 1982.

At the outset of this project, researchers had hoped to relate areas of greenness on the map images to areas that were sampled on the ground. However, ground sampling proved to be much more time-consuming and costly than anticipated, and was not undertaken.

The result of this project is a prototype method for monitoring vegetation greenness over the forest of Ontario. This will provide a tool for provincial fire management agencies to monitor changes in vegetation greenness for specific forest areas and will result in a method for determining areas of increased forest fire hazard. A final report has been prepared and is being reviewed for publication.

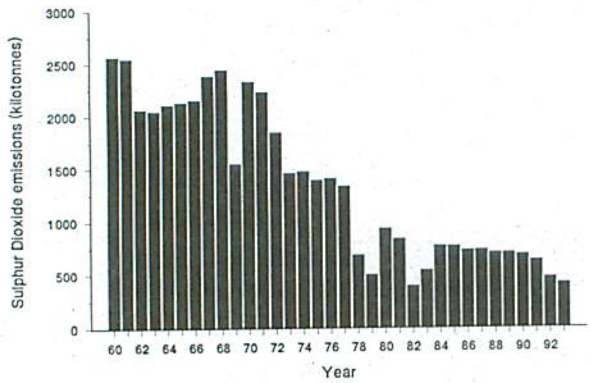

Figure 4029.1. Sulphur dioxide emissions for Sudbury, Ontario, from 1960–1993. (Source: Ministry of Energy and Environment, Sudbury, Ontario).

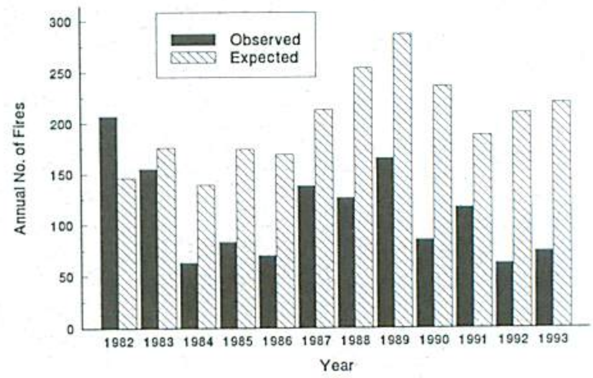

Figure 4029.2. A comparison of observed and expected annual fire occurrence rates for Sudbury, Ontario, from 1982–1993. (Figure courtesy of T.J. Lynham.)

Management Guidelines for Jack Pine Budworm

Principal Investigator: G. M. Howse, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop jack pine budworm (*Choristoneura p. pinus* Free.) impact estimators that will provide accurate predictions of growth loss, top kill, tree mortality, decay, and defect in order to develop guidelines for the management of jack pine budworm in northern Ontario. More information is needed to relate population levels of the jack pine budworm and subsequent damage caused by the insect in terms of individual tree or stand characteristics such as age, height, stand composition, stocking, site, and environmental indicators (e.g., drought).

A total of 96 plots were established in 1992, 52 in northeastern Ontario and 44 in northwestern Ontario. There were some initial difficulties in locating accessible, overmature stands. Foliage samples were collected to estimate defoliation, flowering, and egg-mass and L_2 densities. An additional 83 plots were established in 1993. Jack pine budworm defoliation was aerially mapped in the summer of 1993.

At the conclusion of the 1993 season, researchers summarized the situation and made forecasts for 1994. They noted that the total area of moderate to severe defoliation had increased from 158 784 ha in 1992 to 282 247 ha in 1993. All the defoliation occurred in the eastern part of the province, in the Sudbury, Temagami, Sault Ste. Marie, Parry Sound, Algonquin Park, and Pembroke districts. The largest increase, much of which was new infestation, occurred in the Sudbury District.

Egg-mass surveys carried out in 271 locations showed an increase of 16 percent in 1993 over 1992. Increases were recorded in the Parry Sound, Sault Ste. Marie, Sudbury, and Temagami districts; decreases were recorded in the Pembroke, Algonquin Park, and North Bay districts. These results suggested that infestations in 1994 would probably persist in most of the areas in which they occurred in 1993, and indicated a potential for expansion in the Sudbury and North Bay districts. In the Parry Sound District, where the infestation had persisted for the past 4 years, much of the host in the infested area was damaged in 1993. This suggested that populations may decline in 1994 despite an increase in egg-mass densities. Populations, based on egg-mass counts, remained low in the Northeast Region and declined to very low levels in the Northwest Region.

A survey of stands in affected areas of Parry Sound District showed a single body of dead and moribund jack pine along the Georgian Bay coast between Point au Baril and the Pickerel River. Smaller scattered pockets of dead jack pine were also recorded in Shawanaga, Mowat, Wallbridge, Blair, and Brown townships. Results from four 100-tree mortality plots in this area show the incidence of bare tops ranging from 13 to 40 percent and dead trees ranging from 26 to 38 percent.

A Jack Pine Budworm Workshop was held in Sault Ste. Marie in October 1993. This was followed by another symposium for an in-depth information exchange in Winnipeg in January 1995. An information report, *Aftermath of a jack pine budworm infestation*, has been prepared. It reports on examination of a jack pine budworm infestation from 1982–1986, 5 years after defoliation stopped. A summary follows:

> Based on previous studies, by 1989 stands were expected to recover growth to preinfestation levels. The current study confirmed this for most situations. However, growth loss due to mortality and poor recovery by trees that suffered dead top injury indicated a prolonged period of growth impact for some of the more severely injured stands. Mortality of dominant and codominant trees was negligible in most stands, including a semimature stand with considerable dead top injury. No evidence of *Armillaria* root rot was detected on the root systems of trees in this stand, but the fungus *Armillaria* spp. was recovered from stumps and dead suppressed trees. *Armillaria* root rot was known to be present in another severely injured stand. There, *Armillaria* spp. was noted on trees that had recently died, and on the roots of live trees that showed crown symptoms typical of root rot. In this stand, root rot continues to kill trees, most of which are experiencing poor growth recovery following budworm defoliation. Dead top injuries had very little stain or decay infection present at the juncture with the live crown. Growth recovery was poor for dead topped trees, and trees with dead tops 3 m or more in length generally did not form a new crown top. Those with dead tops less than 3 m in length produced new crown tops that often had several terminals.

Two final reports will be produced as a result of this research. The first will describe the progression of the jack pine budworm infestation and its impact on forest characteristics; the second will present a set of management guidelines for the jack pine budworm.

The results of this research will enable foresters to better target protection efforts and reduce spraying costs.

4112

Advanced Forest Pest Management Training Program

Principal Investigator: C. Howard, NRCan, Forest Pest Management Institute, Sault Ste. Marie, ON.

The objective of this project is to develop two advanced courses in forest pest management and deliver them as part of the Advanced Forest Pest Management Training Program. The two courses, up to 10 days in length, are: The Integrated Forest Pest Management Course and The Forest Insect Management Course.

The Integrated Forest Pest Management Course has been developed and was delivered during the fall of 1994. The Forest Insect Management Course has also been developed, and is scheduled for delivery in February 1996.

In addition, an Integrated Pest Management Course for Forest Nurseries has been developed and will be delivered in June 1995. The Ontario Ministry of Natural Resources (OMNR) provided sponsorship for all of these courses.

Along with the already-developed Advanced Forest Herbicides Course, these courses will form the Advanced Forest Pest Management Training Program, which is administered by the Canadian Forest Service – Sault Ste. Marie in partnership with the OMNR, the Canadian Institute of Forestry, and the Ontario Training and Adjustment Board.

Figure 4112.1. The Advanced Forest Pest Management Training Program will provide the forest management with environmentally sound pest management methodologies.

Root Rot Fungi and their Relationships with Aboveground Decay in Three Conifers in Ontario

Principal Investigator: R. D. Whitney, Forest Pathology Consultant, Sault Ste. Marie, ON.
Scientific Authority: H. L. Gross, NRCan, Sault Ste. Marie, ON.

The project objective is to publish the identity, age, and site relationships of root rot fungi in three coniferous species in northern Ontario, and to determine relationships between the main root rot fungi and their aboveground decay in these conifers.

Findings have been submitted in two papers: *Root rotting fungi in three northern Ontario conifers*, and *Relationship between decayed roots and aboveground decay in three conifers in Ontario*, and are summarized as follows:

Fungi associated with root rot in living trees were isolated and identified in a sample of white spruce (*Picea glauca* [Moench] Voss), black spruce (*Picea mariana* [Mill.] B.S.P.), and balsam fir (*Abies balsamea* [L.] Mill.), ranging in age from 26 to 227 years, in 165 stands across northern Ontario. Trees were pulled out of the ground with the winch of a skidder, root decays and stains were measured, and cultures were made from root and butt sections. *Armillaria ostoyae* (Romagn.) Herink was the most frequently isolated fungus. It occurred in 32, 34, and 46 percent of the white spruce, black spruce, and balsam fir, respectively. *Inonotus tomentosus* (Fr.:Fr.) S. Teng, *Scytinostroma galactinum* (Fr.) Donk, and *Coniophora puteana* (Schumach.:Fr.) P. Karst. were next in frequency, in that order. An additional 25 basidiomycetes were associated with lesser amounts of root rot in the three species. *Armillaria ostoyae* infected and remained mostly below ground in all three species, averaging less than 0.3 m in height up the living stem in living trees. Most of the other major fungi advanced more than .5 m on average up the stem of infected trees. The frequency of *Armillaria ostoyae* in white spruce and black spruce increased with tree age to about 80 years, then dropped off. This was probably due to diseased trees falling out of the stand. An age relationship was not found with this fungus in balsam fir. The other fungi generally increased in frequency of occurrence with tree age. The only major fungus that attacked living tissues (sapwood) exclusively to any extent, was *Armillaria ostoyae*. Some minor fungi such as *Resinicium bicolor* (Alb. & Schwein.:Fr.) Parmasto and *Serpula himantoiodes* (Fr.:Fr.) P. Karst. indicated pathogenicity by initially attacking sapwood. *Armillaria ostoyae* infected significantly higher numbers of black spruce and balsam fir growing on dryer sites (lower Moisture Regimes) than on wet sites (MR 6). The only other fungus apparently related to MR was Unknown F, which infected more black spruce on wet than dry sites. Significantly higher proportions of root and buttwood of all three species were infected with *Armillaria ostoyae* and *Inonotus tomentosus* in northwestern Ontario than in northeastern Ontario. Heavy to severe root rot was required for tree height or diameter growth reductions to be shown when trees were infected either by *Armillaria ostoyae* or *Inonotus tomentosus* alone, or conversely by grouping all fungi. An ascomycete, *Ascocoryne sarcoides* (Jacq.:Fr.) J.W. Groves & D.E. Wilson was associated with pink or faint brown stains, often near bark seams, in white spruce and black spruce. It was isolated from roots of 20 percent and 28 percent of these species, respectively.

Tree damage from root rot that remains below ground is seldom evaluated due to inaccessibility. Indicators of aboveground decay have been described for some conifers, but a considerable proportion of roots can be infected and killed prior to any aboveground external symptoms. The tedious and costly procedure of exposing roots for root rot evaluations could be alleviated if root rot at, or above, ground level could be related to belowground root rot. This relationship was examined in the trees excavated or pulled over for root rot evaluation and identification of causal fungi.

Figure 4117.1. Plantation white spruce windfall with heavy root rot caused by the "white pocket" fungus (Inonotus tomentosus). (Photo courtesy of R.D. Whitney.)

In this study a relationship between root decay and stain below ground, and that at 15 cm above ground, was found. The correlations were high in all three species (R^2=0.82 white spruce, 0.81 black spruce, and 0.79 balsam fir). For individual fungi, however, there was considerable variation. Correlations with *Armillaria* root rot were poorer in all tree species than for other fungi. This could be expected since decay of *Armillaria* does not extend as far above ground as that of other fungi tested.

In addition to these two reports, a workshop to provide a practical demonstration of the types of root rot to forest managers was held during Silvilog '93 in the Copeland Forest near Barrie, Ontario.

Forest Fire Behavior Guidelines for Jack Pine Stands in Northern Ontario

Principal Investigator: B. J. Stocks, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a 90- x 100-cm poster describing fire behaviour in jack pine stands under a broad range of weather conditions. Such a poster should increase the understanding and effectiveness of forest fire managers in Ontario.

The poster is patterned after similar ones that have been prepared for other Canadian fuel types, including 12–15 pictures surrounded by text, tables, and graphics, and is now available.

The poster will be appropriate for display in offices and for training purposes, and will enhance the manager's ability to analyze and make fire management decisions more effectively.

Figure 4119.1. Experimental crown fire in 1948-origin jack pine. (Photo courtesy of B.J. Stocks.)

4120

Field Guide to Ontario Tree Diseases

Principal Investigators: D. T. Myren, C.N. Davis, NRCan, Sault Ste. Marie, ON.
T. Meyer, OFRI, OMNR, Sault Ste. Marie, ON.

This project marks the culmination of the lifelong career in forest pathology of Dr. Myren who, sadly, passed away in June 1994.

The purpose of this project is to produce a pocket-sized guide for use in the field to identify tree diseases, to recognize and understand disease impacts, and to provide recommendations for appropriate forest tree disease management actions for approximately 150 diseases.

When complete, the full color field guide will provide information to forest managers and planners and in turn allow them to address potential disease outbreaks during their planning activities.

Prescribed Fire Ignition Strategies for Northern Ontario

Principal Investigator: D. J. McRae, NRCan, Sault Ste. Marie, ON.

This project will produce a handbook for fire operations, and detail ignition strategies for the purpose of increasing the effectiveness of the prescribed burning program for northern Ontario. The publication will become part of the Canadian Prescribed Fire Expert System, and will incorporate information allowing a prescribed fire ignition boss to plan the specific fire ignition strategy of a burn.

Topics will include: best ignition technique and patterns; manipulation of energy-release rates to control the prescribed fire; proper perimeter ignition procedures to prevent fire excursions; procedures to prevent the burning of Areas of Concern; proper procedures in initial burning out efforts; and the proper distance between ignition incendiaries and ignition lines.

A draft of the manuscript, *Prescribed fire ignition strategies*, has been completed and is being reviewed.

By enabling prescribed fire planners to better achieve their objectives, the handbook will reduce the damage potential and suppression costs related to undesired fire excursions.

Figure 4121.1. Understanding proper ignition strategies is important for maintaining control of the prescribed fire and for achieving treatment objectives. (Photo courtesy of D.J. McRae.)

4201

Application of Portable GPS/Desktop-GIS for Fire Management Support

Principal Investigator: D. Tortosa, ELIRIS Inc., Sault Ste. Marie, ON.
Scientific Authority: B.J. Stocks, NRCan, Sault Ste. Marie. ON.

This four-phase project, completed in late 1993, has provided OMNR's Fire Operations Headquarters with a system that is used in daily fire operations. The following abstract from the final technical report, entitled *Application of a portable GPS/desktop mapping system for fire management support* (NODA/NFP Technical Report TR-15) provides a good summary of project activities:

The objective of this project is to demonstrate the feasibility of implementing a user friendly, portable, low-cost technology using a Global Positioning System (GPS) receiver and a notebook-based desktop mapping system for the rapid updating, inventory, and analysis of forest fires on a near-real time basis".

Field trials of the GPS/desktop mapping system were completed in the summer of 1992 at the Ranger Lake Fire Attack Base, with the support of the Ontario Ministry of Natural Resources (Aviation, Flood and Fire Management Branch and Sault Ste Marie OMNR District Office) and the Canadian Forest Service–Sault Ste. Marie.

Trial tests consisted of helicopter-borne GPS to determine fire perimeter, location of hot spots and lightning strikes, and the location of values. Ground GPS was used to survey logging roads, values, and prescribed burn perimeters, and to access identified locations from helicopter-borne GPS. Traditional methods were compared with the GPS/ desktop mapping system.

All GPS data was transferred to a desktop mapping system in near-real time using ELINX, a GPS-desktop mapping linkage software. The GPS data was initially converted into a database structure containing pertinent satellite, locational, time, and accuracy information. The point data was then filtered using spatial and database queries, and if required, a polyline or polygon was produced.

Operational testing of the GPS/desktop mapping system was completed in the summer of 1993 by a fire crew based in the Ranger Lake Fire Attack Base, Sault Ste. Marie OMNR District.

The results of the project indicate that a portable GPS/ desktop mapping system can be integrated into the day-to-day operations of a typical fire attack base and, if necessary, can be relocated quickly into temporary field camps to assist in fire management. Fire crews and crew leaders can be trained in the use of GPS and desktop mapping within a week. Information on area and perimeter of a fire is available immediately after the transfer of the GPS data; high quality maps showing the location of values at risk and perimeter of the fire, along with drainage, topography, and transportation routes can be produced within a few minutes using plotter emulation software on an inkjet printer.

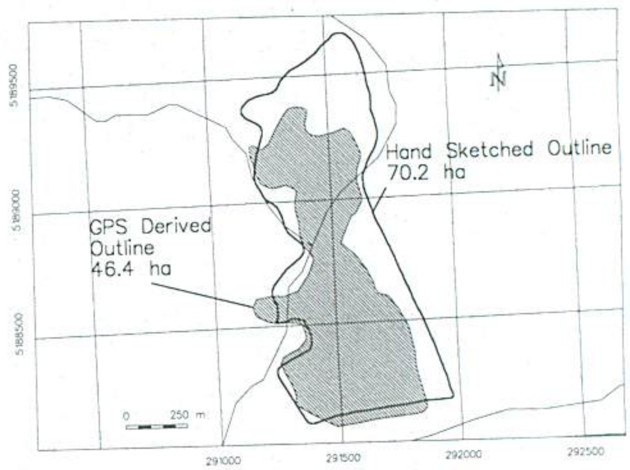

Figure 4201.1. GPS-determined fire boundary overlain by hand-sketched boundary for Fire 28, Ranger Lake Fire Attack Base. (Figure courtesy of D. Tortosa.)

Predictive Tools for Management of the Jack Pine Budworm

Principal Investigator: V. G. Nealis, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a decision-making protocol based on sampling methods and predictive equations that relate information on population levels of various stages of the jack pine budworm (*Choristoneura p. pinus* Free.) to levels of defoliation in a stand. It will provide a method of estimating the risk of damaging infestations at the stand level and will enhance the ability of forest managers to determine meaningful levels of protection.

In 1992, sample units were defined and distribution of egg masses on various branch subunits was delineated. Most eggs were found on basal branch portions. The expression of density was tested in various ways. The total number of egg masses per unit was found to be the least variant expression.

Distribution of egg-mass numbers over various sample units has been evaluated, and final analysis is in progress. The relationship between survival of budworm and the number of pollen cones has been quantified. This data has been analyzed and is now being tested.

During 1993, five scientific presentations were made at two national meetings, one provincial meeting, and one university seminar. Also, data was used by a graduate student for completion of a directed studies course at the University of Waterloo. A scientific symposium on jack pine budworm in Winnipeg, coorganized with G.Howse (FIDS) and J. Volney (CFS–Northern Forestry Centre) was held in January 1995. Proceedings from this symposium will be published as an information report.

The final results from this project are presently being delivered.

Since control programs have a considerable financial, environmental, and political cost, they must be undertaken only where unacceptable damage is forecast. This project will develop risk and forecast models to plan and justify both spray and no spray decisions by forest managers.

4210

Development of an Eastern Spruce Budworm Hazard Rating System for the Forests of Northern Ontario

Principal Investigator: J. H. Meating, NRCan, Sault Ste. Marie, ON.

The objectives of this project are to develop a hazard rating system to assist forest managers in assessing the susceptibility and vulnerability of forests in northern Ontario to spruce budworm (*Choristoneura fumiferana* [Clem.]) attack by developing a spruce budworm susceptibility map; to develop a spruce budworm vulnerability map and predictive vulnerability models for the major budworm hosts; and to develop a process for the production of an annual spruce budworm hazard report.

In 1992, stand information was collected from 490 potential plots and data was analyzed for final plot selection.

During 1993, GIS technology and FRI data were used to develop and produce a "first generation" spruce budworm susceptibility map and to establish a network of impact plots, totaling 225 throughout northern Ontario, to provide data for model development. All plots were surveyed and sampled for budworm populations in 1994.

A vulnerability index was calculated for each basemap/township in Ontario. A rough map was produced, but it will require extensive refinement.

A contract has been established with Aurora Resources Consulting to enable the production of the susceptibility map.

These changes have resulted in delays in further map development, and in the production of the first spruce budworm hazard report.

Predicting Budworm Outbreaks with Pheromone Traps

Principal Investigator: C. J. Sanders, NRCan, Sault Ste. Marie, ON.

The objective of this project is to implement a spruce budworm pheromone trap monitoring system for Ontario based on data collected over the past 7 years. Relationships between pheromone trap catch and other population parameters, such as larval densities, will be examined using data collected annually since 1986 from 50 locations across northern Ontario and from another 100 locations since 1992. These cover the advancing front of a spruce budworm outbreak in northeastern Ontario.

In 1993 ACCESS/IDRISI, Geographic Information System (GIS) PC-based software, was developed for data entry and analysis; 1993 trap-catch data were filed; files were transferred from MINITAB and verified; and digitized and vector maps of Ontario were incorporated to allow GIS mapping to begin.

During 1994, the data entry computer program and manual were refined; GIS mapping of annual trap catch data was completed; maps of annual changes were produced; relationships between trap catch and defoliation were determined; text was prepared for videotape presentation and videotaping of field operations was carried out; final GIS analyses of trap catch and relationships to defoliation forest type were prepared; and a progress report was presented at The Spruce Budworm Research Work Conference in St. John's, Newfoundland, in April 1994.

This project is now being concluded and a user's manual, entitled *Pheromone traps for predicting spruce budworm outbreaks: A user's manual,* has been submitted for review. The manual outlines protocols for deploying and handling the traps in an operational program, and for processing and interpreting data. A report, entitled *Data management system for the spruce budworm pheromone trapping network: User's guide,* has also been completed. A videotape has been prepared for use as an educational tool, and to enlist the support and cooperation of provincial and industry managers. Workshops will be planned to familiarize staff with the use and handling of traps.

4226

Application of Real-time Differential GPS and Real-time Tracking for Fire and Resource Management

Principal Investigator: D. Tortosa, ELIRIS Inc., Sault Ste. Marie, ON.
Scientific Authority: A. Robinson, NRCan, Sault Ste. Marie, ON.

This project is designed to follow up on Project No. 4201 (*see* page 74) and assess the capabilities and limitations of a (Global Positioning System GPS)/desktop-Geographic Information System (GIS) for advanced applications requiring greater accuracy and a "real-time" response capability, and to illustrate its application and utility for aerial spraying. The project has now been completed and the final report and technical note are being reviewed. The abstract from the final report follows.

Several methods of GPS positioning using code-correlating GPS receivers were tested against second order control points to determine accuracy and precision limits. These methods included: standard GPS positioning; real-time Digital GPS (DGPS) using the US Coast Guard radio beacon at Whitefish Point, Michigan; real-time DGPS using UHF radio modems; and postprocessed DGPS for comparison.

The results of accuracy tests for real-time DGPS methods indicated that it is possible to establish survey control and carry out kinematic real-time DGPS surveys that meet the standard 1:20 000 Ontario Base Map (OBM) horizontal position accuracy requirements using standard code-correlating GPS receivers and UHF radio modems, and to quickly incorporate and overlay the results on a digital OBM using desktop-GIS.

The range of operation for real-time DGPS methods indicated that the US and Canadian Coast Guard radio beacon signal can be received inland in areas of low relief, but they do not penetrate typical Canadian Shield terrain north of Lake Superior. The range of operation for real-time DGPS using UHF radio modems is dependent on the surrounding topography and the antenna height. The range of operation for real-time tracking using UHF radio modems for aircraft or vehicles is similar to or less than the range of operations for real-time DGPS.

The necessity of using real-time DGPS is dependent on several factors, such as: the availability of and access to US/Canadian Coast Guard differential corrections; the extent to which navigation is a critical component to the application; the number of applications which require DGPS; the topographic relief and nature of the terrain; and the accuracy requirements of a particular application.

The project demonstrated the potential for GPS/desktop-GIS with real-time capability to meet many of the resource management requirements being brought about due to environmental concerns and new timber management practices. Potential natural resource applications were also described. Together, both projects demonstrated the economic benefits of such technology through the rapid technology transfer that took place during the course of the projects.

Environmental Impacts

Assessing the Short-term Effects of Timber Harvest Within Riparian Zones on the Wildlife of Wetlands

Principal Investigator: R. Koistinen, Teme-Augama Anishnabai, Bear Island, ON.
Scientific Authority: K. Abraham, Southern Terrestrial Ecosystem Section, OMNR, Maple, ON.

The objective of this project is to document the short-term effects of commercial timber harvest in wetland riparian zones on the composition of the associated wildlife community and, if effects are detected, to evaluate the mitigating value of 30-m shoreline reserves.

The establishment and ongoing activities for this project have been greatly assisted by the involvement of a steering committee, with representation from the OMNR, the Mid North Forest Industry Alliance, the Temagami Trapper's Council, and the project coordinator (T.W.'s Ecological). Initially, 45 wetlands in Thistle, Fell, Sisk, and McWilliams townships were included in the study. These represented three harvest groups: 0-meter reserve, 30-meter reserve, and control (no harvest). Both mixedwood and jack pine conifer forest types are represented.

In 1993, the project focused on accumulating and analyzing preharvest data in selected wetland areas. Methodologies and sampling protocols were developed for all aspects of the study through discussion with members of the scientific community, and access trails and observation stations were established. To date, progress is as follows;

- Winter wildlife track counts were carried out by Teme-Augama Anishnabai field personnel in 21 wetlands; 12 species were observed.
- An owl vocalization survey was conducted by volunteers on 41 wetlands; 19 observations of five owl species were made.
- Bird observations were carried out by ornithologists under contract with the Canadian Wildlife Service (CWS) on 45 wetlands; 95 species of birds were observed.
- Water samples were collected from 45 wetlands. Inflow and outflow channels were sampled and 25 parameters were tested.
- Aquatic biota were collected from 24 wetlands. Samples were then frozen and taken to the Royal Ontario Museum for taxonomic identification.
- Water depth and maximum/minimum temperatures were recorded in nine wetlands.
- Wetland perimeter/edge forest was surveyed adjacent to study wetlands.
- Aerial video of study wetlands was taken using a fixed-wing aircraft, so as to offer a more readily accessible perspective of forests before and after harvest.
- Arrangements were made with the OMNR and the forest industries involved regarding winter timber harvesting according to treatment objectives.

Five wetlands scheduled for harvest in the winter of 1993–94 were not, in fact, harvested. As a result, the number of wetlands under study was reduced from 45 to 30 to ensure an appropriate balance of wetland types and harvest conditions. Of the 30 wetlands, 20 are classified as marsh and 10 as fen.

Postharvest monitoring commenced in the spring of 1994. Used once again were the methodologies and sampling protocols carried out for all aspects of the study in 1993.

The data is currently being analyzed and the project is expected to be completed in September 1995. The results of this study will be presented to all local and regional resource managers, and may provide input to provincial guidelines for habitat protection.

Figure 4008.1. Wetland sampling.

4013

Evaluating Changes to Physical Microsite Properties Effected by High-speed Mixing Site Preparation Methods

Principal Investigator: D. Cormier, Forest Engineering Research Institute of Canada, Pointe Claire, QC.
Scientific Authority: B. Sutherland, NRCan, Sault Ste. Marie, ON.

In 1993, the Canadian Forest Service (CFS)–Sault Ste. Marie agreed to use a single-row prototype of the Forest Engineering Research Institute of Canada's (FERIC) rototiller (comprised of a single rotor powered by a 110-KW auxiliary motor and mounted on a 90-KW Clark 667 Forwarder) in a large-scale biological evaluation of various site preparation techniques in northwestern Ontario. The CFS trial will determine the effects of site preparation on soil processes, regrowth of noncrop vegetation, and growth of crop trees (*see also* Project No. 4025, page 83). In Project No. 4013, FERIC conducted a parallel study on adjacent sites to evaluate the effects of various rototiller settings such as mixing depth and intensity upon the soil and site environments. The CFS can then correlate these results with the biological results from their trials. Ultimately, the study aims to define the least intensive form of rototilling that will provide the greatest sustainable benefit, while minimizing environmental impact.

The trials for this project were carried out in June 1993 on forested areas managed by Avenor Inc., about 32 km northwest of Nipigon, Ontario. The study area had been harvested by mechanized full-tree clear-cutting 6 months earlier.

A video of the mixing machine has been prepared and a technical report, entitled *Evaluating changes of microsite properties effected by high-speed mixing site preparation methods*, has been completed on the results, costs and applicability of rototilling in northern Ontario. These results will be published by FERIC.

From an operational viewpoint, it was concluded that a two-row rototiller is necessary to produce the treatment at a reasonable cost. The rototiller's concept is technically feasible, even though several modifications are required before it could become fully operational. It is also necessary to ensure that the concept is biologically viable. The studies conducted by CFS on the effects of the treatment on plant growth, the reaction of competing vegetation, soil fertility, and the soil microbial and faunal environment will permit a more thorough evaluation of the rototiller concept.

Figure 4013.1. The prototype one-row rototiller, powered by an auxiliary motor and mounted on a forwarder.

Assessment of Current and Alternative Site Preparation Methods: Environmental Impacts on Forest Soil and Implications for Vegetation Control and Biodiversity

Principal Investigator: B. Sutherland, NRCan, Sault Ste. Marie, ON.

This project is evaluating selected boreal mixedwood site preparation techniques in terms of vegetation/tree response. Impacts on organic matter decomposition/element mobilization, biodiversity of soil microflora and fauna, and spread of root decay fungi (primarily *Armillaria ostoyae*) are also being considered. The efficacy and environmental implications of soil mixing as an alternative to current boreal mixedwood site preparation techniques are being examined. A related project, NODA/NFP Project No. 4013 (*see* page 82) is assessing the effects of different rototiller settings on soil properties, so that these results can eventually be correlated with the biological results from Project No. 4025.

The study area, in the Superior Forest District (B.9) of the Boreal Forest Region, is located south of Black Sturgeon Lake in the vicinity of Lake Nipigon. Laboratory work and data analysis are taking place at CFS–Sault Ste. Marie.

Four 1-ha treatment blocks, each with twenty-four .01-ha treatment plots and replicates, have been established to accommodate the following treatments:

1. Strip and area mixing
2. Strip and area screefing
3. Standard herbicide control
4. Untreated control

Pretreatment soil sampling that involved an analysis for physical properties, organic matter, chemical properties, and abundance and diversity of soil biota was undertaken in the autumn of 1992 and spring of 1993. Treatments were applied and the plots were planted to black spruce in mid-June 1993. Postsite preparation conditions were sampled by mid-June. The first posttreatment soil sampling and analysis was completed by the late summer of 1993.

Preharvest Site Characterization

Vegetation assessment indicates a highly diverse upland mixedwood stand composed of FEC vegetation types ranging from V14 (balsam fir mixedwood) to V15 (white spruce mixedwood) and V24 (white spruce–balsam fir/shrub rich).

Soil nutrient analysis revealed the study area to be typical of boreal spruce and spruce mixedwood soils in Ontario with respect to soil nitrogen (N), phosphorous (P), and potassium (K), but somewhat higher with respect to soil pH and concentrations of exchangeable calcium (Ca) and magnesium (Mg) throughout the profile.

Armillaria root decay was found to be very prevalent in all plots sampled.

Analysis of the microbial community indicated that the populations of fluorescent pseudomonades were relatively low prior to clear felling. Data collected on soil microbial activity and fungal biomass are still being analyzed.

Two species of earthworm (*Dendrobaena octaedra* and *Lumbricus rubellus*) were found at the site, but, there was considerable spacial variability in their distribution. Preliminary indications are that the soil microfauna of the area is extremely diverse and abundant; 33 species of *Collembola* have been identified. In the preharvest samples, the large majority of individuals occurred in the organic mat and first 2 cm of mineral soil. These are the horizons expected to be affected by harvesting and site preparation.

Posttreatment Analyses

An assessment of tree seedling survival and condition during late August 1993 revealed overall survival exceeding 99 percent.

Populations of fluorescent pseudomonads increased after the area was harvested, but decreased after the silvicultural treatments were done. Numbers of *Trichoderma* were reduced substantially after the area was harvested and increased after the silvicultural treatments. The forest earthworm, *D. octaedra,* was completely absent from all experimental plots in the spring following clear-cutting, and could only be found in one of the uncut control sites. *L. rubellus* was still present in one clear-cut plot and the uncut control in the spring of 1993. Preliminary results indicate that at both 1 month and 4 months following mixing, numbers of both *Collembola* spp. and mites were significantly reduced in mixed plots as compared with clear-cut controls. After 4 months, mite populations were roughly only 16 percent of those found in the clear-cut controls. *Collembola* spp. seemed to be more resilient and recovered to 33 percent of the clear-cut control values.

Soil temperatures in the treatment plots strongly followed fluctuations in air temperature. In the harvested areas, the screefed plots demonstrated the greatest and the harvested controls the smallest temperature fluctuations, as compared to the unharvested controls.

Posttreatment sampling continued in 1994. The results of this project will provide forest managers with an evaluation of the suitability and environmental impacts of different site preparation techniques in boreal mixedwoods. Reports on project results are due in March 1996.

Impact of Harvesting and Site Preparation on Forest Productivity, Soil Nutrient Reserves, and Nutrient Leaching from Jack Pine Cutovers

Principal Investigator: N.W. Foster, NRCan, Sault Ste. Marie, ON.

The objectives of this project are to evaluate nutrient cycling models for simulating the responses of jack pine forests to harvesting; to develop recommendations on pine sites at risk of a loss of forest productivity as a result of intensive harvesting and site preparation; and to identify harvesting and site preparation techniques that favor the early growth of pine regeneration and those that have detrimental effects.

Harvesting/site preparation treatme ts (tree length, full-tree, and full-tree/blading) produce three levels of organic matter removal (tree stems, stems, branches and organic forest floor) from mature, fire-origin jack pine sites.

Short-term changes in soil productivity are being assessed by examining the growth and nutrition of planted jack pine seedlings, nutrient budget studies, and changes in nutrient availability in soil over time. Treatment impacts on (a) site nutrient reserves, (b) nutrient leaching from soil, and (c) recovery of nutrient pools are being examined using one of the field trials in each of three locations, representing good, medium, and poor forest productivity/soil quality.

Ten experimental sites have been harvested and site prepared for treatment. All sites were planted in the spring of 1994. Preharvest nutrient investigations have been completed on the good and medium intensive sites, and postharvest assessment is under way.

Biomass and nutrient budgets for preharvest jack pine stands at Chapleau and Thessalon were summarized and presented in a paper at the 8th North American Forest Soils Conference. Assessment of preharvest leaching of nutrients from soil using lysimeters is continuing at Chapleau, while postharvest nitrogen availability (field incubation) and leaching using lysimeters and resins continues at Thessalon. The 1990 and 1991 solution chemistry data for both sites have been entered, screened and summarized. Postharvest assessment of logging residues and physical and chemical site conditions after site preparation has been completed at Thessalon.

First-year postharvest physical and chemical impacts at Chapleau and second-year impacts at Thessalon are now being assessed. Long-term impacts of organic matter removal on nutrient cycling and pine growth are being simulated.

Data collection is beginning to determine biomass, nutrient content, and nutrient cycling in a very low-productivity jack pine forest. Researchers will develop a short-term simulation of nutrient losses from the soil by leaching and forward projections, through one or more rotations, of vegetation growth and depletion/recovery of nutrient pools in the vegetation and soil. Results and recommendations will be presented in reports and technical notes.

4047

Glyphosate Effects on Nutritional Quality of Moose Browse

Principal Investigator: H. Cumming, School of Forestry, Lakehead University, Thunder Bay, ON.
Scientific Authority: R.A. Lautenschlager, OFRI, Sault Ste. Marie, ON.

This project is designed to determine the effects of the silvicultural use of glyphosate on the nutritional quality of selected plants commonly eaten by moose in early successional forests.

Treatment plots were identified near Obonga Lake, 100 km northwest of Thunder Bay, where the browse quantities have been significantly reduced by glyphosate applications three and seven growing seasons before sampling.

After preliminary development of the methodology, 140 winter twig samples (5 paired samples—treated and control of two browse species in seven areas) were collected during 28 January–3 February 1994. The only deviation from the proposed sampling methodology occurred at the older Obonga Lake plots, where no beaked hazel (*Corylus cornuta* Marsh.) was available and willow (*Salix* spp.) was substituted for the shrub species.

Sample areas were standardized as follows: slope = 5–15 percent; aspect = south; light intensity = no residual cover. Plants selected from within plots were chosen at random. Samples were collected on days with temperature above -30°C and transferred directly to a freezer. All 140 samples were freeze dried and ground, and are being analyzed for percent cutin and lignin and crude protein. Data analysis is taking place at Terra Scientific Laboratories in Thunder Bay.

This project will be completed in September 1995. A report, along with an OMNR research note, will provide recommendations specifically applicable to mixedwood upland sites in the boreal forests of Ontario. Results will allow forest managers to better assess the effects of conifer release with herbicides on moose habitat quality, and to better integrate forest management with wildlife management.

Environmental Impacts of Forestry Practices on Boreal Forest Soil Organisms

Principal Investigators: J.A. Addison, K.N. Barber, NRCan, Sault Ste. Marie, ON.

The objective of this study is to evaluate the impacts of different harvesting and site preparation techniques on the soil invertebrate biodiversity and functions in boreal mixedwood. The study is being carried out in a comprehensive boreal mixedwood research site near Black Sturgeon Lake (*see* NODA/NFP Project 4038, page 29). It will include elements of both the micro- and macrofauna obtained before harvesting and in the first 2 years after harvesting, and will assess the response of the total soil community to different treatments, as indicated by changes in soil metabolism.

Soil invertebrates are known to play essential roles in nutrient cycling, peat control, dispersal of mycorrhizal fungi, controlling (or dispersing) plant pathogens, soil formation, and decomposition.

Pretreatment sampling for epigeal and soil arthropods was completed in September 1993. Sample extractions, processing and tabulation of soil physical characteristics, and preliminary identification and enumeration for macroarthropods and earthworms have been completed. Secondary identification, analysis, and enumeration of microarthropod fauna are in progress.

To determine the pretreatment diversity of the epigeal arthropod fauna, a transect consisting of two parallel lines of six traps (12 traps per site) was installed on each of 17 sites (204 traps in all). Trapping was conducted over a 16 trap-night period from 23 August to 8 September 1993.

Preliminary analysis indicates that the collection rates for carabid beetles (0.06–0.11 beetles/trap-night) are of the same order of magnitude as at least one other study in Ontario (0.2 beetles/trap-night on control plots (Duchesne and McAlpine 1993, PNFI Technical Report 16). Some small mammals and amphibians were intercepted. Specimens and collection data have been forwarded to other researchers involved in the Black Sturgeon Lake projects.

Pretreatment sampling of the microarthropod fauna was carried out in cooperation with the preharvest baseline cut-block survey coordinated by J. Scarratt. Samples for determination of the microfauna were taken from four locations at 11 sites in Stands 1 and 2 (44 samples). On the four proposed burn sites, samples were taken 10 m off the end of the pitfall transects (16 samples).

Fifteen soil blocks were examined for earthworms. The only species of earthworm found was *Dendrobaena octaedra* Savigny, which was present in only one of the plots. Here, it occurred in both the microfauna samples and in the soil block.

Posttreatment sampling, begun in 1994, will continue in 1995. The project will be completed in late 1995.

Being able to measure the health of forest soil through the use of invertebrates may allow for the development of techniques for forest management that could potentially reduce the use of pesticides and fertilizers.

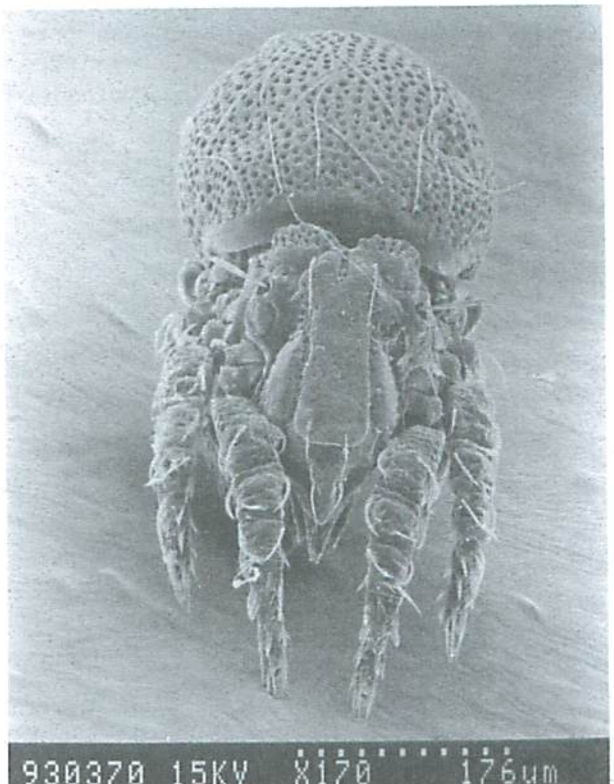

Figure 4050.1. Cryptostigmatid mite: a member of the decomposer fauna in boreal mixedwood soils. (Photo courtesy of Dr. J.A. Addison, taken by C.N. Davis.)

4116

Wetland Ecosystem Classification in Ontario, and Impacts of Forestry on Wetlands

Principal Investigator: J. K. Jeglum, NRCan, Sault Ste. Marie, ON.

The objectives of this project are to develop a manual on the classification of wetland types in Ontario based on an updating of the Ontario Wetland Classification; to analyze and report on unanalyzed data sets on wetlands for Ontario; and to summarize the impacts of forestry practices and provide preliminary guides to minimize these impacts.

An early phase of the project included the assessment of needs of users and purposes for classification. Consultations were held with numerous experts to determine needs and approaches for wetland classification.

A first approximation of the Ontario Wetland Classification was completed early in 1994. It summarized the approaches to classification and identified wetland types and areas in the province where data was lacking. This is being reviewed and revised, but is expected to be completed in late 1995. In addition, two NODA/NFP reports on vegetation ecology and classification, based on the analysis of four different data sets, will be completed.

The writing of a report, *Conserving wetlands in managed forests*, was contracted by the North American Wetlands Conservation Council (Canada) to Mr. Gregg Sheehy, an environmental consultant. It was published in the spring of 1993 as Sustaining Wetlands Issues Paper No. 1993 - 2. Funding support was provided by this project.

An "International Symposium on the Ecology and Management of Northern Forested Wetlands", held in Cochrane, Ontario, and Traverse City, Michigan, in August 1994, attracted over 100 participants.

The increased knowledge and classification of wetlands will result in improved forestry practices for Ontario wetland types.

Planning and Forest Resource Management

Satellite and Airborne Remote Sensing for Forest Ecosystem Classification in Northwestern Ontario

Principal Investigator: P.J. Howarth, Earth-Observations Laboratory, Institute for Space and Terrestrial Science, Waterloo, ON.
Scientific Authority: R.A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a procedure for using airborne and satellite remote-sensing data for discriminating among the mature forest classes defined by the Northwestern Ontario Forest Ecosystem Classification (FEC). It is being carried out in the Rinker Lake study area, and includes sites representative of the boreal conifer and mixedwood forests in northwestern Ontario.

The project is examining the relationship between forest ecosystem parameters and remote-sensing data at six spatial resolutions (1.25, 2.5, 5.0, 10.0, 20.0, and 30.0 m). Image-analysis techniques are being tested for discriminating ecological parameters, particularly the FEC classes. These classes will range from the detailed vegetation classes ("V-types") of the FEC to more generalized classes referred to as "treatment units".

Additional data to be incorporated into the analysis procedures include a digital elevation model to enhance the separation of forest ecosystems due to the influence of slope, aspect, and elevation on forest and soil development.

In the 1993 field season, airborne remote sensing data at three spatial resolutions were acquired over the Rinker Lake study area. These data have been converted to reflectances for further analysis. Field data for the study were also obtained in 1993 and 1994. Analysis of both airborne and satellite imagery is currently under way to discern how the information content of the imagery correlates with the FEC characteristics of the vegetation.

Preliminary results of this research were presented at the "Global to Local: Ecological Land Classification" Conference held at Thunder Bay in August 1994. As well, two papers have been submitted for presentation at the 17th Canadian Symposium on Remote Sensing in Saskatoon, Saskatchewan, 13–16 June 1995.

Project results will be submitted when the project is completed in late 1995. In the interim, the data collected in 1993/94 has been summarized and is available in a report, entitled *Rinker Lake data report: 1933–1994* (Earth Observations Laboratory, Institute for Space and Terrestrial Science, Dept. Geography, University of Waterloo, Waterloo, Ontario: Technical Report ISTS-EOL-TR94-002). An additional report, entitled *Remote sensing for forest ecosystem characterization: A review* (NODA/NFP Technical Report TR-12), has been completed and will be published.

It is expected that the findings of this project will improve current capabilities for the collection and extraction of forest ecosystem information from remote-sensing and digital terrain data for improved forest management. The techniques developed will provide a cost-effective means for mapping forest ecosystem classes for large areas of northwestern Ontario.

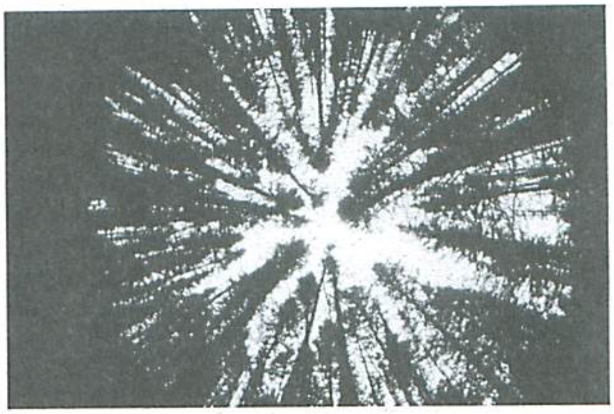

Figure 4002.1. Canopy hemispherical photographs have been taken at research sites to determine crown closure, which is a significant biophysical parameter affecting spectral reflectance. (Photo courtesy of P. Treitz.)

4007

Preparation of a Case Study Report on the Photo Interpretation of NWOFEC Soil Types and Vegetation Types in the Roslyn Lake Pilot Mapping Study Area

Principal Investigator: J. Johnson, For-Site Consulting, Sault Ste. Marie, ON.
Scientific Authority: R.A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to produce a technical report that will provide resource managers in northwestern Ontario with the tools necessary for identifying and delineating Northwestern Ontario Forest Ecosystem Classification (NWOFEC) soil and vegetation types on medium-scale black and white aerial photographs.

Investigators have reviewed draft versions of keys, annotated photo pairs and other related materials developed prior to 1987–88, and reviewed available literature on photo interpretation of soil/landform and vegetation features.

The final report, which is currently under review, provides background information about photo interpretation of soil/landform and vegetation features and a brief overview of the development and application of the NWOFEC system; a description of the methodology during prefield, field, and postfield phases of previous and current work undertaken to develop the photo interpretation keys and the case study report; and the photo interpretation keys for NWOFEC soil and vegetation types specific to the Roslyn Lake area. Discussions of the interpretability of these soil and vegetation types, of the application of each key, and of the implications for forest/land management are also presented. As well, a collection of annotated and mounted photo pairs illustrate example features described in each key, and several toposequence diagrams illustrate and clarify concepts and decision points within the keys.

Although the case study is specific to the Roslyn Lake area, the report illustrates the method of developing photo interpretation keys for any area. The ability to accurately identify soil and vegetation types on aerial photos will greatly reduce the amount of field time required to classify forest stands, and will contribute to more efficient and ecosystem sensitive forest management.

White Pine and Red Pine Volume Growth under Uniform Shelterwood Management in the Algonquin Provincial Park

Principal Investigator: R.D. Pick, Algonquin Forestry Authority, Pembroke, ON.
Scientific Authority: R. Miller, Ontario Forest Research Institute, OMNR, Sault Ste. Marie, ON.

The objective of this project is to determine the volume growth of white pine and red pine stands that have been managed for 17 years under the uniform shelterwood silvicultural system.

Three hundred and ninety plots in Algonquin Provincial Park were initially identified for data collection. That number was reduced to 325, because of requirements to collect additional data in support of other projects, and due to the difficulty of obtaining data from some stands. Field work was completed by 31 December 1993.

The final report, entitled *White pine and red pine volume growth under uniform shelterwood management in Algonquin Provincial Park* (NODA/NFP Technical Report TR-14) has been completed and will be published. This paper outlines the development and use of a compatible growth and yield model for white pine and red pine stands under the uniform shelterwood silvicultural system in the Algonquin Provincial Park. The model incorporates stand age, residual (postharvest) basal area, site index, composition index (proportion of pine basal area), and projected age as predictor variables for estimating residual gross merchantable pine volume and for projecting basal area and gross merchantable pine volume growth over a given projection period. The results suggest that white pine amd red pine stands in the park experience continually increasing volume growth for up to 25 years following uniform shelterwood harvesting over the 40- to 130-year range. The model is best applied to make volume growth projections for periods of up to 25 years following uniform shelterwood harvesting.

Figure 4015.1. Determining height of polewood-size trees.

4020

Development of Methods for Forest Ecosystem Classification (FEC) Mapping for Northeastern Ontario

Principal Investigator: R. Arnup, Ecological Services for Planning Ltd., Timmins, ON.
Scientific Authority: R.A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to evaluate the relative accuracy, speed, and cost of three different approaches to using existing air photography, forest resource inventory (FRI), botanic, edaphic, topographic, and other ecological data to create Forest Ecosystem Classification (FEC) site type polygon maps, at a 1:20 000 scale, for two ecologically representative study areas in northeastern Ontario.

The following three methods for generating FEC inventory were studied: air photo interpretation of standard Forest Resource Inventory (FRI) photography (panchromatic black and white imagery) with intensive ground-truthing; interpretation of standard FRI photography in combination with supplementary large-scale color photography and/or large scale photography and extensive ground-truthing; and the development of predictive algorithms using tabular forest and soil inventory data based on existing maps (e.g., FRI and Prime Land Soil II maps).

During the 1993 field season, 1,400 ground truth sample points were installed in the Timmins and Kapuskasing study areas. These covered all types of imagery, and were incorporated into existing databases. An additional 530 samples were installed for reliability testing. The Kapuskasing area was flown in July 1993 to obtain large-scale color aerial photographs at two scales (1:10 000 and 1:1 200). Large-scale color photographs were obtained from Dendron Resource Surveys Ltd. for the Timmins area.

Photo-interpretation models for all types of imagery have been built to interpret FEC polygon boundaries and attributes from landform, topography, forest vegetation, and other natural features visible on both black and white and color photos. These have been refined for all imagery types, based on ground truthing data. As well, the FEC/FRI predictive model has been built and tested.

Preliminary findings suggest that not all site and vegetation types can be mapped at inventory scales, but because they occur on fairly predictable patterns on land types, they can be mapped as complexes of site and vegetation types. FRI boundaries have been found to be adequate at isolating the distribution of site and vegetation types; approximately 75 percent of FEC types can be explained on the basis of FRI.

The scale of soil and inventory maps available (1:100 000) is too small, and these provide only a very general predictive capability. Researchers are currently building and testing new tools that will help to map at a 1:20 000 scale using air photo keys, topographic sequence diagrams, and landscape cross sections.

A final report will provide information on the relative accuracy, speed of production, and likely costs of each derivation method. A user's guide, which will include practical tools for photo interpretation of FEC types, inventory, and mapping, will also be prepared for use in the training of field staff.

Enhancing Ontario's Forest Resource Inventory with Stand Structure and Forest Ecosystem Vegetation Types Using Large-scale Aerial Photography

Principal Investigator: U. Nielsen, Dendron Resource Surveys Inc., Ottawa, ON.
Scientific Authority: N. Maurer, Northeast Science and Technology, OMNR, Timmins, ON.

This project is using the Timmins Forest in northeastern Ontario as a study site to demonstrate the use of large-scale photography (LSP) to enhance the existing Forest Resource Inventory (FRI) by describing stand structure within forest classes.

During 1993, existing digital files, photos, supplementary air photography, updates, etc. were obtained for the Timmins Forest. The forest was stratified and maps showing the forest strata were plotted. Large-scale photography taken for the QUNO Corporation (formerly Quebec and Ontario Paper Company) in 1991 were recovered and a matrix was prepared showing the number of photos per stratum. Gaps in photo coverage were identified and flights completed to fill them.

A global positioning system was integrated with the Dendron Resource Surveys Inc. LSP system. Software modifications allowed the systems to interface with the on-board computer-based camera controller/data acquisition system.

During the 1993 field season, 300 trees were identified for development of diameter equations and 300 plots were established for the development of nonworking group look-up tables. Trees and plots were numbered, photographed, and measured in the field. The classification and measurement of dead trees–standing and fallen was also included.

During late 1993 and early 1994, several models were evaluated for the development of diameter equations. LSP measurements were taken to compare with ground measurements. Data analysis began for the development of key statistics and tables presenting the species and size class structure of the stands.

A total of 2 750 LSP sample plots were measured and compilations were made of the key statistics and tabular reports for defined strata. The tables presented trees per hectare, basal area, and total and merchantable volume in the form of stock and stand tables showing distribution by species and diameter class.

A report, entitled *Equations for estimating diameter at breast height from large-scale photo tree measurements*, was completed in January 1994. It summarizes the preliminary findings of the project. The report concludes that LSP measurement of tree height and crown area enable the dbh to be estimated with an accuracy of about ±2.5 cm two-thirds of the time using equations developed for the major tree species.

A more general project report, which describes the specifications and procedures used, results and management implications, is being prepared. Several technical notes that detail the diameter equation development methodology, GPS technology, compilation software for key statistics and tables, a comparison of LSP and conventional inventory methods, and the application of LSP technology in wood supply modeling and habitat evaluation have been drafted. A user-oriented workshop was presented in Timmins in November 1994.

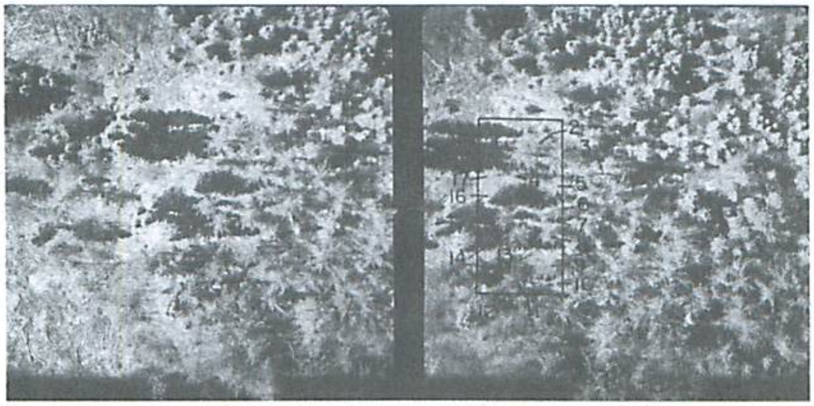

Figure 4021.1. Example of a stereo pair of large-scale sampling photos with an established plot. (Photos couresty of Dendron Resource Surveys Inc.)

4032

Development of Interim Guidelines to Maintain Long-term Productivity in Boreal Ecosystems of Ontario

Principal Investigators: J.K. Jeglum, NRCan, Sault Ste. Marie, ON.
D.M. Morris, OFRI, OMNR, Sault Ste. Marie, ON.

The objective of this project is to identify potentially nutrient-poor sites in the boreal forest region of Ontario and to develop "best-practice" recommendations for harvesting operations as an interim measure, while awaiting results from research initiatives currently being undertaken by the Ontario Forest Research Institute on black spruce and by CFS on jack pine.

Both OMNR and CFS–Sault Ste. Marie agree that nutrient-poor and "sensitive sites", including shallow soils, wet soils, and coarse soils, represent the greatest concern for sustainable forestry in the north. Field plots are in place to study long-term productivity.

The project is designed to develop a site framework for both jack pine and black spruce, based on the same physiographic features and linked with the Forest Ecosystem Classification system; to overlay the framework with site quality classes and their associated site indices; to identify the site requirements of each species, utilizing current literature and expert opinion; to assess this process as a tool for identifying the regional significance of potentially nutrient-poor sites; and to prepare an interim set of "best-practice" recommendations for immediate application while long-term research is being completed.

Long term productivity of boreal forest ecosystems: Annotated bibliography (NODA File Report 8) has been completed. It contains 379 references relating to boreal ecology, with an emphasis on nutrient regimes and nutrient cycling in black spruce and jack pine ecosystems. References relevant to the maintenance of long-term productivity in these systems are also included. The bibliography has been assembled on Pro-Cite software for easy reference, and the disk will be available upon request. A NODA note will also be published.

Reports on a survey of expert opinion, definition of nutrient-poor sites, and best practices are forthcoming. OMNR's Science and Technology Transfer Units will be used to transfer the results to field staff. The information can be used in the timber management planning process to assist in the selection of the most appropriate silvicultural system for individual sites.

Impact Assessment of Scleroderris Canker in Ontario

Principal Investigator: A. Hopkin, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a framework in which to study the impacts of forest pests, and to provide a definitive statement on the losses, economic and other, caused by the Scleroderris fungus (*Gremmeniella abietina* [Lagerb.] Morelet.) in red pine plantations.

In 1992, plots were established in the Parry Sound District to assess the impact of Scleroderris canker on red pine (*Pinus resinosa* Ait.). A report, entitled *The distribution and significance of scleroderris disease in Ontario*, was completed in March 1993 and has been published (NODA/NFP Technical Report TR-7). It concluded that conditions are favorable for an increase in the disease and its impact. The following observations are from that report.

> The North American race of the disease has been present in Ontario since the early 1960's across the range of pine. It is found mainly on red pine and jack pine (*Pinus banksiana* Lamb.), although jack pine is considered less susceptible than red pine. The European strain, first detected in Ontario in 1985, has a more restricted distribution in Ontario. It should be noted, however, that the European race is usually found in combination with the North American race.
>
> In general, the European race is concentrated in central Ontario within the OMNR Parry Sound District where it occurs predominantly on red pine. The general distribution of the European race showed little change between 1985 and 1991, with only limited spread prior to 1992. However, in 1992 it was detected in 13 plantations over six townships, and in 1993 it was detected in 33 plantations over 14 townships.
>
> Perhaps the most interesting observation on the distribution of both races of the disease is their absence in eastern Ontario.
>
> Between 1985 and 1993 the disease has persisted within many areas as a result of failures to eradicate it from infected plantations and/or to prevent its spread to nearby plantations. Complete eradication of the disease is difficult due to its latent nature; it is also seldom necessary if the infestation is at low levels.
>
> In Ontario, both strains of the disease have been found on seedlings and immature trees, but mortality occurs primarily on the former. The average height of affected trees has been between 2.0 and 3.0 m. However, in central Ontario where both races exist, the greatest impact has been to trees under 1.0 m. These are often killed or severely distorted when infected. On larger trees, damage has usually been limited to infection of the lower branches. There is minimal evidence of stem cankering.
>
> An increase in the number and percentage of plantations affected by the disease, in addition to an increase in incidence in some locations, would suggest a possible buildup of the population since 1991. In recent years conditions for spore release and infection have been favorable, and a reduction in control efforts has occurred due to economic restraint.
>
> Both strains of the disease have been associated with high levels of mortality in red pine. The recent buildup in the population will likely continue if suitable environmental conditions exist and if control measures are curtailed. However, whether this increase in disease incidence translates into an increase in disease severity and mortality is a present conjecture.

The economic analysis portion of this project is being undertaken through a contract with the University of Guelph, where a plantation level cost simulation for Scleroderris control is in progress. It is due for completion in 1994–95. A NODA technical report is also in progress.

Additional work is also being performed on a biogeographic analysis of Scleroderris and the relationship of its distribution to climatic variables and microtopography. Progress in this area is dependent on transfer of information from other work. This portion of the project is not listed as a deliverable, but if successful will be published in part as a NODA technical note.

A Frontline Technical Note No. 21, entitled *The distribution and control of scleroderris disease in Ontario*, has been published.

Information from this study will help managers make effective decisions concerning future plantings and stand management practices where the Scleroderris canker disease is a factor.

4035

The Refinement of Prescribed Burning Procedures for Northern Ontario

Principal Investigator: D.J. McRae, NRCan, Sault Ste. Marie, ON.

The objective of this project is to increase the effectiveness of prescribed burning procedures in terms of a sustainable forestry program for northern Ontario. New forest management objectives require that the knowledge of prescribed burning on small clear-cuts and the protection of more areas of concern must be refined and updated if burns are to be conducted safely and with little environmental impact.

Project researchers are quantifying the energy release of prescribed fires by aerially scanning such burns with an infrared camera. They are also modeling fire wind flow by analyzing wind speed and direction data collected during prescribed burns.

In the summer of 1992, two prescribed burns were monitored and preliminary computer programming was completed to analyze infrared digitized imagery. In-fire wind flow data was captured on one prescribed fire.

Working guidelines developed to assist in calibrating and positioning the infrared camera during data collection on burns were tested successfully in the summer of 1993. Hot reference point devices were constructed for use in calibrating digitized computer images, but field tests failed to obtain the high temperatures required for such calibration. They can, however, be used as central points for registering the temporal images. Researchers obtained Green Plan funding in 1994 for a blackbody calibrator to provide calibration capacity.

Data collection using the infrared camera was completed on one operational OMNR prescribed fire in the Wawa area. Analysis of that data verified problems with the camera configuration. Additional funding was arranged through Green Plan to have the camera modified to increase its dynamic range. Modifications to the camera were made through the University of Iowa Physics Department's Aeronautics Program for the 1994 season.

Progress is being made in the fire wind flow modeling portion of the project. Software programs written to allow GIS analysis on an IBM 6000 workstation are working satisfactorily. Analysis of wind flow documented on earlier burns is ongoing.

The projects will be completed in December 1995. Reports will be submitted on the determination of energy release and on fire wind modeling. A video will be produced on the simulation of wind fields. Technical notes on energy release and fire behavior, fire modeling, and operational prescribed burning ignition conditions will also be prepared.

The results of this study will give forest managers more control over the prescribed burning process by enabling them to better predict the behavior and impact of burns during the planning phase.

Impacts of Spruce Budworm and Budworm Spraying on Succession in Boreal Mixedwood Forest

Principal Investigator: C.J. Sanders, NRCan, Sault Ste. Marie, ON.

The objective of this project is to determine the interaction between spraying with pesticides and damage caused by the eastern spruce budworm on stand succession in the boreal mixedwood environment. The project will test the hypothesis that spraying for spruce budworm in stands with a heavy balsam fir component in the overstorey favors the growth of balsam fir regeneration and suppresses the spruce component through competition. In contrast, the understorey fir component is killed by the budworm if no spraying is conducted, thereby leading to a higher spruce component in the regenerating stand.

Four study plots were selected in the Black Sturgeon Lake area in May 1993. Thirty 10-m^2 subplots were established to sample overstorey trees for spruce budworm and 4-m^2 subplots were established to assess regeneration and understorey vegetation. Spruce budworm larvae falling from the overstorey were recorded.

Harvesting was carried out in treated plots. The original proposal was for five harvest treatments: protected by spraying and clear-cut in 1993; protected by spraying and uncut; unsprayed with severe defoliation and clear-cut; unsprayed with light defoliation and cut; and unsprayed with severe defoliation and clear-cut. This was modified because defoliation proved to be highly variable, and it was not possible to delineate boundaries between protected and unprotected areas. As the whole area was defoliated, only two treatments could be established. Each was replicated twice: cut in 1993 and uncut. To compensate for the loss of the original treatments, the cut plots were subdivided into three parts: one-third clear-cut, one-third a low intensity partial cut, and one-third a high intensity partial cut.

During the summer of 1994, spruce budworm populations and impacts were assessed.

The results of this project, expected in March 1996, will provide guidelines for decision making on the impact of spraying on regeneration and stand succession, and will help to predict the future composition of stands in a study area after a budworm outbreak.

4046

Modelling of Post-harvest Forest Succession in Northern Ontario

Principal Investigator: D.A. Welsh, Canadian Wildlife Service, Ontario Region, Nepean, ON.
Scientific Authority: K. Baldwin, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a preliminary classification system for the succession of boreal forest vegetation. The analysis will provide a template for wildlife habitat associations and enable forest managers to predict the implications of management decisions on the future of forest ecosystems.

Two large data sets collected in northern Ontario by the Canadian Wildlife Service and CFS–Sault Ste. Marie for 11 successional stages of forest within the Chapleau Crown Game Preserve and from 18 upland mixedwood successional and uncut stands near Manitouwadge will be utilized. A detailed analysis of the data is being conducted and a preliminary model, which will allow the linkage of wildlife and other data to defined temporal stages in ecosystem supply models, is being prepared.

Technology Transfer: Forestry Canada's HSG Wood Supply Model

Principal Investigator: A. Welch, Dendron Resource Surveys Inc., Ottawa, ON.
Scientific Authority: S. Andersen, NRCan, Sault Ste. Marie, ON.

This project is designed to transfer the Harvest Scheduler Generator (HSG) software, developed at the Petawawa National Forestry Institute (PNFI), from the research laboratory to operational use by forest resource managers and other interested parties in northern Ontario.

The project is divided into six tasks: preparation of software; preparation of support material; design of training material; development of training material; workshops in Thunder Bay and Timmins to introduce forest managers to HSG and to instruct them on its application to various forest modeling and management planning tasks; and revisions to the Training Package based on feedback from workshops.

HSG is a tool designed to assist forest managers and others in the design and evaluation of forest management strategies. HSG differs from conventional forest simulation models in that the spatial identity of individual stands is maintained as a forest as projected in time.

HSG contains a suite of programs designed to assist the user in preparing inputs, running simulations, and generating queries that graphically display and map simulation results.

Other features include:

- a system of interactive menus;
- simulations can be run over an indefinite planning horizon;
- step sizes can range from 1 to 20 years and may vary between iterations;
- a flexible method of modeling the development of forest stands and succession patterns;
- harvest targets can be set for individual species;
- harvest priority rules can be assigned independently to species–volume components;
- preferred silvicultural treatments and priority rules for harvest (e.g., oldest first) are specified by the user and can be changed at each iteration of the model; and
- eligibility constraints as well as mandatory harvest and silviculture activities can be specified at each iteration.

HSG allows a forest manager to examine issues like: "What level of harvest can be sustained from the forest?" "What type of forest will result from the harvesting operations?" "What are the implications for wildlife habitat?" "How will an increased level of silvicultural treatment alter the sustainable harvest level?"

The Harvest Scheduler Generator software is now complete and can be purchased through Dendron Resource Surveys Inc. It is accompanied by a 220-page users' guide.

In addition, demonstration software and an information guide are available from Dendron Resource Surveys Inc. This software utilizes a dataset of 3 000 forest stands from the Ontario Forest Resource Inventory (FRI). It covers 37 000 ha and includes parts of four 1:20 000 Ontario Base Maps, within the Timmins Forest. The full-function version is limited only by available memory and disk space, and has been tested on a 1.2 million ha, 30 000-stand database. An operational trial on the Elk Lake Community Forest was undertaken by Dendron Resource Surveys Inc.

4107

Transfer of Volumetric Wood Supply Analysis Technology

Principal Investigator: K. Lindquist, Forest Computer Consulting, Chapleau, ON.
Scientific Authority: B. Callaghan, OMNR, Sault Ste. Marie, ON.

The objective of this project is to improve upon the transfer of volumetric wood supply analysis technology to forest managers across northern Ontario who are directly involved in preparing timber management plans for Crown lands. The program is also designed to assist in inventory updates and wood supply studies.

Previous training has focused on using the wood-supply model itself (usually FORMAN or CROPLAN), but has largely ignored the critical first step of properly understanding and aggregating Forest Resource Inventory (FRI) data to create input files for these models. Furthermore, no program for the MS-DOS operating system, commonly used by the forest industry, has been available. This project has produced a well-documented FRI aggregation program for the MS-DOS operating system.

The PC Version, Norman File Creation System (PCNFCS) program was implemented in September 1992. It is based on an existing program entitled "Norman File Creation System", which operated on the VAX/VMS platform, and supplies users with forest management options and data analysis techniques through which they can create file inputs for three forest management models: NORMAN, FORMANCP, and FORMAN 2.1.

Access to this earlier version of the program is limited as most forest companies use personal computers with MS-DOS operating systems. The file creation tool is now accessible to forest companies via the new PC-based PCNFCS program compiled for MS-DOS.

The program is comprised of four main components: FRI file check and preparation; forest class aggregation; yield curve development; and forest model file export.

Both a users' manual and a technical manual have been produced: *PCNFCS Norman file creation system PC version: Users' manual* (NODA File Report 3), and, *PCNFCS Norman file creation system PC version: Technical manual* (NODA File Report 4). These have been introduced to field forest managers in a series of miniworkshops across the Northeast and Northwest Regions.

In addition to transferring existing FRI database manipulation technology to field managers, this study will result in a better understanding of the forest management practices and expenditures required to sustain the benefits from northern Ontario's forests.

Publication of Two NODA Technical Reports Dealing With: 1. Boreal Forest Humus Forms in NW Ontario, and 2. *Sphagnum* spp. Habitats in Relation to NW Ontario FEC Types

Principal Investigator: R.A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to publish two reports: one on the classification of boreal forest humus forms, and the second on the ecological site requirements of forest-dwelling *Sphagnum* species in northwestern Ontario. The project will allow for the final writing and publishing of research undertaken during 5 years of field work, and analyzed in conjunction with the development of the Northwestern Ontario Forest Ecosystem Classification (FEC). A report, entitled *Forest humus forms in northwestern Ontario*, has been received and is being reviewed. Figure 4110.1 shows the relationship of forest humus profiles to the terrain within a boreal forest.

The second report, entitled *Sphagnum species in northwestern Ontario: A field guide to their identification*, has also been submitted for review.

The two reports resulting from this project will be published and distributed to field staff. They will complement the Northwestern Ontario Forest Ecosystem Classification system and will provide scientific and technical information that is of value to forest managers in northwestern Ontario.

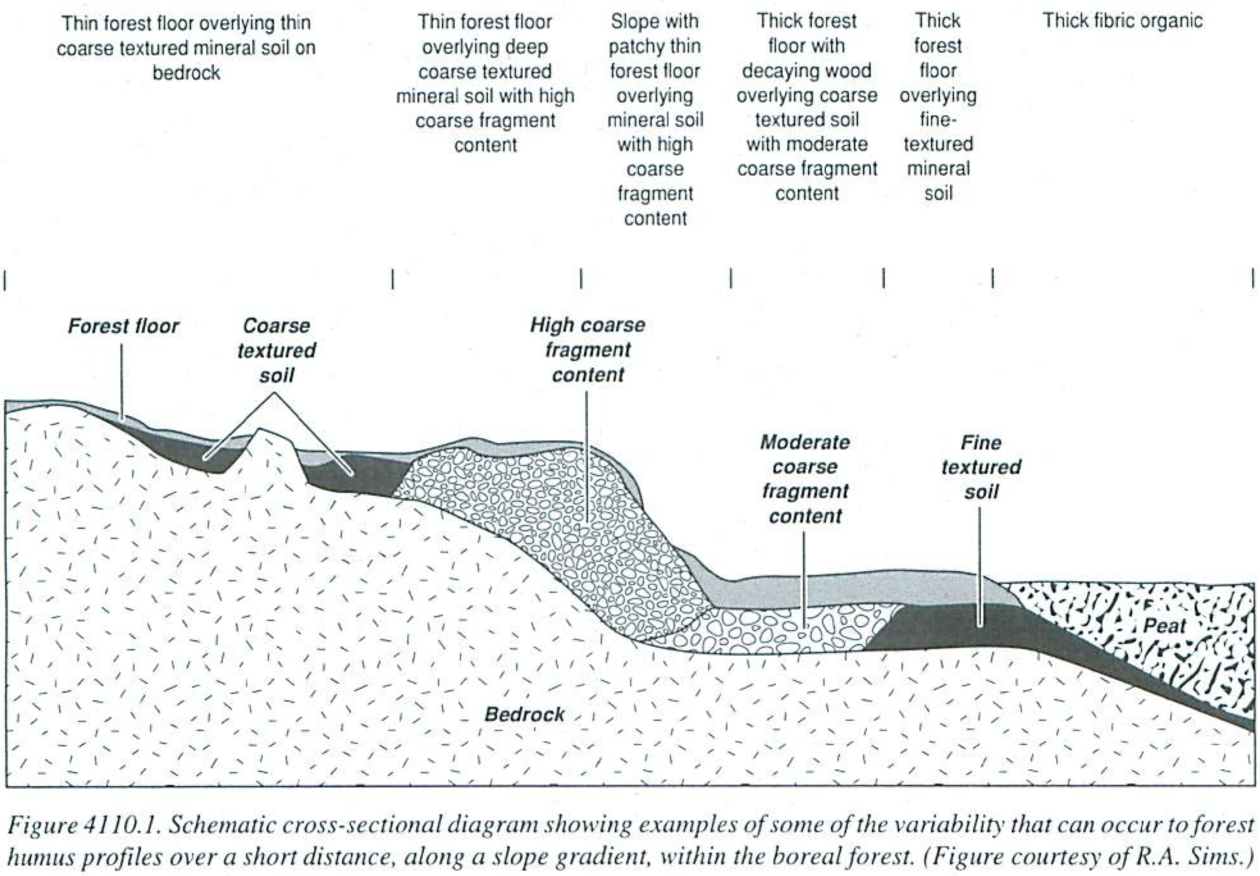

Figure 4110.1. Schematic cross-sectional diagram showing examples of some of the variability that can occur to forest humus profiles over a short distance, along a slope gradient, within the boreal forest. (Figure courtesy of R.A. Sims.)

4202

Development of an Enhanced OLI-based Prime Land Inventory System for Northwestern Ontario

Principal Investigator: G.M. Wickware, Geomatics International Inc., Burlington, ON.
Scientific Authority: R. A. Sims, NRCan, Sault Ste. Marie

In 1990/91, the Northwest Region Science and Technology Unit, OMNR, completed a project to identify and map prime land areas across northwestern Ontario, using an integrated geographic information system (GIS) mapping and prime land modeling approach. The map base used was the 1:250 000 scale, Ontario Land Inventory (OLI). Because of the relatively small scale of the maps, the spatial resolution is low, the polygon size is large, and a wide range of soil and topographic conditions occur within the polygon areas.

This current project is designed to evaluate the degree to which the spatial heterogeneity can be reduced, and to assess the extent to which prime land prediction for individual commercially important species can be improved.

Three methods were developed to delineate and classify soil textures at a scale of 1:50 000 within areas of northwestern Ontario where soil mapping is currently unavailable or available only at smaller scales. These methodologies integrate existing map-based information, such as the National Topographic Series (NTS), Ontario Land Inventory (OLI) land classification, Northern Ontario Engineering Geology Terrain Study (NOEGTS) database, and Forest Resource Inventory (FRI), with digital satellite imagery (SPOT Panchromatic, Landsat TM). These methods are designed to allow forest managers to develop operationally useful soil/site productivity thematic maps, and to include identification of the most productive forest sites.

The final report, which presents the results using each method, is being reviewed.

Sustainable Development Indicators for the Forest Resources of Ontario

Principal Investigator: P. N. Duinker, Forest Management and Policy, Faculty of Forestry, Lakehead University, Thunder Bay, ON.
Scientific Authority: S. Andersen, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop and test a preliminary set of biophysical indicators of sustainable development for the forests of Ontario in order to provide a source of environmental information from which to make sound integrated resource management decisions.

The project resulted in a two-volume report that was subsequently condensed into one report entitled, "*Measuring up: Sustainability indicators for Ontario boreal forests*. The following abstract from the report provides an overview of project results.

Serious adoption of the concepts of sustainable development and adaptive management of forest ecosystems has meant a shift from a commodity focus in forest management to a focus on forest sustainability. Thus, forest managers need to identify and apply indicators that can show whether forest sustainability is being achieved.

The working definition of forest sustainability developed and incorporated in this project is that a forest, to be sustainable, will retain its essential ecological processes, functions, and patterns that support the full range of societal values for the present and in the future. Indicators were determined by developing measures for ecosystem components critical to ecosystem function that also satisfy a broad range of public values. Economic values were not directly considered in the study. Indicator development and application are embedded in the principles of landscape ecology, and are necessary for the implementation of an ecosystem management philosophy. A first-approximation set of indicators designed for application to the managed boreal forests of northern Ontario is presented, as well as a test application of the indicators to a boreal forest near Thunder Bay. Indicators identified and tested in relation to the wilderness are: remoteness, size of the wilderness, and "naturalness". Indicators presented in relation to biodiversity are: forest cover type diversity, forest age diversity, forest fragmentation, old growth forest and old growth interior forest fragmentation, forest edge length, and habitat supply for a specific species (e.g., American marten [*Martes americana*]). Road-related indicators identified and tested included road density and forest conversion by roads and landings.

Recommendations for operational use of sustainability indicators in forest planning include the following points:

The public must be involved in the choice and formulation of indicators.

- Existing digital FRI databases, although problematic in some respects, can be an adequate starting point for indicator measurement.
- A key component of managing for forest sustainability, indicator measurement will require additional personnel and effort.
- Scientifically sound and publicly meaningful forest-level indicators are vital to the achievement of forest sustainability.

4204

Visibility Analysis: A Decision-support Technique for Forest Resource Management Planning

Principal Investigator: A. Welch, Dendron Resource Surveys Inc., Ottawa, ON.
Scientific Authority: H. Jääskeläinen, NRCan, Sault Ste. Marie, ON.

The objective of this project is to enhance a decision-support technique that identifies and quantifies areas of potential conflict between multiple values (with concentration on fibre and recreation), and provides support to the development of integrated resource management solutions.

The project, conducted in the northwest corner of Thistle Township, to the north and west of Thistle and Red Cedar Lakes in OMNR's North Bay District, was well received by stakeholders involved in the study.

Dendron Resource Surveys Inc. has developed a technique for identifying and providing technical support for resolving or reducing conflicts between fibre and recreational values. Its four key components are: the use of GIS technology to determine theoretically visible areas and their spatial and quantitative comparison with other areas of interest, such as those related to fibre values; the use of field photography, which allows the actual situation to be compared with theoretical results; the participation of stakeholders, thereby allowing them to understand the process and have meaningful, early, and ongoing input; and an experienced technical support group, able to match the need with the most appropriate technology.

An initial GIS assessment of forested areas, theoretically visible from the lakes, was made using Ontario Forest Resource Inventory (FRI) maps on a 1:20 000 digital Ontario Base Map. Then, viewpoints were selected from which to assess the theoretical visibility of the entire project area from single and combined viewpoints.

Three key stakeholder groups (Island Lake Camp, Goulard Lumber, and Teme–Augama Anishnabai) identified critical values (timber, natural viewscapes, culture and heritage, wildlife, and water quality/shore protection) within the study area. These were then quantified and included on a digital map.

A summary map which showed areas eligible for harvest, as well as those areas that were visible from the global set of viewpoints was produced. Areas that were both eligible and visible were considered to be in potential conflict between fibre and visual values. This process will allow client groups to identify actual conflict areas on a stand-by-stand basis.

One conflict area was selected for additional analysis, and a sample "conflict area analysis report" was completed. This included a quantitative description of the conflict area, a measure of the theoretical importance of the view from the lake, and a comparison of theoretical with actual views.

This report, entitled "*Visibility analysis: A decision support technique for forest resource management planning*" (NODA/NFP Technical Report TR-3), has been published.

The techniques presented in the report can be considered operational and can be readily duplicated using the methodology and techniques presented.

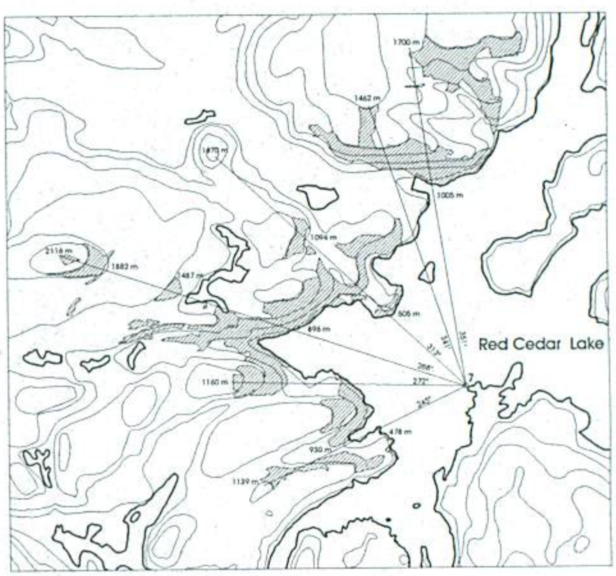

Figure 4204.1. Results of an individual viewpoint visibility analysis showing viewpoint (#7), visible areas (cross-hatching), bearings of lines-of-sight and distances to visible areas (m). Scale is 1:15 840.

Bio-environmental Indices: A New Approach to Trade-off Analysis in Forest Planning

Principal Investigators: D.W. McKenney, Sault Ste. Marie, ON. and B.G. Mackey, Australian National University, Canberra, Australia

The objective of this project is to provide spatially reliable estimates of selected wood and nonwood values for the forests of Ontario for use in Geographic Information System (GIS)-based decision support tools to assist in trade-off analysis. The ultimate aim is to develop empirical approaches for examining the production possibilities for, and trade-offs between, wood production and biodiversity conservation.

The project is a collaborative effort involving the Ontario Ministry of Natural Resources (OMNR), Canadian Forestry Service (CFS), Canada's Green Plan, Agriculture Canada, Northern Ontario Development Agreement (NODA), and the Australian National University.

The Bio-environmental Indices Project: An Overview (NODA Note No. 1, 1994) provides the following summary:

In an operational sense the Bio-environmental Indices Project (BIP) is developing methods to assess the relative contribution particular landscapes make to both the conservation of biodiversity and the supply of wood. It will then be possible to estimate for a given location the opportunity costs, in terms of wood forgone, of favoring ecological conservation and a measure of the ecological opportunity costs of harvesting. In many, if not most, cases, trade-offs need not be a matter of all or nothing; rather, various scenarios need to be explored to resolve competing objectives.

Biodiversity is an umbrella concept that relates to a range of biological and ecological phenomena. It includes genetic, species, and ecosystem diversity. The BIP will be developing spatial models that encompass these concepts based on the following bio-environmental indices: habitat suitability, taxonomic diversity, representativeness, and wilderness quality. These data will be matched with spatial estimates of standing and potential wood supply. Standing wood supply will be examined using the Canadian Forest Resource Data System and the OMNR Forest Resource Inventory. Potential wood supply will be modeled using existing growth and yield estimates and through new analyses of existing growth and yield field observations.

The project consists of three phases: primary database development, biophysical and ecological modeling, and development of decision support tools and trade-off analyses.

The primary database will comprise: a digital elevation model (DEM); climate surfaces; various biological site data; wood inventories; the Rinker Lake case study; geological data on soil parent material; extant land cover; and disturbance history.

An array of GIS-related computer programs are needed to undertake the database development and analyses required. A UNIX workstation GIS package called GRASS is the "hub" of the BIP workstation, while IDRISI is the PC GIS hub. The BIP is producing several customized PC software programs to undertake particular analyses.

A case study has commenced at the Rinker Lake Field Area (*see* NODA Project 4212, page 109). This work aims at analyzing ecological and wood values at an operational scale.

A number of papers have been written and published or presented based on the BIP. These include:

Mackey, B. 1992. The bio-environmental indices project. Paper presented at the GIS Workshop in Toronto, December, 1992.

Mackey, B.; McKenney, D.; 1992. The bio-environmental indices project: An overview. Nat. Resour. Can., Canadian Forest Service–Ontario, Sault Ste. Marie, ON. NODA Note No. 1. 5 p.

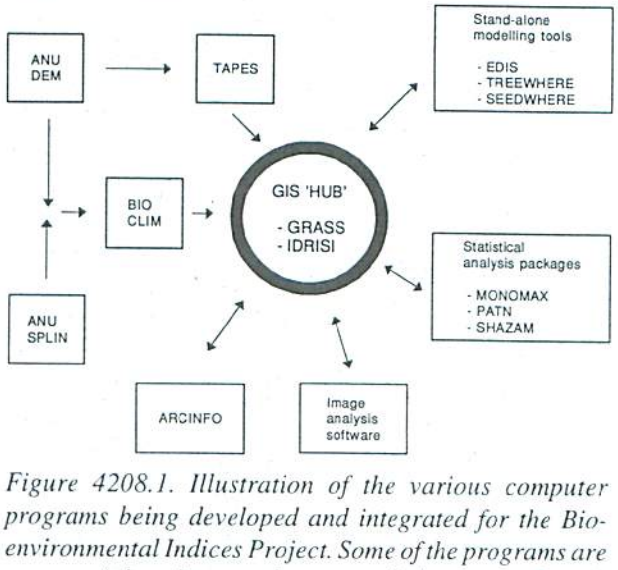

Figure 4208.1. Illustration of the various computer programs being developed and integrated for the Bio-environmental Indices Project. Some of the programs are commercial packages, others are existing research tools for analyzing data within a modeling framework.

Mackey, B.G.; McKenney, D.; Widdifield, C.; Sims, R.A.; Lawrence, K; Szcyrek, N. 1994. A new digital elevation model of Ontario. Nat. Resour. Can., Canadian Forest Service–Ontario, Sault Ste. Marie, ON. NODA/NFP Technical Report TR-6. 26 p. + appendix.

Mackey, B.G.; Sims, R.A.; Baldwin, K.A.; Moore, I.D. 1993. Spatial analysis of boreal forest ecosystems: Results from the Rinker Lake case study. Paper presented at GIS Conference. September 1993, Breckenridge, Colorado.

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Products of this project will include:

1. Spatial Climate Model of Ontario;
2. Digital Elevation Model (DEM)-based Catchment Study (Rinker Lake Area);
3. DEM for Ontario;
4. Ontario Landscape Classification (based on a minimum of climate and terrain analysis);
5. Spatial Prediction Model (TREEWHERE) (PC-based DSS);
6. Biological Modeling for Spatial Analysis (BIOMOD) — a compendium of procedures and computer programs;
7. Forestry and Ecological Trade-off Analysis (FETA) – selected procedures/analyses of trade-offs between alternative land allocations (bio-environmental); and
8. A NODA/NFP final report.

GIS Methodologies to Develop Spatially-based Boreal Ecosystem Models in the Rinker Lake Research Area, NW Ontario

Principal Investigator: R.A. Sims, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a prototype, spatially-based and integrated ecosystem model with the assistance of a Geographic Information System (GIS) for a representative boreal forest area in northwestern Ontario. This is one of a number of projects taking place in the Rinker Lake area.

By the end of 1993, a comprehensive resource inventory had been conducted of the general study area, an area of approximately 900 sq km, using a biophysical resource mapping approach.

In terms of the digital themes, there are several layers that have been or are currently being prepared. A 20-m digital elevation model (DEM) for the area has been constructed using digital 1:20 000 Ontario Base Map (OBM) contour data. At the 1:20 000 working scale, interpreted Northwestern Ontario Forest Ecosystem Classification (NWO FEC) theme maps, vegetation cover-type theme maps, and the Forest Resource Inventory (FRI) photo-interpreted maps for the Rinker Lake Research Area have also been annotated and registered to the OBM digital basemap. A digital surficial map, based upon air photo interpretation and a geological field survey conducted during the summer of 1993, has been completed in cooperation with the Ontario Geological Survey. Additional spatial databases, including remote sensing themes and other feature maps, are also being constructed, derived or acquired, and imported into the GIS.

The field work has provided a network of ground-based data points. Ground truthing studies of the most recent (1985) black and white 1:15 840 air photos of the area were carried out during the summers of 1992, 1993, and 1994. This field work, based out of the Rinker Lake OMNR camp, and was conducted by up to nine persons. Ground points were registered (latitude, longitude, and elevation) using Global Positioning Systems (GPS). NWO FEC plots established in the general area during 1983–1985 were revisited and additional data (GPS coordinates, etc.) were collected. Some new topographic gradients were characterized using GPS and NWO FEC classification (soils, vegetation). Color-infrared 1:10 000 air photos of the entire area were acquired and interpreted. These were also used for field sample plot selection. To help in the calibration of the DEM, extents and shapes of different local drainage catchments were ground-measured and described in terms of soils, site, and vegetation features. The following field plot networks were established during the summer programs (1992, 1993, and 1994); for all plots, summary databases were compiled in electronic form.

- approximately 100 FEC (vegetation, soils, mensuration, stand/site, drainage catchment) plots;
- over 50 University of Waterloo plots (remote sensing calibration, stand/site);
- approximately 200 surficial geology plots (soils, stand/site, surficial features);
- nine bird habitat description stations (forest bird population monitoring, stand/site, FEC description); and
- approximately 80 succession (i.e. previously cutover areas, vegetation, soils, stand/site data) plots.

Construction of first approximation map overlays and GIS data analyses were conducted during the fall and winter of 1992–93 and continued during the winter and spring of 1993–94. Layers are being digitized and interpreted. Polygons will be photo-interpreted, transferred to the OBM base, and imported into a GIS system for modeling work. Bioclimatic variables will be prepared as map layers and DEM projections. The Provincial Remote Sensing Laboratory (PRSL) and University of Waterloo collaborators have cooperated in the preparation of some enhanced and interpreted remote sensing images (SPOT, LANDSAT TM). Using an analytical GIS, ongoing modeling work includes:

- application and refinement of terrain and catchment hydrology models using the OBM elevation data in a DEM framework;
- examination and potential integration of various remotely sensed sources of data that describe soil parent material, surficial deposits, and the distribution of vegetational cover types; and
- investigation of the use of these databases in the spatial extension of other biological site data.

During the fall and winter of 1993–94, the primary model development and ecosystem mapping work was developed and refined. In the summer of 1994, additional field work was undertaken to test and evaluate the reliability and accuracy of the interpreted maps and polygon boundaries, and to provide additional information on nonforested vegetation cover types.

Additional refinements and finalization of all elements of the work will be conducted following the last phase of field checking, during the fall and winter of 1994–95. At this point the final outputs and technology transfer activities will be delivered, and final models and map products will be made available.

A guidebook, entitled *Ecosystem mapping: The leading edge*, was produced for the Rinker Lake Study Area Field Tour, conducted in July 1993.

Preliminary results were presented at the workshop, "Forest Ecosystem Description, Mapping and Modelling Using GIS-based Natural Resource Information—Some Case Studies," in Sudbury in April 1994. The presentation was entitled "Using Surficial Landforms as a Key Component for Ecosystem Modelling in the Rinker Lake Study Area."

The work was highlighted as part of a 1-day tour to the Rinker Lake area in August 1994. Held during the Global to Local: Ecological Land Classification Conference, the tour was attended by over 200 researchers and land managers. A printed tour book was also prepared and provided to participants.

Other products of the work to date include several papers in scientific journals and conference proceedings.

This project will provide an opportunity to develop and test new DEM-based methodologies for forest ecosystem study at approximately a 1:20 000 scale, and may demonstrate potential new uses for digitized OBM data. The project will also permit an objective, case-study evaluation of northwestern Ontario FEC mapping used in conjunction with other spatial databases in order to develop decision-support systems.

The results will provide a demonstrated application of personal computer-based GIS for forest management, and should provide industrial GIS users with some new techniques and methodologies for area-based studies in forestry.

Calibration of "ONTWIGS" Forest Projection System for the Mixedwood Types of North Central Ontario

Principal Investigator: B. Payandeh, NRCan, Sault Ste. Marie, ON.

This project will fully calibrate the forest growth and yield projection system "ONTWIGS" for the boreal mixedwoods in north central Ontario, and demonstrate the model to prospective clients. ONTWIGS is a computer model developed from LSTWIGS, the Lake States version of STEMS, a Stand and Tree Evaluation and Modelling System adapted for the microcomputer environment. This project will focus on model validation, model calibration, and development of new submodels based on local data.

In 1993, data acquisition (197 permanent sample plots, remeasured 4–6 times) was obtained from James River Marathon Co., and data entry, editing, screening, and storage were completed. Several FORTRAN programs were written for preliminary analysis of the data and for preparing input formulation as required by "ONTWIGS."

Preliminary model calibration was begun, and demonstrated to staff of James River Marathon Co., OMNR, and CFS–Quebec. A poster presentation was prepared for display at the International Meeting on Growth Models and Their Use, which was held in Quebec City.

ONTWIGS has been calibrated on the entire data set. The model will be fine-tuned to improve its accuracy, aiming to reduce the 5-year projection error to ±5 percent for the main stand attributes, *i.e.*, density and basal area and average DBH for the boreal mixedwood of north central Ontario.

Additional programming was required for input data preparation because of unequal time intervals between remeasurements (4–7 years), errors in "ingrowth" recordings, and combining of black spruce (*Picea mariana* [Mill.] B.S.P.) and white spruce (*Picea glauca* [Moench] Voss). These factors may affect the accuracy of the calibration results.

When the ONTWIGS growth and yield model is fully adapted and calibrated for local conditions, it will be demonstrated to collaborators and other interested clients in workshops and conferences. A *Users' Manual for ONTWIGS* has been completed and is under review.

Calibrated ONTWIGS will provide a preliminary stand growth and yield projection system for the boreal mixedwoods of Ontario, and will benefit sustainable forestry development in northern Ontario by providing managers with the ability to analyze alternative management activities.

4214

Development of Postplanting Forest Vegetation Management Predictive Models

Principal Investigator: R. A. Fleming, NRCan, CFS–Sault Ste. Marie, ON.

The objective of this project is to develop quantitative predictive models for supporting decisions on vegetation management in black spruce plantations after planting. Basic models describing the effects of weeds on crop growth will be developed using data gathered in 1992 from J. Wood's plantations (*see* NODA/NFP Project No. 4023, page 25).

Data collected from individual crop trees in four 11-year-old black spruce vegetation management and stock comparison experiments across northeastern Ontario are currently being synthesized. These data include the percentage of the crop tree covered by competing vegetation, in addition to proximity factors and size of the competing vegetation relative to the crop tree.

These data are being used to develop quantitative, time-dependent predictive models describing the effects of weeds on crop growth in black spruce plantations. The models describe changes in tree volume, height, survival, and basal area over time as functions of imposed management regimes, which are distinguished by the types and amounts of competing vegetation tolerated in different years since the plantation was started. Accordingly, weed control accounted for little of the gain in the total height of the black spruce outplants until 8–10 years after treatment. By contrast, stem diameter showed an immediate response to weed control. The bareroot stock remained larger in height and stem diameter than did the paperpot stock 11 growing seasons after outplanting, but the relative size difference diminished over time. Generally, the spring-planted crop trees maintained their initial size advantage over the summer-planted ones throughout the experimental period.

The principal output of this project will be a simple manual and user-friendly tables and decision flowcharts outlining the benefits and costs associated with each vegetation management regime. Results will also be available in a software package. Information will be made available to forest managers through a number of workshops and field tours. The project is expected to finish in late 1995.

The models are intended to provide useful information on threshold levels of competition and the cost effectiveness of various treatments for reducing competition density.

Figure 4214.1. Row of 11-year-old spring-planted black spruce transplant stock that had been treated with 2.14 kg a.e./ha of glyphosate three growing seasons after planting. (Photo courtesy of J.E. Wood.)

ENSTRAT: A Decision Support Tool for Selecting Forest Field Plots in Ontario

Principal Investigators: D. McKenney, V. Nealis, A. Hopkin, NRCan, Sault Ste. Marie, ON. and B.G. Mackey, Australian National University, Canberra, Australia

This project is designed to develop a support tool for stratifying environmental conditions as a basis for optimizing the location of forest field plots (e.g., research or monitoring). Although ENvironmental STRATification (ENSTRAT) will be generic, this project will focus on supporting insect, disease, and forest health surveys in Ontario.

ENSTRAT will support the improved allocation of limited resources by focusing plot selection in representative environments; aiding in the development of a more systematic protocol for plot locations, which would help current and historical analyses; and supporting the scientific component of research plot location and subsequent analyses.

The project will refine Forest Insect and Disease Survey (FIDS) Unit data and incorporate it into the Bio-environmental Indices Project (BIP) spatial modeling framework (*see* NODA/NFP Project No. 4208, page 107).

Data sets on jack pine budworm, the North American Maple Project, and the Acid Rain National Early Warning System (ARNEWS) have been collated and made compatible with climate models. This has involved appending latitude, longitude, and elevation to all plots where that information was not already present. Figure 4215.1 shows the application of maximum and minimum monthly temperatures to the jack pine dataset as an example of what can be done with this system. A data set on Sclerroderris canker is currently being adapted and analysis is beginning.

A technical note, entitled *Towards an environmental stratification for optimizing forest plot locations: A compilation and representativeness assessment of selected Ontario forest insect, disease, and health plots*, is presently under review. A users' manual and decision-support system will be developed.

By providing the ability to identify the minimum number of plots and replicates that will achieve the desired level of representation, this project will save time and money in plot establishment, and reduce the need to establish additional plots to achieve the desired confidence levels.

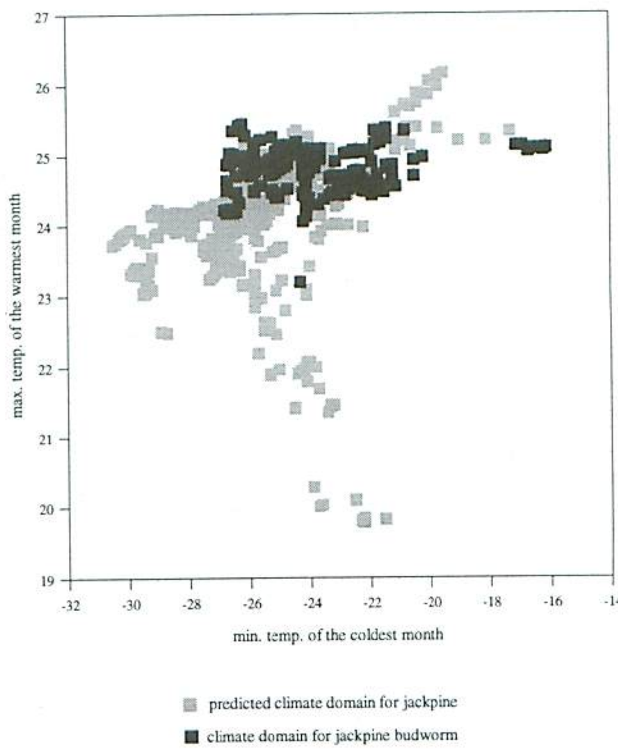

Figure 4215.1. Jack pine budworm/jack pine climate domain analysis. (Figure courtesy of J. McKee.)

4216

Forestry Investment Analysis Made Simple

Principal Investigators: A. Ghebremichael, NRCan, Sault Ste. Marie, ON.; J. Williams, Consultant, Scarborough, ON. and M. Vasievich, U.S. Forest Service, East Lansing, Michigan.

The objective of this project is to explain the concept of forest investment in terms that can be readily understood by the field forester. A simplified decision making tool will allow the forest manager to make economic decisions on how and where to best invest his budget to achieve the maximum results of the stand at rotation age. The financial analysis software QuickSilver© will be modified to handle Ontario forestry conditions and a user-friendly manual will be developed.

Dryden had been chosen as the initial case study site, but further discussion with local foresters suggested there was no decision-making issue. Researchers chose istead to collect data from a variety of regions in Ontario.

A draft of the manual, entitled *Managers' guide to forestry investment analysis: A decision-making support tool for forest management*, has been completed and is being reviewed.

Researchers originally intended to develop an Ontario version of QuickSilver©, but found a high demand for a national version. As a result, the project was expanded to include the development of a Canadian version of the software package, which is being called Canadian QuickSilver 4© (CQS4). The software has been developed and subjected to a preliminary test run. Comments and problems that arose from a workshop held in Thunder Bay in October 1994 are being addressed by the program developer. A users' manual is also being written.

The results of this project will be communicated to forest managers through a series of workshops and seminars. The software and user's manual will provide forest managers with a comprehensive, easy-to-follow decision-making tool that will allow them to consider the most efficient use of scarce funds.

Economic Wood Supply from Alternative Silvicultural Systems

Principal Investigator: L. Van Damme, Lakehead University, Thunder Bay, ON.
Scientific Authority: B. Callaghan, OMNR, Sault Ste. Marie. ON.

The purpose of this project is to quantify the effects of implementing alternative silviculture systems on the long-term economic wood supply, using the Seine River Forest as a case study area. An understanding of the economic and biological consequences of the various alternative silviculture systems is required to determine their biophysical limits and the suitability of new forest policies.

Information, including the Abitibi–Lakehead University Research Forest data of alternative silvicultural systems, will be processed through a PC-based version of the Harvest Schedule Generator (HSG-lite) simulation model to examine the long-term consequences of alternative silvicultural systems at both the stand and forest level.

The data set has been compiled and tested. The current model required significant modification to simulate silviculture activities associated with selection and shelterwood systems.

A preliminary literature review shows that the analysis of alternative silviculture systems in North America has been largely focused upon stand level evaluations, which are based upon financial maturity theories. Forest scale analysis that specifically deals with the location or arrangement of forest operations that result from the application of alternative silviculture systems has not been found in the literature search.

Work has been undertaken outside this project on forest-scale analysis of forest management operations that incorporate spatial information. Their approach uses linear programming, which differs from the deterministic simulation approach used in this project. One of their case study areas in the province's Timber Production Policy initiative includes the Seine River Forest.

At the conclusion of this project in September 1995, a report will be submitted. It will outline a total cost scenario for a fully integrated wood harvest, transportation, and silviculture program, and will address questions of additional costs and revenues for alternative harvesting, establishment, and thinnings versus clear-cutting.

4219

Even-aged Boreal Forest Management Planning Models: Applications

Principal Investigator: P. W. Street, MITIG Forestry Services Ltd., Thunder Bay, ON.
Scientific Authority: D. Hayhurst, OMNR, Timmins, ON.

The objective of this project is to undertake a comparative analysis and demonstration workshop of selected even-aged boreal forest management planning models.

The relative strengths and weaknesses of a variety of models were assessed, given a specified set of forest management planning objectives common to the boreal forest. The models tested included FORMAN (version 2.3), GLFC-FORMAN, NORMAN, CROPLAN (FORMANCP), FORMAN + 1, HSG, and SFMM (Strategic Forest Management Model). The evaluation also incorporated the use of ancillary data generators: PCNFCS and the Canadian Forest Service's data generator for FORMAN + 1. The models were evaluated within the context of three case studies in selected northwestern Ontario forest management units. The case studies are designed to test model applicability with respect to:

- developing 5-year operational and 20-year strategic timber production plans;
- economic analysis of the impact on timber production possibilities given land alienation arising from the setting of reserves; and
- economic analysis of the impact on timber production possibilities given prohibitions against specific management activities.

A questionnaire was finalized and sent out in early 1994. This was followed by interviews. The Avenor Inc. data for their timber management plan was also ready in early 1994.

The final report, including all model runs, has been submitted. This report has been summarized and will be published. Two demonstrations of project results were given during the Northern Exposure Workshops in Dryden and Timmins, early in 1995. This project will provide potential users with an objective picture of the capability of each model, and which best serves a particular objective or need.

An OBM Terrain Analysis Toolbox for Resource Managers

Principal Investigator: P. W. Street, MITIG Forestry Services Ltd., Thunder Bay, ON.
Scientific Authority: K. Lawrence, NRCan, Sault Ste. Marie, ON.

The purpose of this project is to develop, using Geographic Information System (GIS) technology, a "toolbox" of user-friendly programs that provide decision support for resource managers through the utilization of digital topographic information from the new series of the Ontario Base Maps (OBMs).

The resulting products are especially useful to the forest industry in timber management planning by providing an improved capability for a cost-effective and environmentally sensitive allocation of capital resources for harvesting, access road construction, and silvicultural activities.

This toolbox is based on Arc/Info, the GIS standard for the forest industry in Ontario. Arc/Info Version 7.0 has incorporated the ANUDEM software developed by Michael Hutchison of the Australia National University. This addition has significantly improved the ability of Arc/Info to process digital elevation data and thereby produce accurate watersheds.

The project is complete and the draft final report has been submitted, along with a users' manual and programmers' manual. The conclusions reached in the final report are as follows:

- The OBM Terrain Analysis Toolbox is a valuable decision support tool for resource managers. The results produced are an accurate reflection of the input data provided.
- The Variable Width Buffering Tool is a product that can be considered an unbiased basis for negotiating Areas of Concern (AOCs) when following the *Timber management guidelines for the protection of fish habitat*. The buffers also provide an excellent tool for determining the total areas within AOCs when doing wood supply analysis or similar modeling exercises. Because of the raster techniques used to produce the buffers, there is an inherent inaccuracy that cannot be overlooked.
- The Slope and Aspect Tools provide resource managers with the ability to take a "quick look" at an individual basemap. The Road Profiling Tool provides a quick means of evaluating a variety of road location options. While not able to select the appropriate option, it will allow the resource manager to eliminate certain road location options. Limited resources can then be concentrated on the remaining viable road location options.
- The Watershed Delineation and Culvert Calculations Tools, while producing excellent results, are very sensitive to the input elevation data set. The DTM data provides consistently good results, while CONTOUR data produces marginal results in some instances.
- It is recommended that a thorough evaluation and verification of the Variable Width Buffering Tool, the Watershed Delineation Tool, and the Culvert Sizing Tool should be undertaken before these tools are used operationally. This work should also study the accuracy of the OBM elevation data sets and the ability of each of the sets to support these applications.

4222

Image Analysis of Wetlands in Northwestern Ontario

Principal Investigator: B. G. Warner, Wetlands Research Centre, University of Waterloo, Waterloo, ON.
Scientific Authority: J. K. Jeglum, NRCan, Sault Ste. Marie, ON.

The objective of this project is to develop a high resolution scanning technique for wetlands in boreal Ontario, and to test this technique as a wetland inventory tool.

Aerial photographs at standard scales (1:15 840 or 1:20 000) are scanned with high intensity image scanning equipment capable of providing resolutions at up to 3 600 dots per inch (DPI). In conjunction with multivariate statistics and field sampling, boreal wetlands are delineated at the level of the physiognomic Wetland Classification System for Ontario. Test areas include wetlands in the Geraldton Community Forest and the Rinker Lake Research Area.

This project had to address four areas in order to become practical for large scale classification:

1) data set storage;
2) photographic overlap;
3) equating pixel densities across various sets of photographs; and
4) a user-friendly method, which does not assume any knowledge of photo interpretation of wetland classes.

One of the main difficulties that researchers encounter with high resolution scanning is the size of the images. A 40-megabyte file is not uncommon. The use of removable hard drives (available up to 160 megabytes) and optical disks (up to 1 gigabyte) were investigated. Both methods were found to be satisfactory for storing these images; however, each is expensive and this may make the work inaccessible. Therefore, the researchers have developed advanced data reduction techniques similar to those used by NASA and the USA military to store the images. By storing the images as sets of harmonic orthogonal coefficients, a 90 percent reduction over the original image was achieved. This would make all work accessible to anyone with a 40-megabyte hard drive.

The final product of this project will be a manual on computer aided wetland classification. Included will be a set of modular programs to produce an image classification and determine its statistical accuracy. This technique will enable the field forester to produce reasonable and accurate wetland inventories using existing photographs and the software modules developed through this project.

Figure 4222.1. This project is developing a high-resolution scanning technique for wetlands in Ontario.

Socioeconomic Analysis

Assessment of Plylog Availability in the Chapleau Area

Principal Investigator: Kevin R.Lindquist, Forest Computer Consulting, Chapleau, ON.
(Agreement between the Chapleau Cree First Nation, OMNR, and NRCan)

The objective of this study was to assist in the assessment of wood quality of white birch (*Betula papyrifera* Marsh.) for use in veneer/plywood products; to determine the diameter distribution of white birch across the various stand and site types in the Chapleau area; and to establish birch plylog yields per tree and per hectare based on stand strata.

The sampling program consisted of two methods: destructive sampling and a product timber cruise. The results were used to estimate the overall annual availability of white birch and other species' plylogs suitable for a "Finnish-style" veneer/plywood plant within an 80-km radius of Chapleau.

The estimated total volume of white birch plylogs available was determined to be 5.4 million m^3 or 268,000 m^3/year if spread over 20 years. The total plylog estimate for yellow birch (*Betula alleghaniensis* Britton), hard maple (*Acer saccharum* Marsh.), and aspen (*Populus tremuloides* Michx.) is about 1.6 million m^3 or 85,000 m^3/year. Those data suggest that there is ample plylog volume available for a plywood mill in Chapleau.

The study was completed in August 1992.

4305

Community Development Impact Model

Principal Investigator: A. A. Kubursi, Econometrics Research Ltd., Burlington, ON.
Scientific Authority: A. Ghebremichael, NRCan, Sault Ste. Marie, ON.

The objective of this project is to address community development concerns and resource sensitivities of northern Ontario communities by focusing on three typical and vital communities, and by producing a user friendly computer model that captures the economic impact of capital investments, industrial expansion, and demand changes at the local level.

The proposed model, which integrates input–output analysis, location theory, and economic base models, will encourage coordination between the two main components of economic renewal and diversification: the identification, exploration, and evaluation of existing and potential economic opportunities, and the creation of a climate for economic expansion and entrepreneurship through parallel and on-going community initiatives. Participating communities are Kapuskasing, Sault Ste. Marie, and Thunder Bay.

A thorough literature survey and review was completed during 1993. It covered two basic subjects of interest to the study: community development models in general, and Canadian systems in particular. Literature on forest dependency ratios and the various approaches developed in Canada to gauge this dependence were also reviewed.

Data templates for the three communities were designed in Lotus format and sent to designated persons responsible for data collection in the community. Data on all relevant variables was then collected, codified, and organized. A working prototype of the model was developed.

A NODA/NFP note, entitled *CDIM—An overview*, will be published. Four file reports are also available: the *Technical Manual* (NODA File Report 9), the *Sault Ste. Marie Users' Guide* (NODA File Report 10), the *Thunder Bay Users' Guide* (NODA File Report 11), and the *Kapuskasing Users' Guide* (NODA File Report 12).

This model will give community planners a much better concept of the impact of various projects and potential investment opportunities on the local economy. The planning tool can be adapted to any northern community at a relatively low cost.

Economic Evaluation of Forest Research: A Framework for Allocation of Research Funds

Principal Investigator: G. Fox, Department of Agricultural Economics and Business, University of Guelph, ON.
Scientific Authority: D.W. McKenney, NRCan, Sault Ste Marie, ON.

The objectives of this project are to develop an Ontario version (Ontario Forest Research Evaluation Model – OFREM) of the research evaluation model developed by the Australian Centre for International Agricultural Research; to compile the necessary database to analyze potential research benefits for forestry research in Northern Ontario; to characterize the likely benefits of at least three NODA/NFP research projects; and to develop an Ontario forestry research valuation scoring or questionnaire model.

Several computerized databases and other bibliographic sources were accessed to identify relevant literature on this topic. Contributions on allocation models for research and development resources have been published in the economics literature, the agricultural economics literature, the forestry engineering management literature, and in several specialized technology journals and proceedings. A comprehensive list of citations, studies, and models has been compiled and is being categorized for the purpose of preparing a survey paper.

Criteria including project status, budget, investigator (internal/external), and the nature of the project were applied to select three NODA/NFP projects for evaluation. Those chosen were: Project 4004, *The development of bialaphos and glufosinate-ammonium as silvicultural herbicides*, G.R. Stephenson, University of Guelph (*see* page 58); Project 4042, *Unevenaged silviculture for peatland second-growth black spruce*, R. Gemmell, Abitibi-Price Inc. (*see* page 34); and Project 4201, *Application of portable GPS/desktop GIS for fire management support*, D. Tortosa, ELIRIS, Inc. (*see* page 74). Draft reports on the expected impacts of the three NODA/NFP projects have been submitted and are under review.

The project is expected to be completed by September 1995. Reports on the feasibility and potential usefulness of OFREM as a tool for forest research planning and on the research valuation scoring model will be submitted at that time.

Figure 4306.1. This project will report on the feasibility and potential usefulness of the Ontario Forest Research Evaluation Model (OFREM) as a tool for forest research planning. (Photo courtesy of Dr. R. Sutton).

4307

The Economic Value of Canoeing in Relation to Forest and Park Management

Principal Investigator: P. Boxall, NRCan, Edmonton, AB.
Scientific Authority: D.W. McKenney, NRCan, Sault Ste. Marie, ON.

The objective of this project is to examine the economic value of recreational canoeing in the park system of the Ontario–Manitoba–Minnesota region. The study will construct a system of demands in a travel cost framework across the park system and assess the values of individual canoe routes. Estimates of the influence of forest and landscape characteristics and the presence of recreational facilities on the economic value of canoeing will be made. User information will be linked with geographic data to build economic models to measure the impacts of forest/park management schemes.

This project is part of a larger study, initiated by the CFS–Sault Ste. Marie, which will examine recreational canoeing in Woodland Caribou, Quetico, Bright Sands, Wabikimi, and Turtle River provincial parks in Ontario; in Atikaki, Nopiming, and White Shell parks in Manitoba; and in the Boundary Waters Canoe Area in Minnesota (USA).

The results of the project will be presented in a series of information notes on the individual parks and canoe routes. A computer model linking these characteristics with economic value is being constructed. The project will be completed in March 1996.

Results of this project will develop a greater understanding of the interaction of forestry and park management activities with recreational canoeing, and allow resource planners to better gauge the effects of management interventions upon the recreational value of the forest. The economic models produced could also be used to predict changes in values and visitation rates that may result from changes in the physical characteristics of the canoe routes.

Figure 4307.1. This project is examining the economic value of recreational coanoeing in the park system of the Ontario–Manitoba–Minnesota region.

Integrated Resource Management
Demonstration Areas

Jack Pine Demonstration Forest

Partners:	E. B. Eddy Forest Products Ltd., Espanola, ON.
	Ontario Ministry of Natural Resources, Gogama, ON.
Partner's Representative:	K.A. Ley, Management Forester, E.B. Eddy Forest Products Ltd., Espanola, ON.

The objective of this project is to establish a demonstration forest portraying integrated resource management (IRM) techniques as a means of improving professional and public understanding of jack pine silviculture, and to illustrate general forestry themes, including wildlife, fisheries, biodiversity, and aesthetics, so as to broaden the area of interest to the general public.

This demonstration forest is located halfway between Sudbury and Timmins within a 10-km radius of the intersection of Highways 144 and 560 in the townships of Chester, Invergarry, Benneweis, and Vrooman. The site is situated on a glacial outwash plain surrounded by morainal deposits and occasional dunes, which provide a wide range of sites for jack pine in various stages of development. The area is managed for sustained yield timber production, and is a popular destination for fishermen, hunters, and canoeists; it also has a history of scientific study of jack pine silviculture and associated wildlife.

Eleven sites were chosen to form the basis of an IRM demonstration forest. Signage is being prepared for each site, as is a demonstration forest brochure for use by the general public.

Proposed sites for development include examples of site preparation methods (barrels and chains, Bräcke Kultivorn, Young's Teeth), regeneration methods (aerial and hand seeding, bareroot and paperpot seedlings), maintenance (juvenile spacing, aerial release, glyphosate, CFS experimental spacing trials, motorized brushsaw), damage (rabbit browsing), various harvest methods, and age classes.

In addition to silviculture themes, a warm-water fishery and pickerel spawning site are included in potential sites. A self-guided walking tour is also proposed.

Work began in the fall of 1993 and has been completed.

4404

Porcupine Demonstration Forest

Partners: Timmins Economic Development Corporation (TEDC), Timmins, ON.
Ontario Ministry of Natural Resources, Timmins, ON.

Partners' Representative: S. Doucet, Office Manager, TEDC, Timmins, ON.

The objective of this project is to establish a demonstration forest portraying integrated resource management (IRM) techniques as a means of improving professional and public understanding of jack pine and black spruce silviculture and to illustrate general forestry themes, including wildlife, fisheries, and aesthetics, so as to broaden the area of interest to the general public.

This demonstration forest is located between Timmins and Matheson and is comprised of two self-guided driving tours, one south of Highway 101, along the Gibson Lake Road and the other along Highway 610 and the Ice Chest Lake Road. It lies within the Northern Clay Belt climatic region and is representative of the boreal forest. The area is managed for sustained yield timber production.

In all, 21 stops are identified to provide an overview of an IRM demonstration forest. Highly visible signs, numbered to correspond with a colorful tour booklet and audio cassette tape (available in English or French), make it easy and fun to learn about forests and how they are being managed for the good of all. Tour booklets and tapes can be obtained from the local tourist bureaus and from the park office at the Kettle Lakes Provincial Park.

Stops include a variety of examples of ongoing resource management practices, including environmentally considerate horse logging, gravel pit reclamation through planting, quarry fish stocking, plantation establishment and tending, block cuts, and fire ecosystems.

The Porcupine Demonstration Forest was officially opened in June 1994. The Timmins Economic Development Corporation has received two prestigious national awards for advertising and development of the demonstration forest package since the opening.

Figure 4404.1. Tall signs on the Porcupine Demonstration Forest self-guided driving tour are easy to see from the road. (Photo courtesy of A. Cameron.)

Claybelt Demonstration Forest

Partners: 6/70 Community Forest, Kapuskasing, ON.
Ontario Ministry of Natural Resources, Kapuskasing Area Office, Kapuskasing, ON.

Partner's Representative: D. Haldane, Manager, 6/70 Community Forest, Kapuskasing, ON.

The objective of this project is to establish a demonstration forest portraying integrated resource management techniques and systems in black spruce as a means of improving professional and public understanding of black spruce silviculture, and to illustrate general forestry and ecological themes, including wildlife biodiversity, sustainability, and water quality.

This demonstration forest, officially opened 24 May 1995, is located in the townships of Swanson and O'Brien, south of Kapuskasing along the Swanson Road. The area is typical of the Clay Belt and supports a variety of black spruce age classes in pure and mixed stands. It has been and continues to be managed for sustained yield timber production and is a popular destination for fishermen, hunters, and bird watchers. Recently, the 150 millionth tree planted on Spruce Falls limits was planted on this site.

Eleven demonstration sites have been identified and located within the area. A demonstration forest pamphlet and booklet is available for a self-guided tour. In 1993 initial groundwork and background documentation was begun. Trails, appropriate signage, parking, and picnic areas enhance the enjoyment of this demonstration forest.

This area exhibits almost every example of current silviculture practice and moose habitat prescription in the Clay Belt. Renewal treatments include harvest, site preparation, and bareroot planting on uplands; chemical site preparation; natural regeneration via careful logging around advanced growth, group seed trees, feller-buncher seeding, aerial seeding; and plantations using container stock and clonal stock on lowlands. These treatments are all present on recent cutovers. There is also a diverse range of natural and intensive renewal treatments on other age classes of cutover within the demonstration area.

Plantations established in the 1960s have been tended and provide an excellent example of the use of tending as a silvicultural tool.

Moose habitat prescriptions include no-cut blocks and corridors in various stand types to provide for all aspects of moose habitat and feeding area, and reserves along water bodies.

This demonstration provides an accessible opportunity for forestry professionals and the public alike to learn what silviculture tools are being applied in the Clay Belt, to see their expected results, and to be able to view and compare these with the established second growth forests. There are permanent sample plots, songbird census plots, old trials, and recent treatments that have capability for analysis and measurement. New demonstrations can be added within the context of the area.

Technology transfer will occur through the use of descriptive signage within the demonstration forest and via two publications: a general pamphlet and a booklet describing the treatments in greater technical detail. Both will be available locally. Advertising in local newspapers and presentations to educators and the media is planned to improve awareness of this demonstration forest.

4406

IRM Demonstration Forest Exhibit

Partners: The Friends of Algonquin Park, Whitney, ON.
Ontario Ministry of Natural Resources, Algonquin Park, Whitney, ON.

Partner's Representative: P. Tozer, The Friends of Algonquin Park

The objective of this project is to illustrate the forest management practices employed in the Algonquin Provincial Park, as a means of improving professional and public understanding of integrated resource management techniques in red pine and white pine and northern hardwood forests, by creating an exhibit of eight information panels and a video program.

This demonstration exhibit is located at the Algonquin Park Logging Museum on Highway 60.

Visitors to Algonquin Provincial Park may familiarize themselves with the logging history of the area via at least 12 walking trails, each with specific themes and accompanying descriptive booklets, situated along Highway 60 through the southern portion of the park. All aid in a general understanding of the environment, but do not specifically address present day logging and integrated resource management practices.

The existing logging museum and trail, which introduces past logging practices in the park and brings visitors up to date with logging today, provides an ideal opportunity to reach a large number of people with a factual and positive program of current management techniques.

Eight information panels and a video show, including actual and computer generated footage for a 5-minute program on video laserdisc, is housed in the restored ranger cabin at Stop 19 on the Logging Museum Trail. This exhibit was opened to the public in the spring of 1995.

Figure 4406.1. Exhibit housed in the restored ranger cabin at Stop 19 on the Algonquin Park Logging Museum Trail. (Photo courtesy of A. Cameron.)

Woodland Community Partnership Demonstration Forest
The Wolf Tree Trail

Partner: Abitibi-Price Inc., Thunder Bay, ON.
Partner's Representative: B. Smith, Freehold Supervisor, Abitibi-Price Inc., Lakehead Woodland Division, Thunder Bay, ON.

The objective of this project is to establish a demonstration forest portraying integrated resource management techniques as a means of improving public and professional understanding of jack pine and black spruce silviculture, and to illustrate how general forestry themes, including wildlife, aesthetics, biodiversity, and recreation, fit into the enhanced stewardship philosophy of Abitibi-Price Inc.

This demonstration forest is located in Abitibi-Price Inc.'s private land Block 2, some 100 km west of Thunder Bay and approximately 5 km north of Highway 17. The area is an outwash plain with gentle slopes and several water-filled kettles. The deep soils are dry to fresh, well drained, coarse sands. The site is generally dominated by fire origin jack pine (*Pinus banksiana* Lamb.) stands with balsam fir (*Abies balsamea* [L.] Mill.), tamarack (*Larix laricina* [DuRoi] K. Koch), and black spruce (*Picea mariana* [Mill.] B.S.P.) components in some stands. The area has been and continues to be managed for sustained yield timber production. A large seed orchard and two family tests sites have been established in this area. The demonstration site and adjoining Raith Forest have a 35-year history of research trials and experiments.

A central demonstration sign shelter, parking loop, and picnic and rest area is the focal point of the demonstration forest. A 1.15-km walking trail runs through a sequence of treatments (scarification, tree planting, vegetation management), insect damaged areas, and old-growth areas. A scenic lookout observation deck at the half-way point of the trail provides an opportunity to view special geological features and learn of the management strategies for wildlife habitat and erosion control. Approximately 10 stops are envisioned with suitable IRM theme-related messages.

Programs planned on or adjacent to the demonstration forest area include: intensive silviculture; cooperative studies in vegetation management with Lakehead University and the OMNR; development of an ecotourism resort; an array of silvicultural systems to effect biodiversity, preserve aesthetics, and protect wildlife habitat; specific areas for agroforestry practices relating to blueberry and Christmas tree production; examples of management for scenic values; demonstrations using soft touch harvesting equipment; and simultaneous cover crop seeding.

Highway signage 5 km east and west of the Dog Lake Road–Highway 17 intersection will inform and entice the public to enjoy the trail.

Trail, site, and signage work have been completed and the official opening took place in August 1995.

4408

Elk Lake Demonstration Forest

Partner: Elk Lake Community Forest, Elk Lake, ON.
Partner's Representative: P. Tufford, Manager, Elk Lake Community Forest, Elk Lake, ON.

The objective of this project is to establish an integrated resource management demonstration forest, within a one-half hour's driving distance of Elk Lake, for public education purposes and to provide opportunities for the advancement of technical expertise of resource managers; and to consolidate the link between the Elk Lake Eco-Resource Centre and the Elk Lake Community Forest.

Located within the Elk Lake Community Forest, and extending across six townships (Chown, Corkill, Haultain, Lawson, Mickle, and Nicol), the area is characterized by a mosaic of even-aged stands, over 60 percent of which are between 41 and 80 years old. Predominant commercial species are jack pine (*Pinus banksiana* Lamb.), white spruce (*Picea glauca* [Moench] Voss) and black spruce (*Picea mariana* [Mill.] B.S.P.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.). Three major logging operators are based at Elk Lake. Many commercial tourist outfitters are located on or adjacent to the area and utilize the fish, wildlife, and aesthetic resources of the forest.

A self-guided driving tour of up to 15 stops is being developed. Vehicle pull-offs, parking, short trails, and signage kiosks are planned. An introductory display at the Community Forest office and eventually at the Eco-Resource Centre will feature IRM activities in the area. Poplar and jack pine regeneration, release, tending, prescribed burn block cuts, restricted access for remote tourist outfitters, water crossings, spawning sites, moose habitats, and a picnic/rest stop are proposed.

In addition to the display at the Community Forest office, the use of descriptive signage within the demonstration forest and a public-oriented brochure will be prepared.

The demonstration forest will provide educational opportunities to local and southern Ontario students. The Timiskaming District Secondary School has designed a credit course centered around participation in the project. The course will provide students with credits in English, environmental geography, environmental science, and technology. The demonstration forest tour will form an integral part of all community forest curriculum development for both elementary and secondary school programs. The Elk Lake Community Forest also envisions the Eco-Resource Centre and the demonstration forest as providing outdoor education opportunities for schools in southern Ontario as well.

Vehicle pull-offs have been completed; signage, trail, and brochure work is also being completed.

Kingfisher Lake Demonstration Forest

Partner: Kingfisher Partner Group, Thunder Bay, ON.
Partner's Representative: L.A. Thomson, Chairperson, Kingfisher Partners Group, Thunder Bay, ON.

The objectives of this project are to create a managed demonstration forest area, with easily accessible walking trails within walking and driving distance of the Kingfisher Lake Outdoor Education Centre, that will provide students and the general public with opportunities to learn about boreal forest ecology, biodiversity, forest management principles, and forestry practices of harvesting and regeneration; develop programs and activities that foster a better understanding of the forest and forest industries in northern Ontario; and encourage tourism to the area through signage and promotional material.

The Kingfisher Lake Outdoor Education Centre and Demonstration Area site is approximately 20 km north of Highway 17 on Highway 527, north of Thunder Bay. Utilization of sites within a 25-km radius north of Kingfisher Lake is also anticipated.

The area includes mixed poplar and birch stands on the hills and predominately black spruce in the lowlands. Most boreal species are readily seen and many representative shrubs are present. For more than 20 years the site has been used for outdoor education interpretive programs for students and other groups. The Kingfisher Partner Group was created to draw upon the resources of a wide range of expertise and interest, and to open the use of these facilities to a wider spectrum of the population.

A self-guided walking trail, being developed adjacent to the current center's facilities, will convey information about forest ecology, succession, competition, biodiversity, and species identification and, in the long term, will illustrate forestry cutting and regeneration practices. The area north of Kingfisher Lake has been logged to show checker-board clearing, strip cutting, and shoreline reserves. The cut blocks will be planted or otherwise regenerated and methods of competition control will be demonstrated.

A driving tour, with interpretive stops along the way, will allow visitors to view IRM in operation.

Trail work was undertaken during the summer of 1994. Walking and driving tour development and supporting promotional materials, including interpretive stop markers, signage, and a brochure were also begun. An audio cassette to complement the driving tour will also be developed.

The Kingfisher Partner Group includes: The Lakehead Board of Education, The City of Thunder Bay, Avenor Inc., Abitibi-Price Inc., Scouts Canada, Lakehead University, Kingfisher Parents and Friends, and Northern Adventures.

4410

Natural Resource Centre IRM Interpretive Trail—The Pennock Creek Trail

Partners: Mitig Forestry Services Ltd., Thunder Bay, ON.
Ontario Ministry of Natural Resources, Northwest Region Science and Technology, Thunder Bay, ON.

Partner's Representative: P. Street, Mitig Forestry Services Ltd., Thunder Bay, ON.

The objective of this project is to establish an interpretive trail system with appropriate descriptive signage and a draft trail leaflet/brochure to demonstrate an integrated resource management approach to forestry.

The demonstration is located on the site of the former Thunder Bay Forest Nursery, partly within the boundaries of the city of Thunder Bay.

Forest stands, plantations, long-term experiments in growth and yield, and tree improvement, along with a riparian zone and a resident deer population, are now accessible and available to demonstrate a wide variety of IRM themes. The close proximity of an urban population in excess of 100,000 provides an excellent opportunity for public information. The varied subject matter will also be of use to technical and professional audiences.

The 1.8-km trail, beginning near the Northwest Region Natural Resource Centre buildings, travels north through a number of natural and managed forested and unforested areas, and passes through the riparian zone surrounding Pennock Creek. From there, it leads to a natural mixedwood forest, active deer yard, tree improvement area, spacing trial, and operational reforestation area.

Trail development, interpretive signs, and a brochure in English and French have been completed for this project. The trail was opened to the public in the spring of 1995.

Figure 4410.1. Entrance to the Pennock Creek Trail. (Photo courtesy of A. Cameron.)

Boreal Mixedwoods Demonstration Area

The objective of this project is to provide a focal point for the work at the Black Sturgeon Boreal Mixedwood Research Project area (*see* NODA/NFP Project 4038, page 29), and to provide a basic technical treatment of the information on boreal mixedwood programs being addressed. The site is located on the Black Sturgeon Lake Road, north of Highway 17 between Nipigon and Dorion.

The Black Sturgeon Boreal Mixedwood Ecosystem Research Project is the site of an integrated and multifaceted approach to management of this forest type. Fifteen research projects funded under NODA/NFP and other partner agencies are on-going.

Two 3-poster kiosks will provide overview information of six topic areas for technical and scientific audiences. Identification signage has been developed for 22, 10-ha treatment blocks as part of the demonstration area. A main sign, and a public-oriented 3-poster kiosk outside the main research area at the Camp 7 location on the Black Sturgeon Lake Road, provide basic boreal mixedwood information on the effects of spruce budworm on this forest, the role of fire, the past history of logging and civilization on this area, and the present research program.

During 1994, kiosks were built and temporary signs were erected. Guided tours of the site will be available; the itinerary and focus of these will vary with the group being hosted. Permanent signs for the blocks and a public kiosk were completed during the winter of 1994–95. These were installed in the spring of 1995.

4412

Elliot Lake Ecotourism Area

Partners:	Elliot Lake Research Field Station of Laurentian University, Elliot Lake, ON. Ontario Ministry of Natural Resources, Blind River Area Office, Blind River, ON.
Partners' Representative:	D. Berthelot, Manager, Elliot Lake Research Field Station, Elliot Lake, ON.

The objective of this project is to establish four self-guided trails portraying integrated resource management (IRM) techniques as a means of improving public understanding of some general forestry themes, including wildlife, fisheries, biodiversity, and aesthetics. Based on earlier studies of ecotourism opportunities in the vicinity of Elliot Lake (*see* NODA/NFP Technical Report TR-5, p. 8), four sites were identified as highly suitable for publicly oriented ecotourism. These sites display several aspects of IRM.

The sites are located at Elliot Lake and along Highways 108, 639, and 546, north and west of the town. Coupled with Highway 17 between Iron Bridge and the turnoff at Highways 17 and 108, these highways form a loop known as the Deer Trail. The sites occur within the Great Lakes–St. Lawrence Forest Region and display typical examples of old-growth hemlock (*Tsuga canadensis* [L.] Carr.), yellow birch (*Betula alleghaniensis* Britton), red pine (*Pinus resinosa* Ait.), and white pine (*Pinus strobus* L.), as well as conifer plantations up to 65 years old. Comparison with natural regeneration and other forest management treatments is highlighted.

Walking trail design, signage, and a tour pamphlet were completed to develop these four sites as active learning locations. The ecological and forest management points of interest will be incorporated into the existing self-guided Deer Trail driving tour package offered to area visitors. Site maps and signage at each site will enhance the learning opportunities and outdoor experience.

These trails were opened to the public as part of the Deer Trail tour in the spring of 1995.

Aboriginal Forestry Program

Aboriginal Forestry Program
Reserve Lands Forestry Subprogram

The Reserve Lands Forestry Subprogram (RLF), in operation since 1991, expired on 31 March 1995; however, funding is available to continue operations until at least 31 March 1996. The main objective of the RLF program is to support First Nations economic development through integrated, and sustainable forest practices on their lands. The goals for this subprogram are as follows:

a) in cooperation with the First Nations, to establish long-term integrated forest management plans for reserve lands;
b) to undertake appropriate training and technology transfer with First Nations to equip them to achieve the management and silvicultural objectives of their respective plans;
c) to promote opportunities for economic development in the forest sector; and
d) to enhance the awareness and understanding of forestry, particularly native forestry among First Nations and the general public.

In the last century, the forest on many First Nation reserves has deteriorated to a poor state. This has resulted, at least in part, through a history of:

a) unregulated harvesting;
b) fire and insect outbreaks; and
c) a lack of long term commitment to coordinated forest management.

Canada's native peoples have long been associated with the land and many of these people feel that they should be protecting and managing their forested area. Under the current Contribution Agreements (CAs), the First Nations are managing their natural resources in order that restoration of these lands can continue.

Of the 126 First Nations in Ontario, 57 (45 percent) have a current management plan for their reserve area. In the past 4 years (1991–1994) 40 (31 percent) have been active in some form of forest management operations under the Reserve Lands Forestry subprogram.

The following is a summary of the activities completed over the 5-year period 1990/91 to 1994/95:

<u>Planning and information</u>	14 management plans			
Management plan preparation				
Operating plan preparation				
Management/operating plan update				
Management Information System development				
Work/activity plan				
Records management				
Forest inventory (Cruise)				
Pretreatment surveys				
Posttreatment surveys				
Planning surveys				
<u>Site preparation</u>			1 262	ha
Mechanical				
<u>Regeneration</u>	3 183 000	trees	1 594	ha
Artificial regeneration				
Bareroot stock planting	2 628 000	trees	1 308	ha
Container stock planting	555 000	trees	275	ha
Natural regeneration				
Marking for seed trees			11	ha

Tending

Vegetation control	4 342	ha
Manual tools	973	ha
Brush saws	1 045	ha
Mats/newspaper	3	ha
Chemical ground spraying	2	ha
Timber harvest		
Improvement/sanitation cut	483	ha
Juvenile spacing/precommercial thinning	157	ha
Pruning		
High, 17'	92	ha
Low, 8'	148	ha
Marking: improvement/sanitation cut	1 372	ha
Hardwood girdling	67	ha

Boundary line marking

Silvicultural access

Technical support

- Consultants to First Nation offices
- First Nation forestry units:
  - Mitigonaabe Forestry Resource Management Inc.
  - North Shore Tribal Council, Forestry Unit

Training

- Tree planting
- Careful harvesting
- Silvicultural techniques
- Chainsaw operation
- Brush saw operation
- Geographic Information Systems
- Fire management
- Timber marking

Workshops, seminars

Special projects

- Medicinal plant study
- Wood fibre evaluation
- Undergraduate education study
- Business opportunities evaluation

Communications activities

- Newspaper articles
- Displays
- Pamphlets
- Reports

Employment generated — 4 535 person-weeks (92 person-years)

An integral part of this program has been an increased effort in the areas of forestry training and technology transfer. Through this approach community members are able to gain experience for local job opportunities in their area.

Figure 1. Silvicultural workers course for Aboriginal forest technicians, September 1994. (Photo courtesy of J-P Gladu.)

The following is a summary of activities, in each of nine Federal Electoral Districts for Northern Ontario for the period 1990/91–1994/95. This is followed by a further breakdown by Federal Electoral District for activities undertaken by each First Nation.

<u>Parry Sound–Muskoka District</u>

2	management plans prepared
8	hectares site prepared
87 000	trees planted on 44 hectares
927	hectares tended
3	kilometres of boundary line maintenance
384	employment generated (person-weeks)

<u>Nipissing District</u>

38	hectares site prepared
61 000	trees planted on 31 hectares
18	hectares tended
62	employment generated (person-weeks)

<u>Nickel Belt District</u>

55	hectares site prepared
75 000	trees planted on 38 hectares
246	hectares tended
124	employment generated (person-weeks)

<u>Algoma District</u> (figures include North Shore Tribal Council)

5	management plans prepared
178	hectares site prepared
314 000	trees planted on 157 hectares
1 083	hectares tended
1 036	employment generated (person-weeks)

North Shore Tribal Council

The forestry unit provided forestry planning and technical assistance to the six First Nations in the North Shore Tribal Council area. The forestry unit also provided appropriate forestry training for communities members.

Timiskaming District

1	management plan prepared
348 000	trees planted on 174 hectares
171	hectares tended
257	employment generated (person-weeks)

Timmins –Chapleau District

11	hectares site prepared
30 000	trees planted on 15 hectares
18	hectares tended
56	employment generated (person-weeks)

Kenora–Rainy River District (figures include Mitigonaabe)

4	management plans prepared
930	hectares site prepared
2 072 000	trees planted on 1 036 hectares
1 735	hectares tended
2 294	employment generated (person-weeks)

Mitigonaabe Forest Resource Management Inc.

Mitigonaabe forestry staff provided forestry planning and technical experience to 12 First Nations in the Grand Council Treaty 3 area. The forestry staff assisted the First Nations in completing the silvicultural projects identified in the management plans.

Thunder Bay District

1	development of 20 year management plan
10	hectares site prepared
15 000	trees planted on 8 hectares
67	employment generated (person-weeks)

Cochrane–Lake Superior District

1	development of 20 year management plan
40	hectares site prepared
181 000	trees planted on 91 hectares
144	hectares tended
99	hectares surveyed
255	employment generated (person-weeks)

Reserve Lands Forestry Projects on Reserve Lands
Thunder Bay – Atitkokan District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4552/4543, Fort William First Nation			
Management planning			52
Management plan update			
Mechanical site preparation		10 ha	1
Regeneration		15 000 trees	6
Total person-weeks			59

CA 4554, Lakehead University

Aboriginal Forestry and Undergraduate Education: A Framework and Implementation Plan for Lakehead University

Principal Investigators : Dr. P.N. Duinker, Dr. J.K. Naysmith, and J. Crichlow

Aboriginal people in Canada are increasingly expressing a desire for forestry education opporunities. Few postsecondary education institutions have yet responded to this need. This project anticipates that Aboriginal groups will frequently enter into partnership arrangements with colleges and universities for delivery of forestry education to Aboriginal students, and also for delivery of Aboriginal forestry concepts to all students. The report presents a framework for such partnerships, from early explorations through program design and delivery to ongoing long-term relationships. The framework consists of a goal, a set of principles, and guidance on partnership development. The framework is offered for use anywhere in Canada, and it is hoped that early applications will bring revisions and refinements to benefit subsequent users.

Parry Sound – Muskoka District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4545, Henvey Inlet First Nation			
Management planning			
Management plan update			59
Forest surveys			
Mechanical site preparation		3 ha	1
Regeneration			
Tree planting		25 000 trees	15
Tending			
Improvement/sanitation Cut	13	192 ha	46
Low tree pruning	20		
Marking (improvement/sanitation cut)	153		
Manual release	3		
Vegetation control (newspaper)	3		
Technical support			13
Training			1
Total person-weeks			135
CA 4547, Wasauksing–Parry Island First Nation			
Management planning			
Management/operating plan update			34
Forest surveys			
Geographic Information System mapping			
Regeneration			
Tree planting		29 000 trees	11
Tending			
Improvement/sanitation cut		470 ha	55
Marking improvement/sanitation cut	380	90	
Silvicultural access		3 km	17
Technical support			32
Total person-weeks			161

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4551, Magnetawan First Nation			
Management planning			3
Management plan update			
Operating plan/update			
Forest/posttreatment surveys			
Regeneration		33 000 trees	5
Tree planting			
Tending		265	56
Low tree pruning (8 feet)	90		
High pruning	82		
Manual release	8		
Hardwood girdling	61		
Improvement/sanitation cut	10		
Juvenile spacing	14		
Technical support			23
Total person-weeks			87
CA 4556, Shawanaga First Nation			
Management planning			1
Operating plan update			
Total person-weeks			1

Timiskaming District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
C.A. 4546, Temagami First Nation			
Management planning			11
Management plan preparation			
Forest surveys			
Regeneration		34 000 trees	7
Tree planting			
Seedling protection			
Tending		74 ha	30
Hardwood girdling	6		
Manual release	48		
Juvenile spacing	0		
Technical support			5
Technical assistance			
Training			6
Total person-weeks			59
CA 4549, Wahgoshig First Nation			
Management planning			16
Operating plan update			
Regeneration		314 000 trees	133
Tree planting			
Tending		97	30
Manual release	97		
Technical support			19
Total person-weeks			198

Nipissing District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Subactivity area Activity/subactivity	Area treated (ha) (ha)	Employment or trees planted	(person-weeks)
CA 4542, Dokis Bay First Nation # 9			
Management planning			
Forest surveys			
Mechanical site preparation		38 ha	7
Regeneration			
Tree planting		61 000 trees	26
Tending			
Low pruning	10	18 ha	18
Juvenile spacing	8		
Technical support			10
Total person-weeks			61
CA 4562, Nipissing First Nation			
Management planning			
Management plan development (initial phase only)			1
Total person-weeks			1

Nickel Belt District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4537, Whitefish Lake First Nation			
Management planning			16
Management plan update			
Operating plan preparation			
Forest inventory surveys (cruise)		900 ha	
May 31, 1995			
Regeneration		75 000 trees, 11 ha	453
Tree planting			
Marking–seed tree, natural regeneration			
Tending		246 ha	46
Tending–motor release	15		
Improvement/sanitation cut	55		
Marking improvement/ sanitation cut	176		
Boundary line marking			3
Technical support			1
Technical assistance			
Training			10
Total person-weeks			124

Figure 4537.1. Brush saw thinning at Whitefish Lake First Nation. (Photo courtesy of J-P Gladu.)

Kenora - Rainy River District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CAs 4505/06 and 4519/20, Mitigonaabe Forest Resource Management Inc.			
Management planning			
Operating plan preparation			192
Forest surveys			
Forest inventory cruise			
Post treatment surveys			
Other planning surveys			
Regeneration			
Prepurchase of stock		453 000 trees	10
Training/workshops/seminars			
Technical support			244
Technical assistance			11
Total person-weeks			457
CA 4507, Big Grassy First Nation			
Management planning			
Forest surveys			1
Mechanical site preparation		81 ha	3
Regeneration			
Tree planting		114 000 trees	53
Tending			
Manual release	64	64	31
Total person-weeks			87
CA 4508, Dalles First Nation			
Management planning			
Forest surveys			1
Mechanical site preparation		37 ha	2
Regeneration			
Tree planting		99 000 trees	39
Tending			
Manual release	9	9 ha	6
Total person-weeks			47

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4509, Eagle Lake First Nation			
Management planning			1
Mechanical site preparation		81 ha	3
Regeneration		65 000 trees	32
Tree planting			
Tending		143 ha	64
Manual release	54		
Motor release	74		
Juvenile spacing	15		
Training/technology transfer			15
Total person-weeks			114
CA 4510, Grassy Narrows First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		93 ha	4
Regeneration		206 000 trees	107
Planting			
Tending		178 ha	58
Motor release		91	
Manual release		87	
Training			1
Total person-weeks			170
CA 4511, Lac Seul First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		115 ha	4
Regeneration		275 000 trees	120
Tree planting			
Tending		168 ha	104
Manual release	85		
Motor release	45		
Juvenile spacing	38		
Training			4
Total person-weeks			232

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4512, Naicatchewenin First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		81 ha	3
Regeneration		148 000 trees	71
Tree planting			
Tending		91 ha	40
Manual release	67		
Motor release	24		
Training			3
Total person-weeks			117
CA 4513, Nicickousemenecaning First Nation			
Forest management planning			1
Forest surveys			
Tending		15 ha	9
Motor release	15		
Training			2
Total person-weeks			11
CA 4514, Rainy River First Nation			
Management planning			
Forest surveys			
Mechanical site preparation		83 ha	3
Regeneration		152 000 trees	67
Tree planting			
Tending		162 ha	86
Motor release	66		
Manual release	96		
Training/technical transfer			5
Total person-weeks			161
CA 4515, Seine River First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		107 ha	5
Regeneration		28 000 trees	57
Tree planting			
Tending		160 ha	100
Manual release	75		
Motor release	85		
Training			6
Total person-weeks			168

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4516, Wabaseemoong Independent Nation, Islington Band Logging			
Management planning			1
Forest surveys			
Mechanical site preparation		104 ha	5
Regeneration		224 000 trees	84
Tree planting			
Tending		527 ha	309
Manual release	20		
Motor release	507		
Training			2
Total person-weeks			400
CA 4517, Wabigoon Lake First Nation			
Management planning			1
Forest suryeys			
Mechanical site preparation		87 ha	3
Regeneration		155 000 trees	80
Tree planting			
Tending		181 ha	130
Manual release	83		
Motor release	98		
Training			2
Total person-weeks			215
CA 4518, Washagamis Bay First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		61 ha	2
Regeneration		153 000 trees	78
Tree planting			
Tending		37 ha	13
Manual release	35		
Motor release	2		
Total person-weeks			93
CA 4558, Mishkeegogamang First Nation			
Management planning			20
20-year management plan preparation			
Total person-weeks			20
CA 4559, Shibogama Interim Planning Board			
Management planning			2
Total person-weeks			2

Cochrane – Lake Superior District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4541, Constance Lake First Nation			
Management planning			1
Forest surveys			
Mechanical site preparation		40 ha	
Regeneration		80 000 trees	19
Tree planting			
Tending		2 ha	0
Ground chemical release		2	
Technical support			2
Technical assistance			
Total person-weeks			22
CA 4544, Ginoogaming First Nation			
Management planning			77
Forest surveys			
Mechanical site preparation			
Regeneration		101 000 trees	57
Tree planting			
Marking, uniform shelterwood			
Tending		142	82
Manual release	142		
Technical support			17
Total person-weeks			233

Figure 4544.1. Bareroot tree planting at the Ginoogaming First Nation. (Photo courtesy of J-P Gladu.)

Algoma District
1990–91 to 1994–95

The objectives of the following Reserve Lands Forestry (RLF) Contribution Agreements (CA) are to enhance the overall quality of the forest resource on reserve lands.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4531, Batchawana First Nation			
Management planning			
5-year work activity plan			6
Management Information System development			
Records update			
Tending		30	6
Improvement/sanitation cut	5		
Marking/sanitation cut	25		
Total person-weeks			12
CA 4532, Garden River First Nation			
Management planning			
Management plan update			7
5-year work activity plan			
Management Information System development			
Records update			
Forest inventory/cruise			
Mechanical site preparation			
Regeneration		68 000	46
Tree planting			
Tending		421	61
Precommercial thinning			
Marking	395		
Improvement cut	26		
Juvenile spacing			
Training			11
Total person-weeks			125

Figure 4531.1. Forest surveys at the Batchawana First Nation. (Photo courtesy of J-P Gladu.)

CA 4557, Garden River First Nation, Medicinal Plant Knowledge/Study

The objective of this projective was to conduct ethnobotanical studies of plants that have been traditionally used by Aboriginal people in the Sault Ste. Marie area. Study of these plants focused on both medicinal uses and their potential for controlling forest pests and diseases. The project also provided additional educational training opportunities for Aboriginal people.

The project involved the collection of plant samples with further studies done of 10–15 of the most promising plants. Two students from the Garden River First Nation conducted the field work with assistance from Dr. Mamdough Abou-Zaid of the Forest Pest Management Institute, of Natural Resources Canada, Canadian Forest Service in Sault Ste. Marie, Ontario.

A technical report listing the ethnobotanical information will be prepared, as will a 6–8 page pamphlet for distribution to First Nation offices. This information will eventually be incorporated into the management planning process for forest operations.

Person-weeks	16
Total person-weeks	141

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4533, Mississauga First Nation			
Management planning			51
Management plan update			
5-year work activity plan development			
Operating plan update			
Management Information System development			
Tending		137	5
Juvenile spacing	9		
Improvement cut marking	128		
Training			
Technical support			48
Total person-weeks			104
CA 4534, Sagamok Anisnawbek First Nation			
Management planning			3
5-year work activity plan			
Management Information System development			
Mechanical site preparation		41 ha	7
Regeneration		22 000 trees	8
Tree planting			
Total person-weeks			18
CA 4535, Serpent River First Nation			
Management planning			15
Management/operating plan			
5-year work activity plan			
Operations plan update			
Management Information System development			
Records update			
Mechanical site preparation		49	1
Regeneration		20 000 trees	13
Tree planting			
Tending		115	8
Marking, improvement/sanitation cut		115	
Total person-weeks			37

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4536, Thessalon First Nation			
Management planning			6
5-year work activity plan			
Management Information System development			
Records update management			
Mechanical site preparation		44 ha	3
Regeneration		52 000 trees	37
Tree planting			
Tending		24 ha	28
Marking, improvement/ sanitation cut	16		
Juvenile spacing	8		
Total person-weeks			74

Figure 4536.1. Soil pit analysis for preparing stand prescriptions at the Thessalon First Nation. (Photo courtesy of J-P Gladu.)

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
CA 4548, Ojibways of Sucker Creek First Nation			
Management planning			
Mechanical site preparation		8 ha	1
Regeneration		30 000 trees	9
Tree planting			
Tending		44 ha	36
Improvement sanitation cut			
Marking, improvement/sanitation cut			
Total person-weeks			46
CA 4550, Wikwemikong First Nation			
Management planning			6
5-year work/activities plan			
Mechanical site preparation		36 ha	4
Regeneration		122 000 trees, 16 ha	17
Tree planting			
Tending		312	161
Improvement/sanitation cut	236		
Low tree pruning	38		
Juvenile spacing	38		
Technical assistance			6
Total person-weeks			194
CA 4555, Cockburn Island First Nation			
Management planning			1
Management plan/operating plan update			
Total person-weeks			1

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)

CAs 4530/4538 North Shore Tribal Council, Forestry Unit

The objective of this project is to provide forestry planning and technical services to the six First Nations of the North Shore Tribal Council. The forestry unit, consisting of a professional forester, a forest technician, and other contract technicians, assisted in enhancing and preserving the forest resource of each First Nation. The unit also provided appropriate forest training for community members.

Clerical services are purchased from the North Shore Tribal Council on a fee-for-services basis. All of the work undertaken by the unit is directly applicable to the silvicultural and forest management planning work being jointly funded between Natural Resources Canada (Canadian Forest Service) and the individual First Nations.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
20-year management plan preparation			110
Management plan preparation			
5-year operating plan preparation			
5-year work activity plan			
MIS development update			
Resource management strategy			
Forest inventory cruise			
Other planning survey			
Regeneration		100 000 trees	10
Prepurchase of trees			
Technical assistance			263
Training			23
Education program training			
Technology transfer–silviculture			
Technology transfer			3
Total person-weeks			409

Timmins – Chapleau District
1990–91 to 1994–95

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)

CA 4540, Chapleau Cree First Nation

A wood fibre evaluation study for a proposed veneer / plywood plant was undertaken for the Chapleau Cree First Nation / Fox Lake Development Corporation. The fibre was to support the establishment of a veneer production facility and a speciality plywood plant in a joint venture operation with a plywood manufacturer. As a result of this study , it was determined that wood supply in the area was sufficient to support the plant.

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
Management plan preparation			6
Special projects			25
Total person-weeks			31

CA 4553, Brunswick House First Nation

Activity/subactivity	Subactivity area (ha)	Area treated (ha) or trees planted	Employment (person-weeks)
Management planning			
5-year operating plan update			
Mechanical site preparation		11 ha	1
Regeneration			
Tree planting		30 000 trees	13
Tending			
Improvement/ sanitation cut	18	18 ha	11
Total person-weeks			25