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Pacific Forestry Centre
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Canada

Examining Canada's Oldest Permanent Sample Plots

"This information is invaluable in making informed decisions about red and white pine sustainability."

Just like cellars of aged red and white *wine* are invaluable to an oenologist, plots of aged red and white *pine* are invaluable to a forest researcher.

At the turn of the last century, heavy exploitation of red and white pine near Petawawa, Ontario, sparked an interest in improving management of pine stands. Since 1918, field data has been collected periodically from research plots set up in the area to determine the effects of thinning on natural white and red pine. Recently, Dr. Darwin Burgess, a research scientist at the Canadian Forest Service, Pacific Forestry Centre, compared long-term data from the oldest successively thinned plot to an untreated control plot. These permanent sample plots were set up in a natural pine stand within the 100-km^2 area now known as the Petawawa Research Forest.

Thinned plot in the Petawawa Research Forest showing overstory and a second cohort (ingrowth) of white pine.

"These are probably the oldest sample plots in Canada," says Dr. Burgess, a member of the Effects of Forestry Practices Network who worked at Petawawa before coming to the Pacific Forestry Centre. "Such long-term permanent plot studies are the source of current knowledge about the effects of silvicultural treatments on stand dynamics and productivity."

The plots studied represent two widely different management approaches. The treated plot was thinned often (six times) during the last 82 years and maintained at a relatively low pine basal area. The control plot was never treated except for the removal of some understory brush in 1919 (although no tree was removed then or since). Dr. Burgess, assisted by Craig Robinson, a senior silvicultural technician working at the Petawawa Research Forest, examined stand development within each of these plots.

"The plot that was thinned yielded early multiple harvests, retained 'unweeviled', disease-free, larger pines of higher quality and value," says Robinson. "It also had a more stable periodic annual increment and a second cohort (ingrowth) of white pine. However, disadvantages were the uncertainties about the best intensity and frequency of thinning and the cost of conducting several harvest operations."

Dr. Burgess adds, "There was also less timber capital remaining on-site, and an under-utilization of growing space during some stages of stand development. Other disadvantages included heavier hardwood invasion in need of control, reduced tree species diversity in the overstory and a failure to establish red pine in the younger cohort."

In contrast, the plot that was not thinned had no harvesting costs to-date, a higher standing volume, and a high potential return from future thinning operations. It also had a natural mortality rate 10 times greater than the treated plot providing greater down woody debris, and a higher tree species diversity.

Disadvantages include high timber losses due to natural mortality, less crown development and smaller average stem diameter of residual trees. There was also a marked decline in the periodic annual increment during the last decade, no development of a younger pine cohort and no timber volume being harvested from the stand through time.

This information is invaluable in making informed decisions about red and white pine sustainability. "Such evaluations require an on-going commitment to maintain and monitor these plots in future," says Dr. Burgess. "The knowledge gained from continuing to monitor such long-term studies should more than pay for the investment required."

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The Effects of Allelopathy and Microbes on Reed Grass

"There is a need to understand this sort of biocontrol for all types of weeds causing regeneration problems."

While the issue probably won't find its way to a national unity debate, scientists at the Pacific Forestry Centre are studying a trouble-maker that is found from coast to coast to coast. Marsh reed grass, also known as bluejoint, is a hardy rhizomatous grass spanning the vast Canadian landscape. "I have collected the grass from Nova Scotia to Vancouver Island, and Sault St. Marie to Tuktoyaktuk. I have seen it grow on the tundra right up to the Arctic shore," says Dr. Richard Winder, a microbial ecologist at the Pacific Forestry Centre. The overwhelming 'success' of this plant in harvested forest areas has serious implications for timber regeneration.

According to Dr. Winder, reed grass has become a major impediment to western boreal reforestation. Windblown reed grass seeds can rapidly disperse into clearcuts to produce seedlings more than 2 meters in height. As an inhibitor of seedling growth, this weed poses particular problems for regeneration of white spruce, lodgepole pine and aspen.

"While the plant itself competes with tree seedlings, much of the damage is caused by accumulation of dense straw mats," says Dr. Winder. "These mats cause a host of problems ranging from suffocation of seedlings during snow press to delayed thawing of the soil and exaggerated lateral growth in surviving conifer seedlings."

Marsh reed grass suppressing conifer regeneration near Mile 73 of the Alaska Highway.

Although there are no simple solutions to this problem, Dr. Winder maintains that, "Fungi have potential as biocontrol agents of marsh reed grass when considered as one component of an integrated strategy. We are looking at endemic agents in order to develop a strategy that, in a sense, 'outwits' the plant in order to free conifer growth. There is a crying need to understand this sort of biocontrol for all types of weeds causing regeneration problems."

This is where Donna Macey of the Pacific Forestry Centre, Dr. Ken Mallett of the Canadian Forest Service, Northern Forestry Centre and Dr. Winder come together. Dr. Winder focuses on the effects of allelopathy and fungi in suppressing the shoots of reed grass. Macey complements this approach by looking at deleterious rhizosphere bacteria that attack seedling roots. And Mallett is developing the use of snow mould, a native fungus, to control established perennial populations of the grass as a part of a comprehensive effort in biomanagement.

"In the search for innovative biocontrol agents, it is becoming increasingly apparent that there are no simple solutions; combined efforts to discover and develop cooperative microbial agents show greater promise than single agents," explains Dr. Winder.

Macey adds that, "we are able to show that we can get a certain level of suppression through an integrated approach. By using multiple (biocontrol) pathogens in combination with appropriate silvicultural methods, we aim for both the 'roots and the shoots,' in seedlings and mature plants, and in doing so yield better results than a singular effect."

Research findings indicate that reed grass eventually becomes allelopathic to itself as straw from successive generations of the plant accumulates. Test results also suggest that allelopathic stress may affect pathogenicity and host resistance in diseases of reed grass. As Dr. Winder points out, "There are challenges and unknowns in the discovery, development and deployment of alternative management methods, such as biocontrols controlling *our* biocontrols. Because of this there is a constant need for ongoing improvement and an integrative approach. This type of research ranges from molecular, to cellular, tissue, organismic, population, species, and ecosystem levels of organization: we look at several levels when trying to figure out how organisms behave, how they affect populations."

While exact figures on loss due to marsh reed grass are difficult to ascertain, according to Dr. Mallett, "It is not uncommon for plantations in western Canada to be retreated and replanted several times because of the grass."

"This is a serious issue for forest managers," adds Dr. Winder. Because the grass is native to North America, "application of endemic bioherbicides may be preferable to leasing non-indigenous pathogens or other classical biocontrol agents. There is a lot of identified potential out there, but we have only seen the tip of the iceberg, in terms of biocontrol possibilities. For example, fungal diseases like *Dilophospora alopecuri* may still have biocontrol potential, providing that suitable

story continued on page 16

Screening for Genetic Resistance to *Phellinus weirii*

"Laminated Root Rot has a devastating effect on Coastal Douglas-fir productivity."

There is an "underground movement" going on at the Canadian Forest Service, and Pacific Forestry Centre researchers are directly responsible. Far from clandestine, Rona Sturrock, a researcher with the Canadian Forest Service, and her colleagues at the Pacific Forestry Centre take a unique approach to combating laminated root rot, the most serious root disease affecting second-growth Douglas-fir. In an effort to better understand the subterraneous transmission of *Phellinus weirii*, the fungus causing this disease, they are using a novel inoculation technique to bring both pathogen and host resistance to light.

An inoculation technique developed by Sturrock in 1991, provided the means to screen a wide variety of Douglas-fir seedlings. This technique involves the use of inoculum units prepared from *P. weirii*-colonized stem segments of red alder and branch segments of Douglas-fir. By using a Douglas-fir branch as a 'conduit' for the inoculum on the alder block, Sturrock's inoculation technique mimics the natural transference of *P. weirii* onto healthy roots. This is a significant improvement on former techniques, most of which relied solely on fungus-colonized wood stem segments for disease transmission.

Coastal Douglas-fir (*Pseudotsuga menziesii*) trees inoculated with* Phellinus weirii*, including one killed (red-brown discolouration) by the fungus. An inoculation unit is present at the base of each tree.

Phellinus weirii *decay in Douglas-fir, a disease commonly known as laminated root rot.*

Sturrock and her team in the Effects of Forestry Practises Network, have now identified evidence of genetic-based resistance by coastal Douglas-fir to *P. weirii*. While this finding marks definite progress, the team must now determine why some families appear more resistant to the fungus than others. "The screening trial showed that no families had 100% survival but also, that none had all inoculated trees killed. Also, we discovered that one of the two isolates of the fungus that we used killed more trees and killed faster."

Sturrock is confident in the wider applications of both her research findings and in the inoculation technique, which could be used to conduct comparative studies of host susceptibility among root pathogens and to study aspects of disease development. "Ultimately, we'd like to give foresters Douglas-fir trees that can be safely planted on root-diseased sites. But first we need to answer basic questions like how does the fungus get into Douglas-fir roots and how does this host respond? Then we'll be able to answer why some individuals and some families are more resistant than others."

Dr. Yousry El-Kassaby of Pacific Regeneration Technologies Inc., is optimistic about the research possibilities. He feels that, "this project has the potential to improve timber productivity tremendously," citing Sturrock's multi-disciplinary approach as an important factor in achieving 'biological intimacy' or a deep understanding of both pathogen and host. "This is a very important program. Laminated root rot has a devastating effect on coastal Douglas-fir productivity, leaving big pockets scattered all over where the fungus exists."

Working in partnership with geneticists at the BC Ministry of Forests, Research Branch, and foresters at TimberWest Forest Corp. and Western Forest Products Ltd., Sturrock and her team at the Pacific Forestry Centre are investigating the occurrence of resistance to the disease by coastal Douglas-fir. Forest Renewal BC has been instrumental in funding research aimed at identifying resistance mechanisms and tracing infection processes of *P. weirii* on this conifer host.

"Genetic resistance to *P. weirii* has never been looked at in Douglas-fir before," says Sturrock, who has been working on the issue since 1992, "and now we are on the track of finding out whether or not families of coastal Douglas-fir react differently to the disease."

Sturrock feels that the expertise at the Pacific Forestry Centre, such as that provided by Garry Jensen in host-pathogen interactions and histology and by Dr. Abul Ekramoddoullah in protein chemistry, will help her to shed some light on these findings. "It covers a lot of ground having these people on board."

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A SPECIAL SUPPLEMENT

The Landscape Management Network

Managing Canada's forests for the benefit of present and future generations is a complex undertaking. It requires an understanding of how the environment, human activities and natural disturbances interact to shape the country's forest landscape. Forests do not respect the artificial boundaries between provinces and landowners. Consequently, there is a need for well-informed forest management that includes "the big picture."

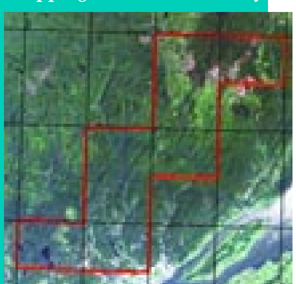
As Canada's only national forest research organization, the Canadian Forest Service has a major role to play in developing tools, technologies and databases to ensure sustainable forest management in Canada. The Landscape Management Network works at both the national and regional scales on the synthesis of knowledge and integration of information to support national forest policy needs and forest management decisions. The Network also works to bring knowledge, information and data to bear on critical issues and for the provision of forest management tools and decision support systems.

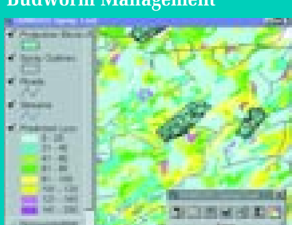
The Network's activities are focused on the following key areas:

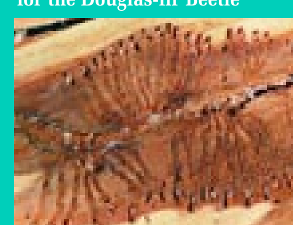
- **Information Management** - to synthesize knowledge and integrate information to support national and international policies and to provide support to operational forest management decision making. Specific activities include the development of the following:
  - National Forest Information System (NFIS)
  - National Forest Inventory (NFI)
  - National georeferenced databases (NATGRID)
  - Information and data capture systems to support Criteria and Indicator reporting and climate change initiatives
  - Tools to assess and report on local level indicators of sustainable forest management
  - Key biological and physical databases to support forest biodiversity studies

- **Systems for Sustainable Forestry** - to develop a range of forest management tools for integrated pest management, landscape level planning, planning for timber and non-timber values, and emulating natural disturbances in management. Specific activities include the development of the following:
  - Spatial and temporal landscape disturbance models
  - Tools to predict and monitor the sustainable potential Net Primary Productivity of major forest ecosystems
  - Sustainable forest management tools to be applied to the forest management unit at the landscape level
  - Inventory and remote sensing tools to assess health and change over time in the forest

The following stories feature some of the work currently underway in the Landscape Management Network.







A New Map of Canada

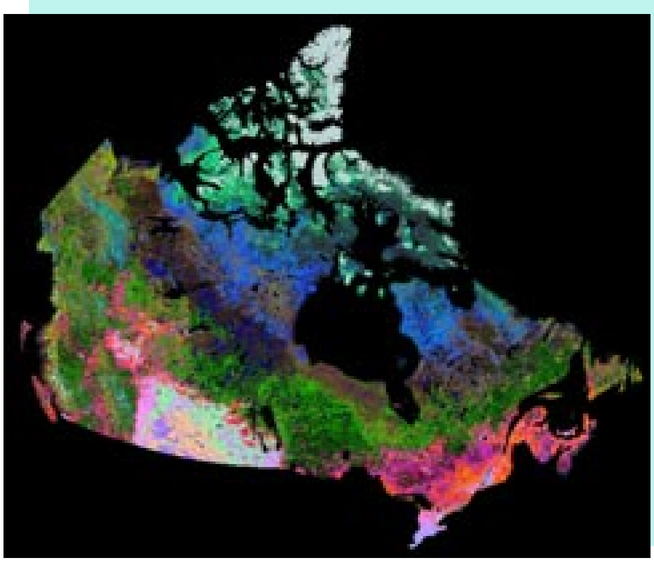
"The most immediate benefit of this map is that it provides a new overall view of the forests of Canada."

Dr. Jean Beaubien, a research scientist with the Canadian Forest Service, has recently collaborated with the Canada Centre for Remote Sensing on the development of a comprehensive land cover map of Canada, the first of its kind ever developed. Generated through remote sensing technology, the map shows 31 different land cover classes across the country.

"Land cover plays an important role in many environmental programs currently going on," says Dr. Beaubien, who is part of the Northern Biosphere and Modeling Experiment (NBIOME) at the Laurentian Forestry Centre. "For example, the map can be used for climate change studies or for general land management planning."

NBIOME aims to improve the understanding of the relationship between the climate and northern ecosystems. As a part of this experiment, the land cover map was developed to provide an up-to-date, spatially and temporally consistent map of the landmass of the country, which can be used by scientists interested in environmental information at national and regional scales.

This map is important from a number of perspectives. Land cover type is used in computer models designed to study environmental processes, and is also required by international environmental conventions on climate, biodiversity and desertification. From an economic standpoint, land cover information is crucial to resource management and policy decisions. With no map of this type currently in existence, Dr. Beaubien's work will find application in a variety of different fields.



Part of a comprehensive land cover map of Canada.

"But the most immediate benefit of this map is that it provides a new overall view of the forests of Canada," says Dr. Beaubien. "With this in hand, researchers can then perform more detailed work."

Dr. Beaubien notes that because land cover varies greatly over space and time, obtaining this information through field surveys is often very expensive and time-consuming. But for this project they have utilized satellite technology, which allows for repeated measurements over large areas, with less time and expense.

Based on satellite data obtained in the 1995 growing season (from April to October), the researchers were able to distinguish 31 land cover classes: 12 forest; 3 shrubland; 6 barren land; grassland; 7 developed land types including cropland, mosaic and built-up areas; and 2 non-vegetated land cover types. The data were acquired with the Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA-14 satellite (operated by the United States National Oceanic and Atmospheric Administration). This equipment allows for daily observation in five spectral channels, which helps to avoid problems associated with cloud cover.

"Because the spatial resolution of the data was only about 1 km and the data often contained various noise interference, it was necessary to apply complicated data processing methods to the images, consisting of two phases - the preparation of a noise-free data set, and the extraction of land cover information," says Dr. Beaubien. From this process they were able to compile the finished map, which will benefit environmental studies across the country.

"The land cover map is valuable in that it shows the general vegetation classes across Canada," says Helmut Epp of the Northwest Territories Centre for Remote Sensing. "In the north we essentially have large areas of land that are blank, with little or no information about them. For general purposes, the map can help fill in these blanks, and then we can do a more detailed survey."

This collaboration between the Canadian Forest Service and the Canada Centre for Remote Sensing has been recognized globally, as the land cover map recently won two awards at the International Cartographic Association conference in Ottawa for Best Example of Satellite Image Mapping.

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Tools to Map Forest Productivity

"By using this approach, we are able to provide concrete evidence of the merits of a new technology."

Canadian Forest Service scientists at the Laurentian Forestry Centre in Quebec have taken an innovative approach to the study of forest productivity. The Extended Collaboration to Link Ecophysiology and Forest Productivity (ECOLEAP) is a Canadian Forest Service research project aimed at improving the understanding of the environmental controls on boreal and sub-boreal forest productivity, while developing tools for predicting stand level forest productivity over large areas. The project incorporates remote sensing, mensuration, ecophysiology, geomatics and ecological modeling.

"We started this program about four years ago, the idea being to link current knowledge on tree growth and remote sensing into forest management tools. The project combines the activities of seven Canadian Forest Service scientists (as well as two professionals and four technicians) as well as collaborators in many other institutions," says Dr. Richard Fournier, a scientist in the Landscape Management network of the Canadian Forest Service, and member of ECOLEAP. "With all of the different expertise, the project moves from the detailed processes of the individual tree to the coarser information at the regional level."

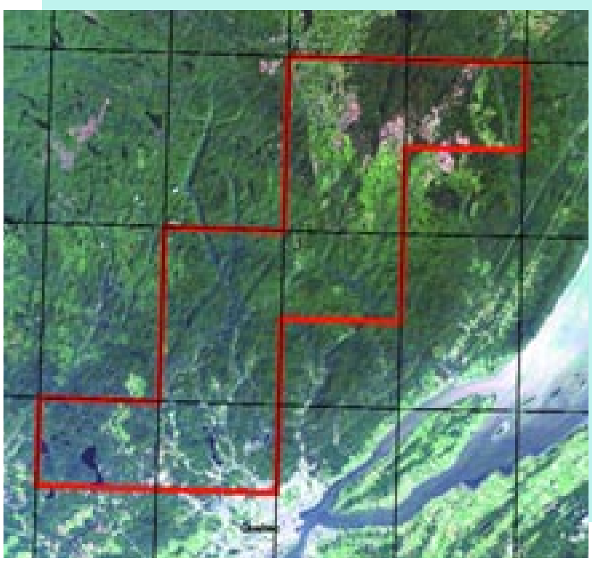

Image of the Quebec region.

This movement involves field work to study the detailed processes, the modeling of these processes at the tree and stand level, and finally the production of spatially explicit products such as site potential, biomass and forest productivity maps. Modeling the growth processes of trees is the cornerstone of the project, and is supported by the detailed field studies. Although studies on the factors which control productivity are conducted at the leaf, tree and plot level, the application of these findings will have to apply to stands, landscapes and regions. Consequently, another significant part of the project involves spatially extrapolating the results to scales that are useful to forest managers. This process utilizes the satellite remote sensing technology in which Dr. Fournier specializes.

"ECOLEAP has proven to be very important in transferring new remote sensing and modeling technologies. After creating a baseline with standard products such as forest inventories, we can then bring in the new technologies to see how they will improve the accuracy of the estimate, or obtain new information. By using this approach, we are able to provide concrete evidence of the merits of a new technology."

Dr. Fournier foresees two levels for the ECOLEAP project: 1) Contribution to Canadian Forest Service research effort on Criteria and Indicators and climate change with the ability to run different scenarios through the models; and 2) Application to forest management at the stand level, as the project reaches those managing the landscape (provinces and industry), and allows them to assess forest productivity and distribution of biomass.

"Our goal is to produce a modeling tool to simulate productivity at the stand level," says Dr. Fournier. "This will act as a forecasting tool for productivity – we will be able to run different scenarios through it, such as climate change situations."

They currently have a calibrated model for several different eastern species, and will carry out the first landscape level modeling in the Quebec pilot region, a 4,200-km^2 band of forest extending north from Quebec City. In addition, the group will implement (in March 2000) another pilot region in about 6000 km^2 of the Abitibi area, to map forest productivity which can then be linked with the provincial inventory for more comprehensive data.

"ECOLEAP is a timely project that attempts to integrate recent advances in ecophysiology, ecosystem science, forest productivity modeling and remote sensing in a manner that will make a significant contribution to forest management," says Dr. Hank Margolis, a professor at Laval University and member of ECOLEAP. "This is one of the rare projects in Canada that offers a significant potential to make use of the next generation of satellite sensors from the Earth Observing System for the advancement of forest management."

ECOLEAP is starting to gain attention from other groups across the country. As Dr. Ron Hall, a Canadian Forest Service research scientist at the Northern Forestry Centre notes, this approach will provide an invaluable framework for future collaborations at the national level for methods and applications to other regions in Canada.

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The National Forest

"The NFIS will provide timely, accurate and spatially explicit forestry information to respond to policy issues."

It's a jungle out there. Or at least it's a thick forest of information.

Decades of research have resulted in an invaluable but overwhelming quantity of information on Canada's forests. But how can such an abundant collection be made readily accessible to address the country's growing need for information? No single discipline or agency can resolve complex policy questions or respond to the country's national and international forest reporting commitments. Such a task requires a cooperative effort.

To meet the challenge, the Canadian Forest Service has teamed up with other Natural Resources Canada sectors (Earth Sciences through GeoConnections, Energy and Metals and Minerals) and other federal departments and provincial governments. Together they are developing the National Forest Information System (NFIS). The NFIS will not only be a means of organizing, storing, and maintaining information from a variety of sources, but will make extensive analysis of Canada's resources information possible.

"The NFIS will provide timely, accurate and spatially explicit forestry information to respond to policy issues," explains Jim Wood, Director, Forest Resources Program at the Canadian Forest Service, Pacific Forestry Centre and Network Manager for the Landscape Management Network. "It will integrate core data sets, such as the plot-based National Forest Inventory, with national and regional resource data from other federal and provincial geographic information systems by using the latest data handling technologies and modeling."

NFIS is a data management, data handling, data analysis and reporting system for federal, provincial, territorial, industrial, research and other forest resources data sets.

"The NFIS is not just a system," explains Dr. Robin Quenet, a research scientist at the Pacific Forestry Centre, "but a set of conventions for shared information management, integration and analysis by resource management agencies and others. It will play a central role in assessing and reporting on the indicators of sustainable forest management and also provide transparency for third party verification." Work on the NFIS at the Pacific Forestry Centre has focused on two key components: *a data warehouse* for delivering spatial and non-spatial data for efficient reporting and display, and *metadata* for implementing a framework for the creation and search of metadata documenting Canadian Forest Service holdings.

"The NFIS data warehouse includes support for the storage and indexing of objects that have a spatial representation such as protected areas, forest cover records, logging roads, locations of lightening strikes, land classifications and elevations," explains Rick Morrison, Senior Systems Scientist at the Pacific Forestry Centre. "Metadata - data about data - documents such aspects as ownership, location and quality of data. In the NFIS, this metadata is being recorded in a distributed search framework that allows any user on the Web to locate Canadian Forest Service data holdings by a variety of search criteria."

The Pacific Forestry Centre team is also working on the definition of the network "glue" that will allow distributed geographic information to portray natural resources information in a single integrated Web viewer. Morrison explains that a forest manager could, for example, get a spatial representative of the forest stands most susceptible to insect attack by integrating scientific information about the pest held in a Canadian Forest Service content server, with forest inventory themes held in one or more provincial content servers.

The National Forest Inventory is one of the key data sets in the NFIS. The plot-based inventory system will monitor forest changes over time for both the amount and the location of a variety of forest resources. This information is vital for the criteria and indicator processes to monitor sustainable development, and for national and international inquiries.

"To provide reliable area statistics, the objective of the inventory is to survey a minimum of 1% of Canada's land mass using a combination of air photo and ground plots," explains Mark Gillis, manager of the National Forest Inventory at the Pacific Forestry Centre. "Remote sensing data will also be used to enhance the National Forest Inventory to assess whether the location of plots are skewed in any fashion, to assess the extent of change and to define the need to revisit plots, to extend the inventory, and to provide other

Information System

area-based parameters such as forest condition." The inventory will be stored and reported through NFIS.

The NFIS will be a means to meet Canada's international reporting responsibility. After nation-wide consultation with industry representatives, environmental organizations, aboriginal groups and academics, the Canadian Council of Forest Ministers approved a suite of parameters (Criteria and Indicators) to describe Canada's progress toward sustainable development. Examples of such indicators include area, percent and representation of forest types in protected areas, percent and extent of area by forest type and age class relative to total area, as well as mean annual increment by forest type and age class.

Another key data set within the NFIS is the Digital Elevation Model (DEM) which is part of the national spatial modelling framework known as NatGRID (National Geo-Referenced Information for Decision-Makers). Partnerships have developed between the federal and provincial governments to build a DEM at both the national and provincial levels.

"Applications of the modelling include analyses of the distribution, abundance and productivity of forest vegetation, wildlife, exotic species, insects and diseases," says Dr. Dan McKenney, Chief of Landscape Analysis and Applications at the Canadian Forest Service, Great Lakes Forestry Centre in Sault Ste. Marie, Ontario. "We are integrating the national DEM with new national climate models, land cover characteristics and field-truthed biological data to provide new types of spatial data relevant to forest science and sustainable forestry."

There are, of course, many other data sets that will be part of the NFIS. Such a project requires partnerships among many federal, provincial, territorial and industrial organizations to accurately address collective policy issues. The Canadian Forest Service provides a coordinating role but interested agencies are welcome to join this national forest resources information infrastructure. For information on how to get involved or to provide input on the initiative please contact Jim Wood at jwood@nrcan.gc.ca. More information about NFIS is at: http://nfis.cfs.nrcan.gc.ca.

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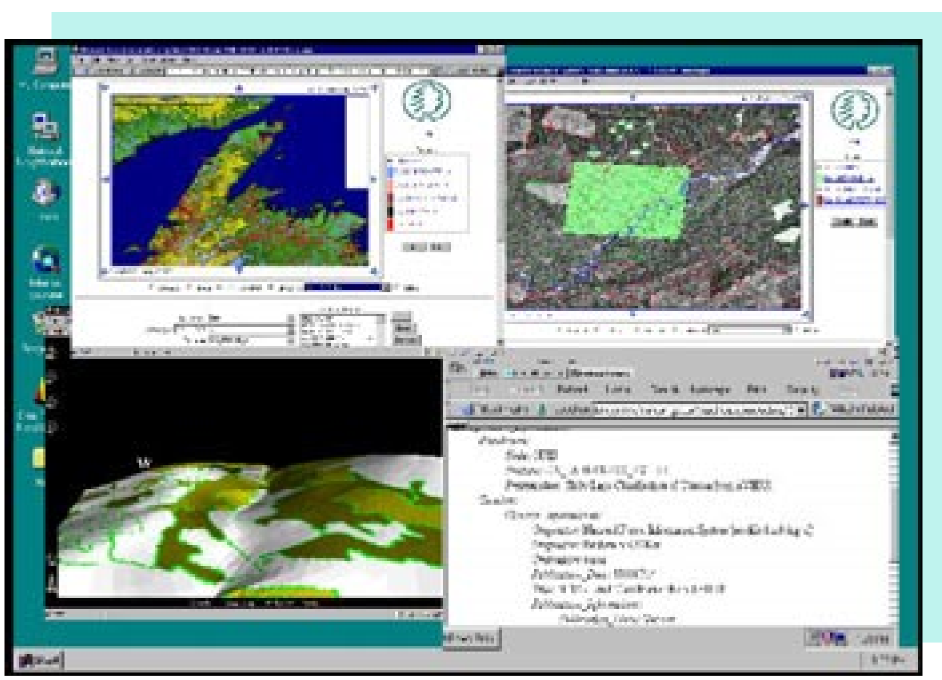


Sample Netscape screens showing data visualization from the NFIS warehouse.

Decision Support for Budworm Management

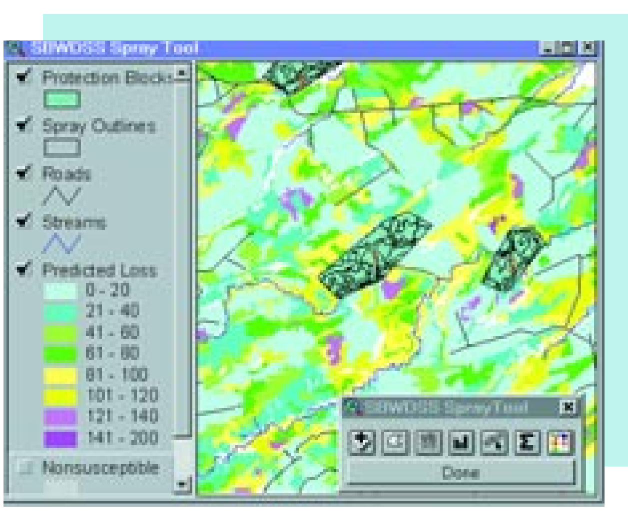
"PROPS quantifies the timber supply benefit of protecting stands against spruce budworm defoliation."

Scenario planning is a disciplined way to hypothesize possible futures. It's one of the primary means of looking at the consequences of alternative management actions, and the one chosen by the Pest Decision Support Systems Group at the Canadian Forest Service, Atlantic Forestry Centre to implement its Protection Planning System (PROPS).

Kevin Porter is an analyst with the Pest Decision Support Systems Group. He says that PROPS is the latest phase of their suite of tools called the Spruce Budworm Decision Support System. "PROPS is a GIS-based system that quantifies the timber supply benefit of protecting stands against spruce budworm defoliation. It allows the user to determine the effects of various budworm protection strategies on forest development and sustainability, and quantifies the timber volume benefit of spraying one block or another."

Three major spruce budworm outbreaks hit northeastern North America in the 20th century, in 1910, 1940, and again in 1970. Each was worse than the one before, with the 1970s outbreak reaching about 58 million hectares of forest. Previous patterns indicate that there's another outbreak on the way.

"We adopted a scenario planning approach for PROPS implementation because of the uncertainty associated with predicting the timing and severity of budworm outbreaks," Porter explains. "We suggest probable defoliation scenarios based on data about past outbreaks, and interpret the results as, 'if this defoliation scenario actually occurs, here is the stand response that can be expected.' The user can try additional scenarios or try to look at best case, worst case, and most probable case."



Planning a protection program with the Spruce Budworm Decision Support System.

By 1996, the Pest Decision Support Systems Group had developed an initial version of PROPS. They had also completed test implementations in New Brunswick, on a 400,000-ha Crown Timber License and a 32,000-ha portion of the Fundy Model Forest.

Based on this, the New Brunswick Department of Natural Resources and Energy and the Crown Timber License holders in the province agreed to provide funding to implement PROPS on each of the province's ten crown licenses and on three major industrial freehold landbases. Funding amounting to $135,000 from 1996-99 was provided through Forest Protection Ltd., a collaborating agency.

Porter says that getting involved in a major implementation project isn't a step a research group should take lightly. "It's a major commitment, and our staff effort has easily exceeded the value of the outside funding. But we believe we made the right choice. It resulted in securing partnership funding and a client base who believed in the product sufficiently to bring dollars to the table. It also gave us valuable experience that we are using to make enhancements to the system."

PROPS will be used on 8 million ha of forest land in New Brunswick, and its success there has provided the impetus to develop partnerships for test-case implementations in Alberta (funded by the Alberta Land and Forest Service and Daishowa-Marubeni International Ltd.), in Ontario (in cooperation with the Ontario Ministry of Natural Resources and the Canadian Forest Service, Great Lakes Forestry Centre), and in Quebec (funded by the Société de protection des foréts contre les insectes et les malaidies).

"Potential users are much more likely to use a system if they or their colleagues have had a role in its development," Porter adds. "If you expect people to use your results, it truly is worth the effort to patiently cultivate their understanding of your work. The science has to be explained, the results justified, and the limitations of the approach need to be made clear.

"There is no room for black boxes in DSS (decision-support systems). It is not a decision-making system, it is a decision support system. It should provide new and valuable information that can be used to support decisions, and do so in an interactive environment where users modify parameters and see the new results within a reasonable time frame."

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Dendroecological Analysis of a Two-Year Cycle Spruce Budworm Outbreak

"This study has provided some base information that wasn't known before on the frequency of outbreaks and defoliation."

The spruce budworm is a serious pest in the forests of BC, causing severe defoliation, growth loss and tree mortality during outbreaks. The forests of north central BC continue to battle an outbreak which has lasted for 10 years.

Dr. Rene Alfaro, a research scientist at the Canadian Forest Service, Pacific Forestry Centre, and PhD candidate Qibin Zhang, also working at the Centre, have recently completed a study of the history of outbreaks in this region. Severe outbreaks have a substantial impact on BC's interior forests - from topkill and reduction of growth to reduced lumber quality and tree mortality.

"Our hope is that this analysis will help in the estimation of the potential duration and severity of the current outbreak," says Dr. Alfaro, a member of the Landscape Management Network. "Knowledge of the patterns of past outbreaks will help managers with forest planning and the implementation of contingency measures."

Dr. Alfaro's group examined 429 wood cores from spruce, subalpine fir and lodgepole pine taken from areas that have experienced chronic defoliation, including stands in the Fort St. James and Mackenzie forest districts.

Tree rings from defoliated trees show alternating wide and narrow pattern.

"We used dendroecological techniques to determine the patterns of outbreaks in the past two centuries," says Dr. Alfaro, noting that this analysis involved the precise measurement of tree ring-widths, and the assignment of a calendar year to each ring. Each ring-width sequence was then standardized to remove age-related growth trends. Finally, by comparing the growth patterns in trees that were hosts to the budworm (spruce and fir) and non-host trees (pine), they were able to detect past outbreaks.

Four outbreaks, occurring approximately every 32 years, were identified in the last century. The study found that past outbreaks generally had a growth reduction phase that lasted from 7 to 11 years, revealed a pattern of alternating wide and narrow tree rings – a "saw-tooth" pattern. This pattern stems from the biennial nature of the two-year cycle budworm's life cycle, which causes damage to the host tree every second year. Each growth reduction phase was followed by a growth recovery phase that lasted 3 to 5 years, where ring widths gradually returned to pre-outbreak levels.

"Overall, the entire growth loss period could last from 10 to 16 years, and has the potential to cause an average annual loss in radial increment from 16 to 21 percent," said Dr. Alfaro.

This study found that the 32-year recurrence pattern of two-year cycle budworm outbreaks is probably due to cyclic structural changes in these forests. It has been found that the two-year cycle budworm has a better fitness and survival rate when feeding on subalpine fir compared to spruce. Consequently, an increasing proportion of subalpine fir in a stand will naturally increase the stand's susceptibility to outbreak. But as more of the fir trees are killed or defoliated during an outbreak, the stand gradually becomes more resistant to attack as the pest is forced to feed on spruce which has less-optimal foliage. This will eventually cause the collapse of the outbreak, until the surviving fir in the understory mature and change the forest structure so that it is once again susceptible to the budworm (approximately 32 years).

"As a result of these findings, we recommend that foresters favour spruce over subalpine fir in planting and during spacing and thinning operations," says Dr. Alfaro.

However, based on the tree ring analysis of previous outbreaks, Dr. Alfaro estimates that the current outbreak will last just a few more feeding seasons and then collapse. But it will probably take another three to five years for the surviving trees to return to their pre-outbreak growth rates.

This study is part of a large research project that Dr. Alfaro and Dr. Vince Nealis, another research scientist at the Pacific Forestry Centre, have initiated on the two-year cycle budworm, in cooperation with the BC Ministry of Forests and the forest industry.

"This study has provided some base information that wasn't known before on the frequency of outbreaks and defoliation. These numbers are important for estimating impacts in timber supply," says Stuart Taylor, Team Leader for Silviculture and Research, BC Ministry of Forests, Prince George. "But it is only one of many important contributions that Drs. Alfaro and Nealis have made towards a better understanding and management of the two-year cycle budworm."

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Mapping Conifer Understory

"This research works to directly service the needs of the forester."

Dr. Ron Hall, a research scientist in the Canadian Forest Service, has been working with satellite remote sensing technology to map conifer understory within deciduous-dominant mixed-wood stands in Alberta. White spruce is a secondary successional species that often occurs as an understory in deciduous-dominant mixed-wood stands, and this understory is important to future white spruce timber supply. Because some forest companies manage forests according to their landbase allocation, (for example, conifer or hardwood), more than one company may have a license to operate on the same geographic area. Harvesting and silvicultural activities of the two companies must therefore be coordinated for forest management to be successful.

"The problem is that current inventory maps depict the overstory composition of our forests, but do not show the location, structure or distribution of conifer understory – information that the forest industry needs," says Dr. Hall, who works in the Landscape Management Network at the Northern Forestry Centre in Edmonton, Alberta.

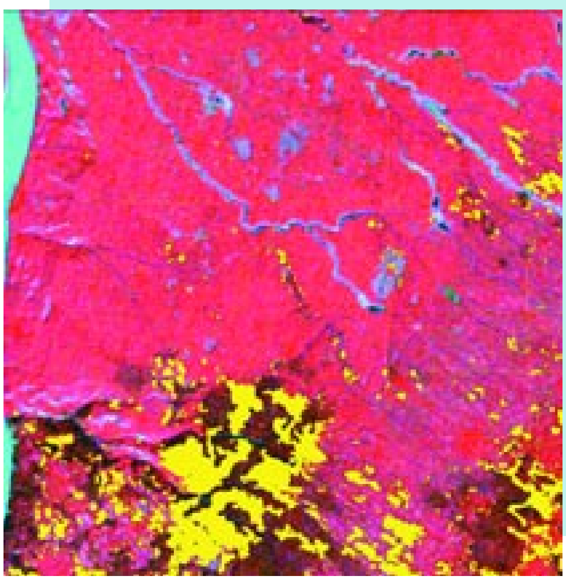

Image classification depicting heavy understory in deciduous-dominant mixedwood stands.

Many companies are currently re-flying their entire landbase during leaf-off conditions (in the spring or fall) to see the understory, but this is very expensive and time-consuming. Satellite technology can tell them where the understory is located over large areas , and then they can go in and perform more comprehensive surveys as required.

The key to Dr. Hall's research is the integration of multi-source data to produce a usable model of conifer understory. This involves interpreting leaf-off aerial photos of the sub-area, digitizing this information into a Geographic Information System (GIS), and then integrating this data with existing forest inventory data. Finally, this information is overlaid on top of the satellite data, and a knowledge-based image classifier is applied.

The final map product is an image classification overlaid onto the forest inventory at an operational scale of 1:20,000.

"We are working from the bottom up, as the landscape is heterogeneous," says Dr. Hall. "With multi-date data, the satellite sees both the overstory and the understory, and we marry this information with photo and field information. Then we can apply the results to a larger area."

White spruce understory trees beneath overstory of aspen.

There has been a 70 percent correspondence between field and image classification, which, according to Dr. Hall, is an excellent result and about as high as could be expected.

"Ron has taken an innovative approach to using satellite data – one that is oriented around a real problem," notes Don Leckie, a Canadian Forest Service research scientist at the Pacific Forestry Centre. "This research works to directly service the needs of the forester, and it works extremely well."

With this research now firmly in place, the focus will shift to extending the scope of the method to other areas without having to obtain other ground data.

"Knowledge of the extent and condition of spruce understories in mixedwood stands is critical to the successful management of such stands," says Dave Morgan, Head of Forest Inventory, Ministry of Alberta Environment. "The development of a methodology based on satellite imagery should make the mapping of coniferous understories feasible and greatly enhance our ability to successfully manage mixedwood stands."

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To be in a Tree or Not to be:

A Susceptibility Rating System for the Douglas-fir Beetle

"The plan is to provide a tool for preventative management by identifying stands at risk to beetle epidemics."

When one thinks of the giants of the BC forest, the Douglas-fir tree often comes to mind. Reaching heights of 60 meters on the coast and 40 meters in the Interior, this native tree is an integral part of the province's forests. Equally important to the ecosystem is the Douglas-fir beetle which attacks and breeds under the bark of its host. These beetles prefer trees recently felled by nature or man's activities but can attack and kill large numbers of live trees when conditions are right.

In the East and West Kootenays of the Nelson Forest Region, the Douglas-fir beetle has reached epidemic proportions. Since 1991, when heavy winds blew down a number of trees in the area, the beetle has thrived on the damaged Douglas-fir. Ordinarily, once the downed trees have been utilized by the insect, Douglas-fir beetle populations decrease. However, now the beetle is attacking apparently healthy trees in the area.

The Douglas-fir beetle can greatly damage its host.

"In our study area near Nelson, the Douglas-fir growth rate has been declining, which seems to be a factor in susceptibility to the Douglas-fir beetle," says Dr. Terry Shore, a research scientist at the Pacific Forestry Centre and part of the Canadian Forest Service Landscape Management Network. "Another factor is old age. The Douglas-fir in this area are about 150 years old and may be less able to resist attack because they are producing less resin."

Dr. Shore also suggests that the insect may prefer the thicker phloem of the older tree, the primary food for developing larvae, or it may just be attracted to its thick bark that acts as insulation for the beetle. Another possibility is that older but apparently healthy trees may be weakened by root disease or stress from drought or competition from surrounding vegetation.

All of these variables are being considered in the development of a biological model of host susceptibility to the Douglas-fir beetle. Researchers at the Canadian Forest Service are developing the model in partnership with the BC Ministry of Forests. The plan is to provide a tool for preventative management by identifying stands at risk to beetle epidemics.

A number of tree and stand characteristics are being studied among 19 infested and non-infested groups of trees in a 6000-ha forest along the west arm of Kootenay Lake. A prototype susceptibility rating system has been developed for that area.

"We have been using the prototype system with great success," says Julie Castonguay, Forest Health Forester with the BC Ministry of Forests in the Kootenay Lake Forest District. "It has provided us with a valuable tool for predicting where the areas of concerns are in a large landscape unit and consequently, for prioritizing management activities."

Studies indicate that many of the measured characteristics are potential indicators of tree or stand susceptibility to the Douglas-fir beetle in the area. But Dr. Shore explains that the interaction of the variables makes it difficult to determine which of them or combinations of them contribute most to beetle susceptibility in a specific area.

"A biological approach to establishing a susceptibility rating system involves detailed knowledge of the interaction between insect, host, and environment," he says. "Further research is required to understand how the Douglas-fir beetle selects its host and to develop a susceptibility and risk rating system for the Douglas-fir beetle which can be used throughout BC."

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Joint Venture Brings the Osoyoos Indian Band into the Forest Industry

"This venture provided a great opportunity for the band to develop its own logging department."

The Osoyoos Indian Band (OSIB) has established a positive reputation with off-reserve clients in both industry and government, thanks to its progressive leadership and quality workmanship. The band's work has put them into a position today where they are able to capitalize on their reputation by establishing long-term business relationships with these off-reserve clients.

The OSIB is situated in the southern Okanagan valley, between Oliver and Osoyoos, and is active in a variety of economic activities, including a vineyard operation, campsite, and mixed farming (an orchard, alfalfa, and hay production). The band also has a successful forestry department, Inkameep Forestry, which provides local forestry contracting services to Weyerhaeuser Canada Ltd. and Pope and Talbot Ltd. These services include forest management, silviculture, logging, and forest protection.

A grapple skidder hauls logs to the landing.

In 1996 the OSIB began to increase their activity in forest harvesting. They were awarded a 10-year non-replaceable forest license by the BC Ministry of Forests, which was jointly developed and managed through cooperative consensus. Included in this venture were the OSIB, Spallumcheen Indian Band, Weyerhaeuser Canada Ltd. and Canwood Furniture Factory Inc. In this partnership the OSIB would do the harvesting for Weyerhaeuser, who then mills the logs to Canwood Furniture's specifications. The wood is then sent to Canwood to make furniture.

This venture provided a great opportunity for the band to develop its own logging department. Beginning in 1996, the First Nations Forestry Program (FNFP) has assisted the development of their joint venture with Weyerhaeuser, and with the band's capacity to become safe and efficient logging contractors. During this period the band has focused on acquiring two pieces of equipment integral to their harvesting operation - a front-end loader and grapple skidder. Without this equipment the band would have had to continue to contract work out, most likely to non-native equipment operators. Therefore, over the last few years the band purchased both an older model front-end loader and grapple skidder for on-the-job training and logging production purposes. Both pieces are in good condition, and have proved invaluable.

As Joe McGinnis, OSIB's forestry manager explains, the band needed some of its own logging equipment, or there would not have been an opportunity to build internal logging capacity. When it comes to actually learning how to run heavy equipment such as skidders and loaders, nobody is likely to let you practice on their machines without compensation and previous experience. With help from the FNFP, the OSIB increased their capital equipment and experience, and was able to avoid this catch-22 situation.

Band members are currently learning how to operate the equipment, receiving training in machine orientation, safety, general operation procedures, Forest Practices Code, basic fire suppression, air brakes, first aid, log sorting, and tree species recognition. Once trained, these individuals will be able to work for the band or seek employment opportunities with other logging companies.

"The ongoing support from the FNFP in assisting Inkameep Forestry with capacity building is greatly appreciated by management and staff," says McGinnis. The FNFP has continued to assist the band over the past few years, and the results are now apparent.

More information about the First Nations Forestry Program is at:
http://www.pfc.cfs.nrcan.gc.ca/main/programs/fnfp/index.html

Glossary

Terminology Used in this Issue

Allelopathy – is a chemical process that a plant uses to keep other plants from growing too close to it.

Dendroecology – is the use of tree rings to study factors that affect the earth's ecosystems. Example: analysing the effects of air pollution on tree growth by studying changes in ring widths over time.

Deleterious Rhizosphere Bacteria (DRB) – live on plant roots or reside in the rhizosphere, a soil zone spanning a few millimetres around roots, where they feed on plant juices. DRB-produced toxins trigger plant cells to produce excessive hormones that keep seeds from germinating, or they damage the plants by putting life processes in overdrive.

Ecophysiology – is a branch of science concerned with the mechanisms of plant response to their environment.

Forest Mensuration – is the determination of dimensions, form, weight, growth, volume, and age of trees, individually or collectively.

Geomatics – systems include: real property boundary determination, aerial and digital mapping, land and geographic information systems (LIS/GIS), geodesy and geodetic surveying (GPS), remote sensing, environmental and resource mapping, geomatics applications programming, project management, route design and construction location.

Phloem – is the layer of cells that forms a pipeline to carry sugars from the leaves to the rest of the tree. As these cells die, they become part of the outer bark.

Rhizomatous – having underground stems.

Recent Publications

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Stockburger, K.A.; Mitchell, A.K. Information Report BC-X-383. Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. 30 p. (1999).

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Kishchuk, B.; Maynard, D.; Curran, M. Notes de Transfert Technologique. Numéro 15. Service canadien des forêts, Centre de foresterie du Pacifique. (1999).

To order publications on-line, visit the Pacific Forestry Centre Bookstore at **http://bookstore.pfc.forestry.ca**. Search our catalog of thousands of forestry publications. Order copies quickly and easily using a virtual "shopping cart".

Upcoming Events

Joint Meeting of the Canadian Phytopathological Society and the Pacific Division of the American Phytopathological Society, June 17-23, 2000 Victoria, BC, Canada

The theme for this meeting is "Working Together for Healthier Plants." It includes two symposia examining: "Beneficial use of Plant Pathogens, Anti-cancer and Drug Agents," and "Exports – Quarantine Impacts on Lumber and Agriculture Post-harvest Diseases in North America and Pacific Rim countries." For more information on this event check the website at http://www.uvcs.uvic.ca/conf/cps_aps or phone the University of Victoria Conference Management Office at (250)721-8746.
Fax: (250)721-8774
Email: pmcguire@uvic.ca.

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culturing methods can be developed. There is a lot to uncover." The research at the Pacific Forestry Centre and the Northern Forestry Centre has already covered considerable ground, with one patent issued to Dr.Winder for control of reed grass with foliar fungi, and a patent application submitted by Dr. Mallett for the use of snow moulds to control reed grass.

Learning more about allelopathy and biological control has the potential to increase the number of vegetation management options available. Although chemical herbicides like *Vision*® (the forestry version of the familiar *Round-Up*® herbicide) can be effective tools, they can't be used in every situation. For reed grass, they must be applied before straw accumulates, often repeatedly within a narrow window of time to avoid damage to conifer seedlings. Given increasing public concerns about chemical herbicide use in Canadian forests, this research offers bright prospects for new alternatives.

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