ISSN 0706-9413

August 2000

INFORMATION FORESTRY

Pacific Forestry Centre

Victoria, British Columbia

In this Issue...

A Novel Microencapsulation Technique

(See Story on page 3)

Natural Resources Canada
Canadian Forest Service

Ressources naturelles Canada
Service canadien des forêts

Canada

Seeing the Trees for the Forest

"We don't want to eradicate the rust, just prevent it from overtaking the forest."

There is no mistaking a young white pine plagued by blister rust. Branches in the lower part of the crown are brown and dry. There are diamond-shaped, orange-coloured cankers on young stems and branches. And there is death. In BC, few young white pines escape infection; most don't survive more than five years. Once a major species in BC, most western white pines now fall victim to this pathogen, introduced from Asia in 1910. But by studying those trees that do thrive despite infection, the Canadian Forest Service is starting to see the possibility of a white pine forest in BC.

During the 1970s, it was discovered that another pine species, sugar pine, carries a gene that prevents blister rust from destroying the tree. This led to the discovery that white pines in Oregon carry a similar gene which makes them resistant to blister rust. Dr. Abul Ekramoddoullah, a research scientist at the Pacific Forestry Centre, has been trying to understand why this fungus, present yet not fatal in Oregon white pine, has such a devastating effect on the BC population.

"As part of our study, we took seeds from rust-resistant white pines in Oregon and planted them in BC," says Dr. Ekramoddoullah, working in the Forest Biotechnology Network. "We found that they also grew into disease resistant trees despite the different environment. Next, we pollinated the seeds of these trees and looked at their susceptibility to blister rust. We discovered that half of the offspring seeds carried the dominant gene responsible for resistance, meaning that the chances are very high that future generations will also carry this gene."

This form of classical breeding is often successful in re-establishing a tree species. However, it is possible that the fungus could evolve and develop its own resistance to the dominant gene, enabling it to once again cripple western white pine in BC. To counteract this possibility, Dr. Ekramoddoullah studied the pathogen at the molecular level and isolated genes responsible for the disease. By understanding the genes of the fungus, antibodies can be developed for white pine to further prevent the disease from overcoming the tree. (This process is similar to when humans build up immunity by receiving vaccinations against diseases.) These antibodies are monoclonal, meaning they are specific to the blister rust fungus, so will not harm non-target species. Such inoculation is far superior to applying toxic chemicals to save a tree.

"We don't want to eradicate the rust, just prevent it from overtaking the forest. Although the fungus was originally not native to this province, we don't want to upset the delicate balance of the ecosystem which has been living with this pathogen since the turn of the last century. We do, however, want to prevent it from destroying the trees that were a natural part of these forests."

Currently, Dr. Ekramoddoullah is once again studying the host-pathogen interaction in sugar pine and wondering if its dominant gene might also prevent the death of western white pine. By the stacking of barriers to the fungus through classical breeding, developing monoclonal antibodies, and using the sugar pine gene, the chance of blister rust devastation is limited. Further study could result in the re-establishment of western white pine forests in BC.

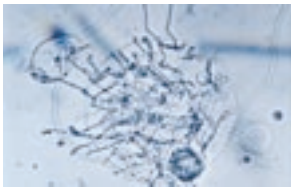
This research was funded in part by the Canadian Biotechnology Strategy Fund and Forest Renewal BC.

Dr. Ekramoddoullah can be reached at:
aekramod@pfc.cfs.nrcan.gc.ca

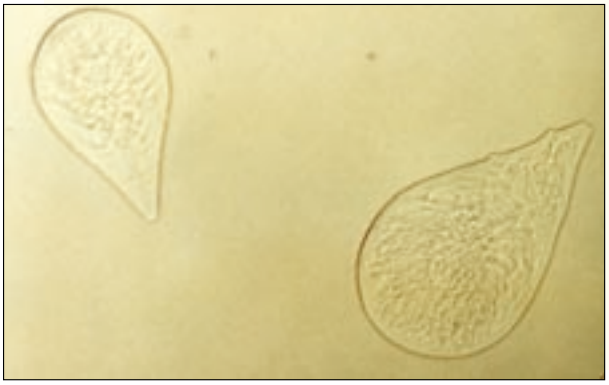
A white pine seedling resistant to infection by white pine blister rust.

A Novel, Inexpensive Microencapsulation Technique

"This is just what we have needed for larger-scale environmental applications."



Fungal biocontrol agent germinating from a 100-micron polymer capsule.



This unique method results in capsules shaped like teardrops.

Good things come in small packages. Tiny packages, actually. Microscopic.

Biological control (biocontrol), or the use of non-toxic alternatives to traditional herbicides, is a major part of forestry research. Over the last few years, many environmentally friendly formulations have been developed, but creating an appropriate medium for them can be difficult. Liquid additives, emulsions, and macroscopic granules are uneconomical to apply in large quantities, and many can't be sprayed with normal equipment. Some biocontrol agents, like fungi, require moisture to germinate, or are susceptible to dilution from dew or rain. Powders are also not desirable, since powdering can damage biological agents.

But what if the biocontrol agent could be encased in a tiny bubble with its own microenvironment containing growth regulators, nutrients and even UV blockers? And what if that bubble could be the size of a cell and could be made simply and inexpensively? It would be an effective way to package biocontrol inoculum. That's what Dr. Richard Winder, a research scientist at the Canadian Forest Service, has developed in partnership with Dr. Jeffrey Wheeler of Prometheus Enterprises Inc.

"Although the ability to encapsulate living cells has been available for some time, we now know the physical chemistry necessary for cheap and efficient microencapsulation of living cells with a variety of polymers. This is just what we have needed for larger-scale environmental applications," says Dr. Winder, working at the Pacific Forestry Centre. "It can be done in five minutes without complicated machinery."

In many microencapsulation processes developed for large-scale use, oils are used to cause capsules to form into microscopic globules. The difficulty, however, lies in efficiently polymerizing the globules and harvesting them from the oil. To date, the methods normally used to polymerize and extract uniform microbeads from oils have involved toxic solvents or cumbersome equipment and methods not suitable for large-scale encapsulation of living cells. Wheeler and Winder discovered that when a non-toxic solvent (for example, n-hexadecane) is combined with the oil and lecithin is used to stabilize the emulsion, the globules can be made to sink into an aqueous layer, polymerizing the moment they leave the oil. Since all of the components of this process are non-toxic, it doesn't harm the living cells that are being encapsulated.

"We avoid the complicated prior procedures to extract the capsules from dispersion media, i.e. the capsules form on their way out of the dispersion medium, killing two birds with one stone," explains Dr. Jeffrey Wheeler. "This is not only a unique method, but also results in a unique characteristic – the capsules are shaped like teardrops once they leave the oil."

Leaving the oil behind is ideal, as oily inoculum can be difficult to manipulate, concentrate, or store, and the oil may affect the performance, cost or behaviour of the encapsulated material.

Winder and Wheeler have applied this novel, inexpensive microencapsulation technique to several biological control agents, achieving nearly 100 percent efficiency of encapsulation in all cases. Their research indicates that having fine control over the properties of materials at the cellular level, and microencapsulating considerable quantities of living cells is not only possible, but is economically feasible.

"Although we have applied this method to biocontrol, the feasibility of creating inexpensive cellular-scale capsules may also open up new avenues and approaches for the use of viruses and microbes in other environmental, biomedical, biochemical, or pharmaceutical applications," adds Winder.

This research was supported in part by the Canadian Forest Service Integrated Pest Management Network and applications have been made for Canadian and U.S. patents.

Dr. Winder can be reached at:
rwinder@pfc.cfs.nrcan.gc.ca
Dr. Wheeler can be reached at:
Wheeler_Sutton@telus.net

Can't See the Forest for the Salal

"This shrub competes with young cedar and hemlock for water and nutrients."

Shrubs look nice but a bunch of them don't make a forest. Not in the same way that towering western red cedar and western hemlock do. But on the west coast of BC on Vancouver Island, salal *(Gaultheria shallon)*, an evergreen shrub with thick shiny leaves and small white flowers, is dominant in many conifer stands.

After harvesting, cedar and hemlock seedlings initially grow well, but after about 5 to 8 years, their growth rate declines. At the same time, there's a vigorous sprouting of salal. This shrub competes with young cedar and hemlock for water and nutrients, and releases chemicals into the soil which appear to slow down conifer seedling growth.

Dr. Caroline Preston, a research scientist with the Canadian Forest Service in the Forest Ecosystem Processes Network, is studying the correlation between salal and reduced conifer seedling growth. For 14 years she has been working in partnership with the multi-disciplinary and multi-agency research group, Salal Cedar Hemlock Integrated Research Program (SCHIRP).

After 5 to 8 years, the growth rate of cedar and hemlock declines due to competition with salal.

"Logging operations on northern Vancouver Island during the 1960s generated large cut-over areas with poor regeneration and slow growth of seedlings," explains Dr. Preston, working at the Pacific Forestry Centre. "Concern over the area stimulated study into forest ecology, harvesting practices, and silviculture. SCHIRP is the umbrella group that united all the research."

The SCHIRP studies involve two forest types on Vancouver Island, cedar-hemlock and hemlock-amabilis. The old-growth western red cedar and western hemlock stands contain salal and experience the growth check, while the second-growth western hemlock and amabilis forests have small amounts of salal and remain healthy and strong.

"Research indicates that salal is a strong competitor with seedlings for nitrogen," explains Dr. Cindy Prescott, coordinator of the SCHIRP team and Assistant Professor in the Department of Forest Sciences at the University of BC. "It also appears that salal adversely affects the ectomycorrhizal fungi that help seedlings take up nutrients, and inhibits nitrogen mineralization in these conifer stands through the production of tannins."

"Condensed tannins apparently play a role in plant defences against herbivory and may be produced in response to stress," adds Dr. Preston. "This seems to occur most often in conditions of high photosynthesis coupled with nutrient limitation."

Tannins are chemical compounds widely found in plants. They are especially evident in decomposing plant material in litterfall and humus. These chemicals bind to proteins, reducing decomposition and nitrogen mineralization.

"Salal components taken from a SCHIRP site near Port McNeill were high in condensed tannins, ranging from a low of 5 percent in old woody stems to a high of 21 percent in foliage," says Dr. Preston. "That's very high considering that the leaves of most temperate tree and shrub species consist of maybe 3 to 5 percent tannins."

Dr. Preston has also found such high percentages of condensed tannins in black spruce stands in northern Ontario. These sites suffer a nutrient limitation similar to that in the BC site, although it is a completely different forest system.

Adds Preston, "A better understanding of the transport and transformation of tannins in these ecosystems is essential in developing management strategies to enhance the desired direction of ecosystem development."

SCHIRP is a partnership between the Canadian Forest Service, the BC Ministry of Forests, Weyerhauser Canada (previously known as MacMillan Bloedel Limited), Timberwest Limited, the University of BC, and Western Forest Products Limited.

Dr. Preston can be reached at:
cpreston@pfc.cfs.nrcan.gc.ca

The Effects of Forestry Practices Network

To ensure the sustainable development of Canada's forests, sound forest management techniques are essential. But the choice of appropriate forestry practices depends on factors such as forest condition, land tenure, socio-economic conditions, and provincial policies that vary widely across the country. The Effects of Forestry Practices Network provides scientific and technical expertise to help forest stakeholders determine practices that support the social, economic and environmental values of the forest.

The Effects of Forestry Practices Network is mostly concerned with three questions:

1. What are the effects of current forestry practices on forest ecosystem productivity and site quality, biodiversity, and water, air, and soil quality?

2. How should or how can current forestry practices be altered to meet environmental, economic and social goals?

3. How well are Canada's forestry practices meeting the goal of sustainable forest management?

The Canadian Forest Service plays an important federal role but Canada's ability to find answers depends heavily on the development of partnerships among research agencies and the ultimate users of research results — land managers. The Effects of Forestry Practices Network promotes interaction between academic and operational communities to respond to demands for new forestry techniques. The linkage between research and operations also permits rapid application of research results, making the move toward sustainable development both swift and orderly.

In order for Canada to respond to national and international policy issues, it requires access to detailed knowledge on how forests are managed. The Effects of Forestry Practices Network is developing an information base in cooperation with other research agencies and forest land managers in order to ensure that this information is available. Thus, information not normally readily available will be accessible for national policy purposes. This synthesized information can be provided to the domestic and international public to help enhance the understanding of Canada's advancements in this area.

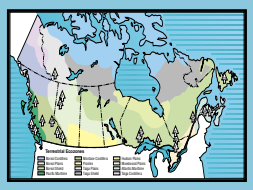
The following stories feature some of the work currently underway in the Effects of Forestry Practices Network.

Mountain Pine Beetles Hit the Road

Page 6

Setting Guidelines for Healthy Soils

Page 7



Forest Ecosystem Research Network of Sites (FERNS)

Page 8-9

Time for a Commercial Thin

Page 10

Studying the Impacts of Alternative Harvesting

Page 11

Understanding Armillaria from Coast to Coast

Page12

Saving Spruce from Root Rot

Page 13

Mountain Pine Beetles Hit the Road

"It's absolutely critical to ensure that forest managers get the information they need."

Mountain Pine Beetle

From an aerial photo of a lodgepole pine forest, it's easy to see where the mountain pine beetles are. Brown spots of dead trees pepper the landscape of deep-green forest for miles. The beetle itself isn't so easy to spot. It lives under the bark of the tree, and its cylindrical black body is no bigger than a pea.

This tiny pest – the most damaging insect to mature pine forests in North America – has killed more than 500 million trees in BC since 1914 when it was officially recognized as a problem. At the peak of the worst outbreak, in 1984, the beetles killed enough trees to stretch loaded logging trucks from coast to coast. The majority of the province's pine forests are now more than 80 years old – the prime age for beetle attacks.

Canadian Forest Service researchers from a range of disciplines went on the road this spring to share their knowledge about the pest with forest managers throughout the province. The Mountain Pine Beetle Science Showcase team visited Prince George, Williams Lake, Cranbrook and Kelowna talking to workers within the forest industry, the BC Ministry of Forests, the BC Ministry of Environment, Lands and Parks, Parks Canada, municipal governments, private interest groups and non-government organizations, as well as university students and professors.

The Mountain Pine Beetle Science Showcase Team

Back row, left to right: Mike Wulder; Roger Whitehead; Les Safranyik; Lorraine Maclauchlan; Allan Carroll; Terry Shore; Bob Erickson. Front row, left to right: Dean Mills; Bill Riel; Steve Taylor. Missing on the picture are: Paul Addison and Brad Hawkes.

"We were able to establish links with the people who will ultimately use our knowledge. Equally important, we were able to identify the issues forest managers are forced to deal with and where we might be able to contribute information," says Dr. Allan Carroll, a research scientist at the Pacific Forestry Centre, working in the Effects of Forestry Practices Network. "It's absolutely critical to ensure that forest managers get the information they need to manage the forests."

Guest speakers from both industry and government joined Canadian Forest Service researchers to answer questions on every aspect of the beetle problem.

"It opened my eyes to more than just the mountain pine beetle, I found it very informative about forestry," says Rick Haney, superintendent of maintenance services for the District of Elkford where 13,000 cubic metres of pine have been cut this year to control the beetles. "Every time you start cutting down trees, people wonder what's going on. Now that I have more information, I'm able to talk to the public with more confidence."

Topics included the industry perspective, non-timber forest values, current responses to the problem, the biology and ecology of the beetle, detecting the beetle, and planning and management to reduce the impact of outbreaks. Planning and management strategies include the computer based Decision Support System to help forecast the beetle's effect on a forest, direct control methods applied to an outbreak, the role and use of fire to manage the forest, and preventive silviculture methods of spacing and fertilization to reduce the impact of an outbreak.

"The concept of preventive silviculture is to grow trees in a way that will maintain tree vigor and have a microclimate that is detrimental to the beetle," says Dr. Les Safranyik, a research scientist also working in the Effects of Forestry Practices Network. "One could maintain these trees on the site longer than without special treatment and avoid the expense and disruption of having to treat them through direct control when the infestations occur."

Mountain pine beetles are not a new threat to BC forests – the native bark beetle has always played a role in the pine forest ecosystem. Prior to effective fire control, natural forest fires maintained a diversity of forest ages.

Continued on page 16

Setting Guidelines for Healthy Soils

"We hope this study will serve as a framework that people can refer to."

Healthy trees need healthy soil. Keeping that soil healthy through a harvest so it can provide for the next generation of trees is a challenge facing forest managers. With few harvesting guidelines to follow, what's good and bad for the soil isn't always clear.

At the Canadian Forest Service, Laurentian Forestry Centre in Québec, researchers are looking at studies on different tree species, soil types and ways of harvesting to set guidelines on which combinations of these three key factors will last and which won't.

"There have been a lot of studies on forest nutrient cycling, but guidelines are vague. In this work, we are looking at the nutrient balance and asking if forest harvesting is extracting more nutrients than the site can provide," says Dr. David Paré, a research scientist with the Effects of Forestry Practices Network. "Using the research available, we are determining, from the standpoint of soil nutrients, which forest practices are sustainable and which are not."

Black spruce after stem-only harvesting.

Dr. Paré and a team of researchers evaluated nutrient cycling studies, forest inventory databases and information on soil types to come up with the guidelines. They compared the harvesting methods of full tree removal, which removes all the above-ground parts of the tree, to the stem-only method, which removes the stem and bark, leaving the foliage and branches on the site. This approach identifies practices that have the greatest probability of causing damage to, or altering the soil in the long term.

"We asked what would be the best guidelines considering the knowledge we have," says Dr. Paré. "The study details what is creating a greater loss of nutrients on a site. It looks at situations that are sustainable and unsustainable."

Interest in this study is high. Traditional forest companies are interested to know what they should do to harvest sustainably. Other forest companies, who use the residue after harvest for creating, for example, essential oils and compost, are interested in the effects of removing that residue from the site. Dr. Paré says it's clear that extracting the foliage from the site causes nutrient loss, whereas leaving the branches and foliage can make a difference in balancing the rate at which nutrients enter and exit a system.

The findings and guidelines suggested from this study will be used to complement other environmental monitoring systems, such as that being developed by the forest company Abitibi Consolidated, says Dr. Alison Munson, a professor in ecology and forest nutrition at Université Laval. She and Dr. Paré are part of a team working with the company to test and implement their indicators of sustainable forest management, in the context of adherence to continual improvement required for certification.

"We do research for environmental management to come up with new indicators that they can use for monitoring sustainable forest management," says Dr. Munson. "As part of our project, we look at indicators suggested by the provincial and federal government, but also may suggest other pertinent local indicators – that's where David's work comes in. We'll go out and analyze conditions at particular forest management units in light of what he's already put together as guidelines, to see if there's a potential problem in those areas."

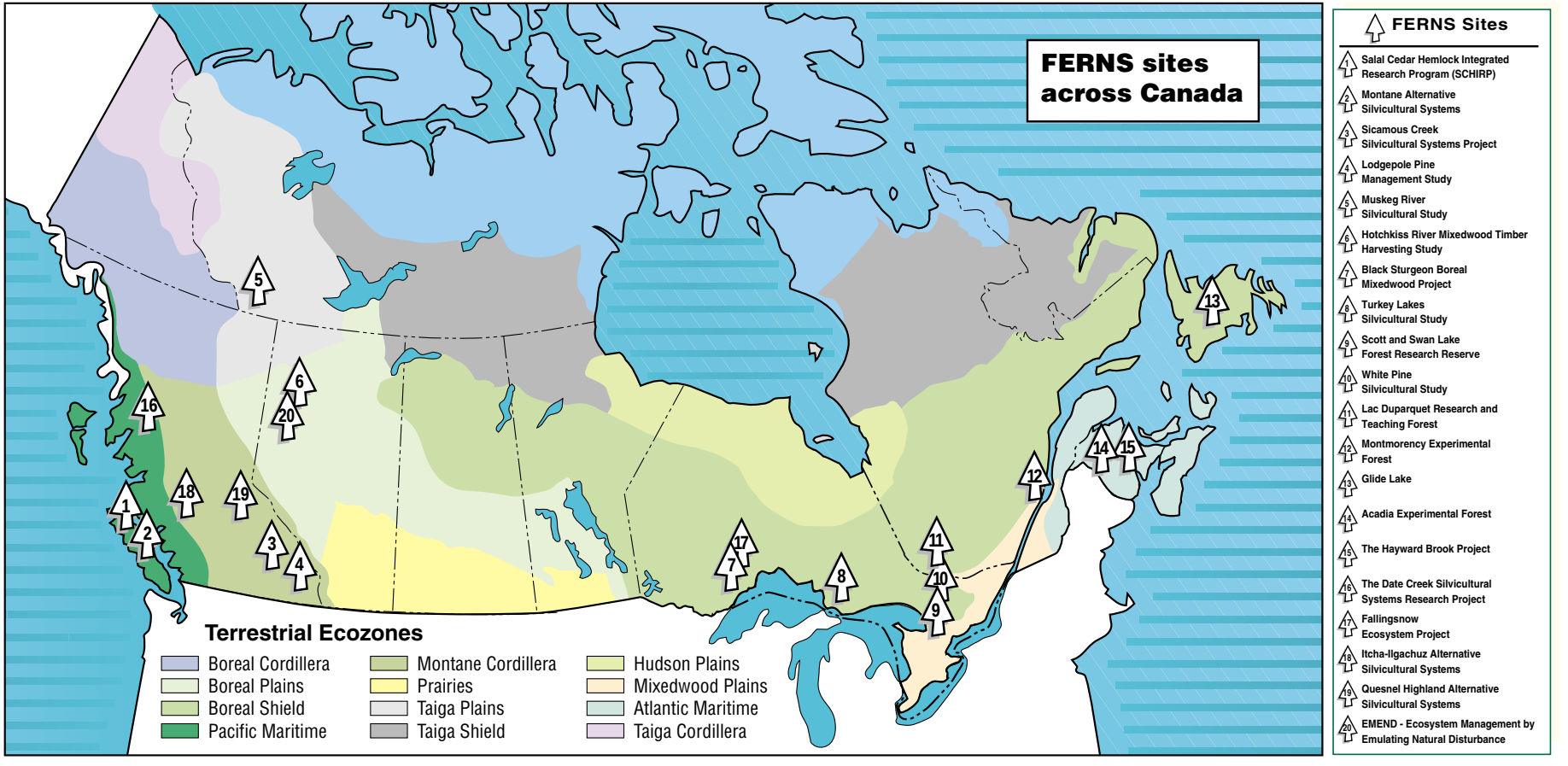
Although the study was done on the boreal forest of Québec, Dr. Paré says it can be applied to the same trees and soil types outside the area.

"We hope this study will serve as a framework that people can refer to," he said. "This is really needed by the forest community."

Dr. David Paré can be reached at dpare@nrcan.gc.ca

Forest Ecosystem Research Network of Sites (FERNS)

The Forest Ecosystem Research Network of Sites (FERNS) was established by the Canadian Forest Service to bring together long-term research sites that share a common theme of investigating forest harvesting options and their effects on ecosystem functioning. Each site represents sound, on-going research that is multi-disciplinary, multi-partnered, well documented, accessible and protected for long-term research values. Below is a list of the sites currently under FERNS. For more information about FERNS and its sites, check the FERNS web site at: http://www.pfc.cfs.nrcan.gc.ca/practices/ferns.htm.



Time for a Commercial Thin

"Thinning is going to be quite a flexible tool for intensive silviculture."

Commercial thinning treatments are the latest thing in New Brunswick's spruce-fir forests. Since the province began an extensive silviculture program in the late 1970s, many stands received a pre-commercial thinning treatment and are now ready for a commercial thinning treatment.

Government and industry joined forces to look at the province's balsam fir forest – a prolific natural regenerator. Together, the Canadian Forest Service, the New Brunswick Department of Natural Resources and Energy, Juniper Lumber Ltd. Inc., Fraser Papers Nextfor, and the Université de Moncton, initiated several experiments last year to learn more about the commercial thinning options for these forests. The study sites are located on provincial Crown licences in northwestern New Brunswick.

Commercial thinning operations at a balsam fir plantation in northwestern New Brunswick.

"The whole gist of this is to determine how we should be thinning. Thinning is going to be quite a flexible tool for intensive silviculture in the future," says Edwin Swift, a forest research officer at the Atlantic Forestry Centre working in the Effects of Forestry Practices Network. "As the wood supply decreases and the demand for quality wood increases, foresters must develop silvicultural prescriptions, such as thinning, that enhance timber production while addressing the environmental concerns of the consumer."

Swift and his team are starting to research different thinning methods to see how the individual trees and overall stand reacts. Their research on balsam fir is only one of many studies on commercial thinning going on in the Maritime provinces. Because different tree species react differently to various methods of thinning, Swift and his team are trying to determine what works best for balsam fir.

"Right now we are trying to come up with a proper treatment procedure that will get the response we need from those stands," said Jean-Louis LaPlante, a management forester for the New Brunswick Department of Natural Resources and Energy. "We've been approaching balsam fir stands with a spruce or jack pine prescription. It's like making chocolate cake with the ingredients for vanilla cake. We need to find the proper recipe for balsam fir. We need stand density diagrams and treatment schedules specific to fir and our site conditions."

The researchers are looking at three types of commercial thinning: low thinning, selection thinning across all diameter classes, and selection thinning across lower and upper diameter classes. The team is also comparing the effects of whether the stands had a pre-commercial treatment, a commercial treatment, or both.

Low thinning involves taking out the smaller stems and leaving the larger ones to keep growing. Selection thinning across all diameter classes means removing trees of every diameter class. Selection thinning across the lower and upper diameter classes means taking some of the thinner and some of the largest trees. The middle size trees are left to continue growing, as they should be the most resistant to long-term concerns of rot and budworm.

"By doing more of these types of intervention, we can regenerate the stand without completely removing it," says LaPlante. "When you do the final removal, the next forest is already established."

To check how the remaining trees are maintaining vigor, the team is looking at the long-term measurements of growth and health, such as, diameter at breast height, basal area, volume, merchantable volume, height, live crown ratio, crown width, tree quality and development of rot. These results will help the team develop commercial thinning guidelines for sustainable wood production in intensive forest management.

"We want to come up with a balance between forestry and economics," says LaPlante. "We want to be sure that what we do will maintain sustainable yield in the forest, because sustainability is the underlying premise for forest management planning."

Edwin Swift can be reached at Edwin.Swift@nrcan.gc.ca

Studying the Impacts of Alternative Harvesting

"This study provides some hard facts and figures on various effects of harvesting."

Researchers at the Turkey Lakes watershed in Ontario see more than trees when they look at the impacts of alternative harvesting. Soil, water, shrubs and birds are just a few of the things they've been checking out since the first experimental harvest on an operational scale in 1997. From clearcut to uncut, their studies in the Effects of Forestry Practices Network, cover the impacts of four methods in the range of harvesting options, focusing on the alternative methods of shelterwood and selection.

The Turkey Lakes site hasn't been harvested since the mid-1950s and other studies dating back more than 20 years provide a database of information on the site in general. These factors, plus being a typical sugar maple and yellow birch forest for the area, make the Turkey Lakes watershed an ideal situation for a harvest impact study.

"When you have something like this with lots of pre-treatment information, you can gain a better understanding of how the treatment affects the environment and what you might do to ameliorate these effects," says Al Cameron, the Canadian Forest Service project coordinator for the Turkey Lakes watershed, working at the Great Lakes Forestry Centre. "This study provides some hard facts and figures on various effects of harvesting that are often lacking."

A shelterwood harvested catchment basin at the Turkey Lakes watershed.

The researchers are checking out in detail the harvest impacts on soil productivity, soil erosion, nutrient cycling, site environmental conditions, biodiversity, and water quality, and comparing them to the data already known for the site.

"What we want to do is develop guidelines for the forest management companies to advise them on which trees to cut and how many. We want to give them a plan to follow for the next 100 years. The saplings today are the trees that will have commercial value in 50 to 100 years," says Dr. Bill Cole, a research scientist in hardwood silviculture working with a team of scientists from the Ontario Ministry of Natural Resources. "We have good guidelines that work well in south-central Ontario. The adaptive management approach is applying these guidelines to the site in north-central Ontario to see if they are ecologically sustainable and economically beneficial there as well."

The methods being tested for suitability at the north-central site include clearcut and uncut blocks to show the extremes of the impacts, as well as shelterwood and selection blocks to show a middle ground. Shelterwood involves removing half of the basal area in an even-aged stand, then returning to remove the second half several years later once regrowth has established. In selection blocks, a third of the basal area is removed from an uneven-aged stand, by taking trees in poor form, like weeding a garden. The selection stand can be harvested in perpetuity, every 15 to 20 years, as regrowth takes the place of the harvested trees.

"With selection, we want to improve the quality of the stand as we harvest. It takes a lot of knowledge and planning to do this properly," says Dr. Cole. "We're helping the logging crews learn to operate their equipment to remove the selected trees while protecting the quality and growing potential of the other smaller trees on the site."

It's too soon to report the results of the studies with any certainty – the next harvest won't be until at least 2007. So far though, says Cameron, a major result has been the increased interest in the site from researchers both inside and outside the Canadian Forest Service.

Al Cameron can be reached at Al.Cameron@NRCan.gc.ca

Understanding Armillaria from Coast to Coast

"In pretty much every forest in the southern part of the country, if you look carefully you'll find Armillaria.*"*

Armillaria

Scientists across the country are getting to the root of the matter as they uncover more about the fungi causing Armillaria root disease from Newfoundland to Vancouver Island.

Species of *Armillaria* occur naturally in many forest ecosystems, and normally live in equilibrium with their host. Forest management practices are upsetting that equilibrium, to the point where the fungi are threatening the health of the forest. The fungi spread from tree to tree through root contact, using the trees' root systems as a food source. The fungi try to kill the trees, but the trees often resist, unless weakened by other things. If it doesn't directly kill the tree it can cause growth reduction and butt rot and can weaken the tree's resistance to windthrow and bark beetles. Stumps left on a logging site provide an abundant food source, and hasten the spread of the disease. It can survive several decades in large roots and stumps, infecting the next generation of trees.

On the west coast, Dr. Duncan Morrison, a forest pathologist with the Effects of Forestry Practices Network at the Canadian Forest Service, Pacific Forestry Centre in Victoria, has been studying many aspects of the disease. After three summers of inspecting tree roots in 225 plots throughout the Nelson Forest Region of southeastern BC, he has completed the most comprehensive study on the disease in the area.

"The findings are important in understanding disease development in young stands," he says. "One of the important things that came out of this work is the percentage of diseased trees that were infected below ground that show symptoms above ground. Only one-quarter to one-half of diseased trees can be detected."

One aspect of the study was to clarify procedures used by the BC Ministry of Forests to survey stands for the disease. Results of this research were incorporated into their surveys, allowing a more precise analysis of stands.

East of BC in Alberta, the disease doesn't behave in quite the same way, and Dr. Ken Mallet, a forest pathologist with the Effects of Forestry Practices Network at the Northern Forestry Centre in Edmonton, has been studying the disease in a different climate. His research looks into a technique used in BC, but untested in other western forests – removing the roots and stumps of trees after harvesting to decrease the food available to the fungus, and therefore preventing spread.

"What we wanted to do was see if this would work in a place like Manitoba," he said. "It might not be a technique you want to use everywhere."

The first of two studies began in 1992 in the Sandilands area of southeast Manitoba. Although no results will be published until after the ten year measurements, Dr. Mallet says there is already significant reduction in the amount of disease – from 14 percent infection in the jack pine forests where the stumps were not removed, to 2 percent in the forests where they were removed. The second study has just begun near Cremona, Alberta. It will focus on how removing the stumps affects the soil and plant communities. Both studies will also produce an economic analysis detailing the costs of removing the stumps versus the costs of losing part of the harvest to the disease.

In the country's most eastern province, Dr. Jean Bérubé, a research scientist from the Laurentian Forestry Centre in Ste-Foy, has just completed a study on the distribution of *Armillaria* species in Newfoundland. Before this study, little was known about the distribution of the fungi on this island province, covered mostly by boreal forest.

"It's important to know which *Armillaria* you've got and where, as the different species don't cause the same kind of damage," said Dr. Bérubé. "The Maritime and Atlantic provinces are the last ones where *Armillaria* distribution has not been documented. This study helps complete the picture. We will be the only country in the world where we have a fairly good picture of *Armillaria* distribution."

Dr. Bérubé and a team of researchers studied 36 collections made between 1978 and 1995 on balsam fir, white spruce, white birch, and American mountain-ash trees. All except eight of the isolates studies were of the same species, *A. ostoyae*. The eight exceptions, of *A. sinapina*, were taken in a park from an exotic tree species. Therefore, the researchers concluded that it was introduced from the mainland, and only *A. ostoyae* occurs naturally in Newfoundland, as it does in the rest of the country.

"In pretty much every forest in the southern part of the country, if you look carefully you'll find *Armillaria*," says Dr. Bérubé.

Dr. Morrison can be reached at
dmorrison@pfc.cfs.nrcan.gc.ca
Dr. Mallett can be reached at
kmallett@nrcan.gc.ca
Dr. Bérubé can be reached at
jberube@nrcan.gc.ca

Saving Spruce from Root Rot

"If you wait, say 50 years, until you see dead trees, it's too late to do anything."

Hidden from view below the ground, *Inonotus tomentosus* infects spruce trees across the country. It rots the tree from the roots up, and can cause up to 2 metres of the trunk to decay. When an infected spruce tree is harvested, there's a good chance that the first log will have be cut off and left behind.

Little is known about this root rot fungus. It can colonize almost any coniferous stand, but needs certain conditions to cause damage. Dr. Gaston Laflamme, a research scientist with the Effects of Forestry Practices Network at the Laurentian Forestry Centre in Quebec, and a team of researchers began an extended study on the fungus four years ago at a 50-year-old white spruce plantation north of Montreal. When the stand was thinned that year, foresters discovered that 75 percent of the trees were decayed with *I. tomentosus*, and some of the trees were dying.

"I believe this problem will increase with more intensive forestry if we aren't careful to do the stand treatments at the right time," says Dr. Laflamme. "This fungus has the potential to cause a lot of damage."

Dr. Laflamme and his team want to find out how the thinning treatment helps the remaining trees resist the fungus, and whether it is possible to replant spruce or other conifers on the infected site. They've been checking the site every year, but won't know how much the thinning helped or if the seedlings will make it until at least the 5-year point.

***Fruiting bodies of* I. tomentosus**

The researchers hope the remaining trees become more vigorous after thinning. When the stand reaches a certain age, it gets too crowded. This causes the trees to weaken, slow their growth and become prime targets for the infection. If you look at the growth-rings, says Dr. Laflamme, they are smaller after 28 years of good growth, and the fungus probably invaded the trees after that point. With their increased vigor after thinning, the trees may be able to hold the infection at bay. They will still be infected, but the disease will be walled off, or compartmentalized, so it doesn't spread beyond the growth-ring of the thinning year.

"The timing for thinning is the key. If you thin at the right time, you shouldn't have this problem," he says. "When you need to thin depends on the site – the more seedlings per hectare there are, the younger you'll have to thin."

The 400 seedlings planted around the 100 infected stumps on the research site are doing fine so far, says Dr. Laflamme. The researchers planted four seedlings of different species around each infected stump – white spruce, red pine, white pine and larch. In natural stands, *I. tomentosus* has been found on all of these species but doesn't cause significant damage to any but spruce. Researchers want to find out whether the fungus attacks healthy trees, or just ones weakened by other factors.

"We think that if the spruce seedlings are nice and healthy they will grow without any of those problems," says Dr. Laflamme. "You have to start work at year zero. If you wait, say 50 years, until you see dead trees, it's too late to do anything."

Inonotus tomentosus isn't often reported since it's easy to overlook as it is mostly underground. It affects spruce trees from to coast, not just in eastern Canada.

"It's found all over BC and Alaska as well," says Kathy Lewis, an associate professor of Forestry at the University of Northern British Columbia who is studying the fungus. "Where we have spruce-dominated forests, we have tomentosus. It could become a big problem on spruce plantations where the site was infected before."

The fungus continues to live in the stumps and roots of trees after harvesting, and can stick around for more than 30 years. From there, it can spread to new trees, decaying them from the base up. That decayed wood has no commercial value, so it is cut off and left behind.

Dr. Laflamme can be reached at laflamme@nrcan.gc.ca

Bears Bear the Brunt of Blame

(or at least they may contribute to spreading white pine blister rust)

"After feeding on berries, bears may wander into root disease sites."

When bears answer the "call of nature", they may be doing more than just fertilizing the forest. They may be contributing to the spread of white pine blister rust.

Caused by the fungus, *Cronartium ribicola*, blister rust can greatly reduce native white pine stocks in southern BC and throughout the northwestern U.S. Young trees are particularly susceptible to this non-native pathogen which grows into and down the branch toward the stem. About 3 years after being infected by the fungus, aeciospores are produced in white blisters that break through the bark and infect *Ribes* (currants and gooseberries). The blister rust is then carried back to the white pine, completing the pathogen's lifecycle. But bears within such sites may add to the spread of the disease.

Ribes flourish in many root diseases sites, increasing the blister rust hazard. Dr. Richard Hunt, a research scientist at the Canadian Forest Service, Pacific Forestry Centre, says that after feeding on berries, bears may wander into these sites to feed on insect larvae or den under fallen timber and defecate *Ribes* and other berry seeds. Studies have shown that *Ribes* seeds germinate in such substances, and it is therefore possible that bears are thus contributing to the spread of the disease.

"On one root rot diseased site, the blister rust incidence reached 98 percent at 8 years, while *Ribes* were estimated to exceed 2,500 bushes per hectare and were still detected in species/abundance plots after three roguing treatments."

Bears feeding on* Ribes *may be spreading white pine blister rust.

"Grizzly bears have been found foraging in downed logs and stumps on armillaria root diseased sites, and black bear dens have been found under a jackpot of root rot fallen timber on laminated root rot sites," says Dr. Hunt, working in the Forest Biotechnology Network.

Berry seeds such as *Ribes* flourish after logging, so it is assumed that they survive from one rotation to the next. But Dr. Hunt suggests that bears may be adding new viable seeds periodically, rather than seeds surviving a complete rotation.

"It is also possible that the shade-tolerant *Ribes* may occasionally flourish and produce seeds at irregular intervals in stand openings created by root disease," he explains. "*Ribes* seeds may build up over time both from bear activity and from periodic germination and growth within root disease sites."

Root disease indicates a site's potential for blister rust infection. The density of *Ribes* within that site determines the blister rust hazard. But bear in mind that bears within such sites may further add to the hazard.

Dr. Hunt can be reached at:
rhunt@pfc.cfs.nrcan.gc.ca

Glossary

Aeciospore – A cylindrical or cup-shaped aecium (fruiting body) formed by rust fungi.

Commercial thinning treatment – A thinning in which harvested trees are removed from the site and used for commercial purposes.

Ectomycorrhizae – A fungus and plant root combination formed by trees in temperate forests that helps them to acquire water and nutrients.

Even-aged stand – A forest stand or forest type in which relatively small age differences (10-20 year) exist between individual trees.

Herbivory – Consumption of vegetation.

Humus – A brown or black substance made of decomposed or partially decomposed plant matter. It provides nutrients for plants and helps soil retain water.

Litterfall – The uppermost layer of the forest floor consisting mainly of decaying organic matter.

Mineralization – The process by which the organic components of an organism are replaced by inorganic materials.

Nutrient cycling – The circulation of chemical elements and compounds, such as carbon and nitrogen, in specific pathways from the non-living parts of ecosystems into the organic substances of the living parts of ecosystems, and then back again to the non-living parts of the ecosystem.

Pre-commercial thinning treatment – a thinning that does not yield trees of commercial value, usually designed to improve crop spacing.

Roguing – A mechanical process of removing or destroying diseased plants or plant parts from a seed crop in order to reduce the possibility of the spread of infection.

Slashburning – Burning of the residue left on the ground after harvesting.

Uneven-aged stand – Stands with a wide range of ages and sizes.

Recent Publications

Building Strength - Khowutzun forest services. Anon. Natural Resources Canada and Indian and Northern Affairs Canada. First Nations Forestry Program, Pacific Forestry Centre, Victoria. (2000).

Building Strength - Community jobs created by Similkameen Band. Anon. Natural Resources Canada and Indian and Northern Affairs Canada. First Nations Forestry Program, Pacific Forestry Centre, Victoria. (2000).

Building Strength - Building forest capacity of Nak'al Koh logging. Anon. Natural Resources Canada and Indian and Northern Affairs Canada. First Nations Forestry Program, Pacific Forestry Centre, Victoria. (2000).

Building Strength - Tree of life essential oil: a new form of value added product. Anon. Natural Resources Canada and Indian and Northern Affairs Canada. First Nations Forestry Program, Pacific Forestry Centre, Victoria. (2000).

Building Strength - Joint venture brings the Osoyoos Indian Band into the forest industry. Anon. Natural Resources Canada and Indian and Northern Affairs Canada. First Nations Forestry Program, Pacific Forestry Centre, Victoria. (2000).

Management of root diseases by stumping and push-falling. Sturrock, R.N. Technology Transfer Note No. 16. (1999).

Microarthropod voucher specimens. Clayton, M.; Humble, L. Technology Transfer Note No. 19. (2000).

Marketing forestry research information on the web: the Canadian Forest Service on-line bookstore. Glover, S.G.; Thomson, A.J.; Mills, D.; Adsett, J. Technology Transfer Note No. 21. (2000).

Towards semi-automatic forest inventories using individual tree crown (ITC) recognition. Gougeon, F. Technology Transfer Note No. 22. (2000).

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

DEMO 2000 International and Technologies for New Millennium Forestry Conference September 11-16, 2000 Kelowna, BC, Canada

Demo 2000 International is North America's largest, active exhibition of wood harvesting and forest management systems. In addition to the 300 new woodlands machines and systems operating in the forest during DEMO 2000, a "Technologies for New Millennium Forestry" conference will bring together some 40 speakers to discuss current issues and challenges affecting woodlands operations in Canada and abroad. For more information check the following websites: www.cwfcof.org or www.forestindustry.com or contact Anne Sawyer, Canadian Woodlands Forum, 740 Notre-Dame West, Suite 810, Montreal, Quebec H3C 3X6; Tel: (514) 392-6947 Fax: (514) 392-0369 E-mail: asawyer@cwfof.org

Mountain Pine Beetle continued from page 6

This reduced the lodgepole pine forests' susceptibility to the beetle. Human activities have changed the natural role of fire in the forest, allowing the beetle population to reach epidemic levels. Outbreaks like this are a huge problem since the industry must salvage what they can by altering logging plans to follow the beetle's path of destruction. Fire hazard increases as the trees die, and wildlife and recreational forest values are affected.

"Although most forest managers are aware of aspects of mountain pine beetle management, they don't necessarily know the biology and ecology of the beetle on which those management techniques are based," says Dr. Carroll. "The showcase was important as an eye opener for some and a refresher for others. You can't manage a forest unless you understand it."

Dr. Safranyik can be reached at lsafranyik@pfc.cfs.nrcan.gc.ca.
Dr. Carroll can be reached at acarroll@pfc.cfs.nrcan.gc.ca.

INFORMATION FORESTRY

Published by

Canadian Forest Service
Pacific Forestry Centre
Natural Resources Canada
506 West Burnside Road,
Victoria, B.C., V8Z 1M5
(250) 363-0600

Editor: Joanne Stone
Contributors: Karina Low; Joanne Stone

For further information:
Phone: (250) 363-0606 Fax: (250) 363-0775
Email: jstone@pfc.cfs.nrcan.gc.ca

Information Forestry is also downloadable from our site at **www.pfc.cfs.nrcan.gc.ca**

What do you like most about Information Forestry?
Are there ways we can better meet your interests?
Are there topics you'd like to see featured?
We'd like to hear from you! Drop us a line at jstone@pfc.cfs.nrcan.gc.ca