Forest Protection Research Update

The Forest Protection Research program of FRDA II is made up of two sections: Forest Health and Fire Management. The aims of the Forest Health Research program are:

- to determine the impacts of pests on present wood supplies, silvicultural investments, and other forest values;
- to develop hazard rating procedures, by correlating the incidence and frequency of pests with ecological factors or forest management practices. Survey methods for pests will be developed and refined. This information will augment forest management plans, leading to improved forest health;
- to develop and refine environmentally sensitive management treatments for the pathogens, insects, and small mammals that cause major damage to forest resources, emphasizing naturally occurring control agents; and
- to develop decision support systems for use by forest managers. This will allow them to weigh the ecological implications of a treatment against the silvicultural benefits as part of the planning process.

The aims of the Fire Management Research program are:

- to develop fire prediction and behaviour models for the key forest types not represented in the fire behaviour protection (FBP) system. Emphasis will be placed on collecting information on factors affecting fire spread and fuel moisture;
- to refine lightning fire prediction models for B.C. fuel types and so improve accuracy at a local level;
- to quantify the effectiveness of various fire suppressants and retardants, and to ensure that the delivery method is appropriate; and
- to develop methods to evaluate costs and benefits of fire protection on both the resource and the communities affected.

This memo briefly summarizes the progress in these research areas to March 31, 1992. Details are available from researchers and project contacts listed on page 10.

Project FC-FP01  Glyphosate-accelerated decomposition of host material to control coniferous root rots

Project Leader:  Zamir Punja, Dept. of Biological Sciences, Simon Fraser University
Agency Contact:  Dave Winston, Forestry Canada

Objectives:
1. To study the uptake and transport of glyphosate in root systems;
2. To determine the uptake and transport of glyphosate in a recently felled tree stump;
3. To evaluate what species of microorganisms are responsible for colonization and breakdown of treated woody material; and

4. To determine the rate of colonization of treated stumps and roots by saprophytic microorganisms.

Proposed Approach

Laminated root rot (Phellinus weirii) of Douglas-fir causes widespread damage in southern B.C. forests. Coastal second-growth stands that have been commercially thinned and harvested are particularly susceptible. Phellinus weirii survives from one generation to the next by remaining in subterranean roots and stumps of previously live, infected trees. The fungus is transferred to the roots of the new stand when they come in contact with the buried, infested roots of the old stand. Persistence of the fungus in buried roots depends on their size and condition. It is possible that spread of the fungus and initiation of new disease outbreaks could be reduced if the natural decay of infested, woody material was accelerated.

The commonly used herbicide glyphosate appears to accelerate the decomposition of woody stems and roots by hastening the invasion of naturally occurring microbial decomposers. This study will investigate this process, to determine the efficacy of using glyphosate in the management of areas affected by P. weirii.
**Expected Benefits**

The production of data on the efficacy of using glyphosate to treat stumps infected with laminated root rot will contribute to a better understanding of the options available to manage the disease. Guidelines will be generated, outlining the most efficient treatment concentrations and methods.

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**Project FC-FP02**  
*Development of survey procedures for Inonotus tomentosus*

**Project Leader:** Kathy Lewis, Industrial Forestry Service Ltd.

**Agency Contact:** Rich Hunt, Forestry Canada

**Objectives:**

1. To develop survey procedures that may be used for *Inonotus tomentosus* alone or for multiple-pest surveys; and
2. To relate above-ground symptoms to fungal infection of the root, and to compare the actual size of root disease centres with the size indicated by above-ground symptoms.

**Proposed Approach**

Tomentosus root disease is widespread in the boreal forests of Canada. The fungus spreads from tree to tree by root contacts and can be carried over from one rotation to the next when regeneration tree roots come in contact with the stumps.

This project will develop a series of survey procedures, each with its ascribed effort and accuracy level, so that researchers can choose a survey design to meet desired objectives. The study will also generate a system by which above-ground observations can be used to estimate the degree and extent of root infection. In addition, de-stumping trials for root disease control will be established.

Two 5-ha blocks (one heavily infected and one lightly infected) or one 10-ha block will be stem mapped and each tree rated for symptoms. The blocks will be push-over logged and the roots and butt of each tree rated for decay. Utilization measurements will be taken as compared to normal stump height, and stem maps will be generated with overlays for crown symptoms, butt rot, and root infections. Different survey methods will be tested using the maps, and estimates from each method will be compared to the “real” data.

**Products**

This project will produce a series of survey procedures with detailed guidelines on their relative accuracies for different survey objectives and intensities. This information will be valuable for planning purposes, as well as for direct management of infected sites. Field data on the efficacy of push-over logging as a control method will also be available.

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**Project FC-FP03**  
*Effects of precommercial thinning (spacing) on crop tree infection and mortality by root diseases in the southern and central Interior*

**Project Leader:** Duncan Morrison, Forestry Canada

**Objectives:**

To evaluate infection and mortality from root diseases following precommercial thinning (PCT) of interior sites.

**Proposed Approach**

Observations suggest that root disease spread may be increased by PCT, just as it is by partial cutting in older stands. In well-stocked stands infected by *Armillaria ostoyae*, the roots of thinned trees provide a food source that may increase the potential for spread of the disease. Less is known about the effects of PCT on the epidemiology of *Phellinus weirii* and *Inonotus tomentosus*. Understanding how intensive forest management techniques such as PCT affect the epidemiology of various root diseases is critical for managing affected areas successfully.

In this study, up to three field test installations will be established on infected sites in each of the Nelson, Kamloops, Prince George, Vancouver, and Cariboo regions. Each test will contain thinned and unthinned 0.04-ha plots, and will be evaluated every 2 years for root disease symptoms and mortality.

**Expected Benefits**

1. An evaluation of PCT effects on the epidemiology of *Armillaria, Phellinus, and Tomentosus* in the Interior;
2. Guidelines for PCT in diseased stands; and
3. Establishment of demonstration sites in each of the interior regions.

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**Project FC-FP04**  
*Effects of juvenile spacing lodgepole pine on the incidence and impact of pine stem rusts and cankers*

**Project Leader:** Bart J. van der Kamp, Dept. of Forest Sciences, University of British Columbia

**Agency Contact:** Rich Hunt, Forestry Canada

**Objectives:**

To quantify the effects of juvenile spacing on the incidence and severity of damage caused by the common stem rusts and cankers of lodgepole pine.

**Proposed Approach**

This project will re-measure a series of permanent sample plots established in 1980, in spaced and non-spaced lodgepole pine. Each tree will be evaluated for survival, size, and infections by each of three rusts and *Atropelta* canker. Analysis will concentrate on the growth and mortality of infected trees, as well as on changes in infection rates in response to spacing.
Expected Benefits

A final report will provide recommendations on juvenile spacing of lodgepole pine in disease-infected stands, including assessments of infection, mortality rates, and stand growth. One or more workshops will also be given.

Project FC-FP05 A decision support system for mountain pine beetle management

Project Leader: Terry Shore, Forestry Canada

Objectives:
To develop a decision support system for the mountain pine beetle, which will provide resource managers with a tool for selecting treatments to minimize losses to this insect pest.

Proposed Approach

The mountain pine beetle is the most destructive forest insect in Canada. Losses to this pest in B.C. over the last 5 years have totalled 8 million m³, double the volume lost to fire. Preventative management tools are needed to assist managers in identifying high-risk stands and selecting treatment options.

Forestry Canada has developed a risk rating system, population dynamics spread, and impact model, all of which will be integrated to create a decision support system. The system will be computer-based and structured to help forest managers select treatments to minimize pine beetle losses.

Products

This project will produce publications, workshops, and a user-friendly computer-based decision support system to assist with system implementation.

Project FC-FP06 Development of an integrated pest management system for spruce weevil in British Columbia

Project Leader: Rene Alfaro, Forestry Canada
Participating Scientists: Rene Alfaro, John Manville, Michael Hulme, and Tara Sahota, Forestry Canada

Objectives:
1. To investigate the possibilities of spruce weevil (Pissodes strobi) control using the natural genetic resistance present in populations of the host trees;
2. To study weevil population dynamics and weevil/host interactions; and
3. To assess the impacts of weevil attack on tree growth and form.

Proposed Approach

The spruce weevil is B.C.'s most damaging spruce pest, yet no operationally feasible method of control is available. Alternate tree species selection is used to avoid pest attacks; however, these species are often slower growing and less valuable. Biological control and host resistance are two areas that show promise, but further investigation is needed. This project will study weevil control options using the natural genetic resistance present in populations of the host trees. The four areas to be studied intensively include: the mechanisms of weevil resistance in coastal Sitka spruce, genetic diversity among weevil populations, the chemical profiles of interior spruce with different degrees of resistance, and tree growth response for the development of computer simulation models.

Products

The results of this project will provide geneticists with information on resistance mechanisms for use in tree improvement programs. In addition, a computer model will be designed for use by forest health officers and silviculture foresters, to help them identify the optimal combinations of control measures.

Project FC-FP07 Reduction of spruce budworm losses in Douglas-fir through silvicultural treatments

Project Leader: Rene Alfaro, Forestry Canada

Objectives:
To determine whether fertilizing and thinning infested stands can compensate for defoliation by western spruce budworm.

Proposed Approach

Western spruce budworm is a continuing threat to interior Douglas-fir forests. Trees that survive a budworm attack are usually left with small, thin crowns, and suffer growth loss. Sub-normal growth continues as long as trees do not have a full complement of foliage.

Research in the western U.S. suggests that silvicultural treatments can be effective in compensating for the impact of defoliators. Forestry Canada and the Ministry of Forests established a joint project in 1990 to determine whether growth losses from western spruce budworm could be reduced by restoring health and vigor to defoliated stands through silvicultural treatments. Thinning and fertilization are currently being evaluated for their ability to restore crown vigor and compensate for budworm losses.

The experiment consists of 36 plots: 9 control, 9 thinned with fertilization, 9 thinned without fertilization, and 9 thinned and fertilized.

Basic, mensurational data have been collected, as well as data on individual tree defoliation severity. Initial pre-fertilization levels of N, P, K, and S have also been recorded. The plots will continue to be monitored and measured until 1995.

Expected Benefits

This project will generate guidelines on reducing the impacts of western spruce budworm through the use of silvicultural treatments.
Project FC-FP08  Hazard rating for western budworm from historical records and GIS analysis

Project Leader:  Allan van Sickle, Forestry Canada

Objectives:
1. To map geographic areas by relative risk of western budworm infestation, using historical records and Forestry Canada’s geographic information system (GIS); and
2. To analyze frequency, location, and duration relationships to aid in the above process.

Proposed Approach
Western budworm has defoliated over 800,000 ha in B.C. during the present infestation, active since 1981. Records show that at least six previous infestations have occurred in the province since 1900. The patterns and overlap of these infestations have never been examined. Their analysis during this project will provide a hazard rating based on location, frequency, and duration.

Forest Insect and Disease Survey (FIDS) infobase records of point source collections back to 1949, and aerial surveys from 1986 to present, will be converted to a more universally available system within the GIS. Earlier map records will also be entered to expand the historical database. An overlay analysis will be done to clarify the patterns of infestation and relationships between frequency, location, and duration.

Expected Benefits
This project will provide a historical, GIS-based record of previous infestation patterns and relationships. Hazard maps will be completed and a report produced for use in forest management planning.

Project FC-FP09  Evaluating the resistance of western larch to Armillaria root disease

Project Leader:  Duncan Morrison, Forestry Canada

Objectives:
To investigate the apparent resistance of western larch to Armillaria ostoyae.

Proposed Approach
Armillaria ostoyae causes the most damaging root disease of conifers in southern B.C. All commercial conifer species are susceptible to damage at some time during a rotation. During the first 10-15 years of a rotation, there appears to be little difference in resistance of conifer species to the disease. Nearly all trees that become diseased are killed. Further observations indicate that, after age 15, differences among species in the rate and incidence of mortality start to show up.

The greatest contrast is evident between Douglas-fir, which is very susceptible, and western larch, which shows resistance. Exploratory excavations have found that when trees of these species over the age of 25 encounter a common inoculum source, the Douglas-fir dies while the larch either remains unaffected or resists the disease. Based on these observations, tentative recommendations were made to favour or establish western larch on sites infested by A. ostoyae. More information is needed on the nature and mechanisms of larch resistance before its use in silvicultural prescriptions can be recommended with confidence.

Investigations will focus on determining the age at which larch begins to show resistance and the nature of that resistance (i.e., meristematic, chemical, physical, or a combination). Sites have already been selected at Eagle Bay near Salmon Arm in the B.C. interior. Additional sites will be established in the Larch Hills near Salmon Arm and at Grand Forks, B.C. Western larch and Douglas-fir (aged 5-50 years) on the selected sites will be excavated to observe the development of A. ostoyae in the root systems and the nature of the host response. Available techniques for examining host response to infection at the tissue and cell levels will be used.

Expected Benefits
This investigation will provide forest researchers with valuable knowledge on the timing and nature of larch resistance, for use in disease management decisions.

Project FC-FP10  Refinement of operational guidelines and improvement of viral insecticide application strategy to control Douglas-fir tussock moth

Project Leader:  Imre Ornos, Forestry Canada

Objectives:
To evaluate the Douglas-fir tussock moth virus for efficacy of operational application, and to determine whether storage affects the performance of the virus.

Proposed Approach
Douglas-fir tussock moth is a serious pest of Douglas-fir, particularly in dry forest types. Defoliation by this pest can result in significant mortality and growth loss within stands.

A naturally occurring insect virus is normally the most important factor in putting an end to tussock moth outbreaks. This Douglas-fir tussock moth virus has been registered as a biological insecticide for tussock moth control. The current outbreak gives us the first opportunity to test this virus-based product on an operational scale.

The project will test the effectiveness of two virus products, as well as fresh virus, to provide baseline efficacy data for virus applications against the Douglas-fir tussock moth. The tests will be carried out in conjunction with operational applications. Virus products to be tested have been stored for about 10 years. One pre-spray and four to five post-spray samples will be taken.

The project will also develop indices of naturally occurring virus, as well as of egg parasitism. These indices will help us predict whether the collapse of an infestation is imminent, so that costly, unnecessary treatments can be foregone.
Products

This project will provide information on the efficacy of treatments using stored tussock moth virus, and will help us formulate indices for deciding whether to treat a given stand infested with tussock moth.

Project FC-FP11 Development of a pheromone control system for Douglas-fir tussock moth

Project Leader:  Tom Gray, Forestry Canada

Objectives:

To determine the efficacy of male disruption, brought about by the dissemination of sex pheromones, for reducing Douglas-fir tussock moth populations to less damaging densities.

Proposed Approach

The only control agent available for the Douglas-fir tussock moth is a naturally occurring virus now undergoing operational testing. Pheromones offer an alternative to virus control. The Douglas-fir tussock moth uses pheromones in its reproductive biology and is an ideal species for field testing, due to its discrete populations and lack of dispersion.

Pheromones will be formulated and sprayed throughout tree crowns in field trials to determine application parameters. This treatment should prevent the males from locating the females, and thus block mating and egg laying. Treatments will take place in 1991/92 with follow-up evaluation in 1992/93. Different application technologies are being tested by the U.S. Forest Service and Agriculture Canada. This network of testing will allow for the selection of the technology most suitable for future use.

Products

This project will be instrumental in the development of an economically and ecologically sound method for controlling Douglas-fir tussock moth, using pheromones sprayed from aircraft.

Over 900 ha of hemlock forest in seven areas north of Revelstoke are currently infested. Infected stands suffered light defoliation in 1990. Past experience suggests that the outbreak may last until 1993 or 1994, with some tree mortality continuing after the outbreak ends.

Nuclear polyhedrosis viruses have been found in the western hemlock looper, as well as in the eastern hemlock looper (L.f. fiscellaia) and the western oak looper (L.f. somniaria). They appear to be cross-infectious to all three subspecies and may be the same virus.

This project will investigate: 1) the identity of the above three viruses; and 2) the efficacy of using the western oak looper virus for controlling the western hemlock looper. The virus to be used in this trial is the western oak looper NPV formulated as a wettable powder. One to 2 m tall western hemlock that have naturally regenerated around mature trees will be used in this trial. Three dosage levels will be tested on first and second instar larvae after egg hatching has been completed and the larvae are feeding on new growth. Twenty trees will be treated with each dose level, and a further 20 left as untreated controls.

In addition to the viral studies, a fungal insecticide (Zoophthora radicans), which has been developed by the USDA, will be evaluated for efficacy in causing an early collapse of the infestation. Work will focus on developing and field testing a local strain.

Projects

Field data on the efficacy of the naturally occurring virus will be generated to be used in future management decisions on control of looper outbreaks. Registration of the virus as a pest control product may also be possible.

Project FC-FP13 Industrial research chair in chemical ecology and management of forest insect pests

Project Leader:  John Borden, Simon Fraser University

Agency Contact:  Dave Winston, Forestry Canada

Objectives:

To advance the understanding and application of semiochemical-based systems for the control of forest insect pests in the areas of:
1. insect pest communication and host resistance;
2. synthesis of new semiochemicals; and
3. survey and management systems.

Proposed Approach

Dr. John Borden of Simon Fraser University heads one of the world's leading laboratories in the study of the chemical ecology of forest insect pests. The semiochemical-based management methods developed in Dr. Borden's laboratory for controlling ambrosia beetles and mountain pine beetles have saved millions of dollars annually. Further research in this area has the potential of decreasing harvest losses from insects and disease and increasing the annual harvest.
In support of that objective, two forest industry councils, nine companies, Simon Fraser University, the Natural Sciences and Engineering Research Council (NSERC), and the Pacific Forestry Centre have funded an Industrial Research Chair for Dr. Borden.

Communication by semiochemicals will be investigated by field experiments and laboratory bioassays on field-collected or reared insects. These studies will be supplemented by core research on the chemical nature of semiochemicals. Behavioural and chemical knowledge will be integrated in the development of trapping systems for monitoring and controlling pest populations. An index for conifer resistance to terminal weevils will be developed and used in evaluating parent trees and their progeny in breeding programs.

Products

This research will produce useful biological and chemical knowledge relating to forest pests, including new microanalytical methodology, new chemical syntheses, synthetic semiochemicals, and semiochemical-based survey and management tactics.

Project FC-FP14  Wildfire behaviour models for spruce-balsam forests

Project Leader: Bruce Lawson, Forestry Canada

Objectives:
1. To develop wildfire behaviour models for spruce-balsam forests; and
2. To link these models with handline and airtanker fireline productivities in various fuel types.

Proposed Approach

The recently introduced Fire Behaviour Prediction System (FBP) contains fire behaviour models for 17 national benchmark fuel types covering a range of forest, grassland, and logging slash fuels. The province's white spruce-subalpine fir (spruce-balsam) fuel type is not one of those represented in the FBP system. This fuel type is one of B.C.'s principal benchmark fuel types, accounting for a large proportion of the remaining mature forests, as well as a significant proportion of provincial fire losses. Having quantitative behaviour models to apply to this fuel type would be useful.

In this project, experimental fires will be conducted in standing spruce-balsam forests in order to model initiating fire spread, acceleration, and threshold of crowning. Wildfires will be monitored to determine equilibrium fire spread rates under severe burning conditions. Operational prescribed burns for national park ecosystem management and wildlife habitat management will also be monitored. As well, models for rate of spread, fuel consumption, and fire intensity will be developed, and the effectiveness of various suppressants and retardants will be related to quantitative fire behaviour in spruce-balsam forests.

Products

This project will generate models of the following aspects of wildfire behaviour in spruce-balsam forests: probability of ignition; acceleration from point ignition; equilibrium rates of spread; fuel consumption and fire intensity; and suppression effectiveness vs. intensity.

Project FC-FP16  The impact of lower-crown mistletoe brooms on the growth of western hemlock

Project Leader: Bart J. van der Kamp, Dept. of Forest Sciences, University of British Columbia

Objectives:
To determine whether dwarf mistletoe brooms, on low-vigour branches in the lower crowns of western hemlock, represent a significant drain on the tree's energy reserves and lead to reduced increment.

Proposed Approach

Observations show that mistletoe branch infections within 1.5 m of the bola often stay alive even though all foliage on the branch is shed. This indicates that branch infections of dwarf mistletoe may be able to tap carbohydrate sources derived from other parts of the tree—a condition that contradicts the traditional assumption that carbohydrate losses from mistletoe infection result only from the interception of photosynthate produced by foliage on the same branch to the outside of the infection site.

To study whether lower crown mistletoe brooms represent a significant drain on tree energy reserves, 15 pairs of matched (size, crown position, and degree of infection), heavily infected trees and 15 pairs of virtually uninfected controls were selected on a cutblock that was clearcut in 1953. In 1982, all the branches bearing brooms were removed from one of each pair of infected trees, while one of each pair of controls was pruned to the same height.

These trees are now over 30 m tall and up to 80 cm in diameter. To calculate the average annual volume increment before and after broom removal, the trees will be harvested and measured. Diameter and annual radial increment over the last 20 years will be recorded at intervals to the top of the tree. Comparisons of the ratio (volume increment 1983-91) to (volume increment 1973-81) for pairs of pruned and unpruned infected trees will show the effect of mistletoe broom removal. Similar comparisons between pruned and unpruned healthy trees will indicate the effect of branch removal, thus allowing a distinction between the effect of mistletoe removal and that of pruning.

Expected Benefits

The results of this project will allow us to estimate losses attributable to hemlock dwarf mistletoe in immature stands on good sites. This information will contribute to more informed management of mistletoe-infected stands, particularly relating to the acceptability of mildly infected advanced regeneration and possible pruning treatments during juvenile spacing.
Project FC-FP17  Quantitative evaluation of enhanced water fire suppression

Project Leader:  Bruce Edwards, FireTech Engineering Inc.
Agency Contact:  Rick Clevette, Ministry of Forests

Objectives:
To compare, in full-scale test burns, the knock-down and rekindle fire suppression properties of Class A foam solution, aspirated Class A foam, and compressed air foam systems, so that promising combinations of foam, equipment, and application method can be identified.

Proposed Approach
Subjective operational experience indicates that Class A foam suppression systems are superior to plain water in effectively achieving ground-based fire knockdown, exposure protection, and suppression of rekindles during mop-up. This anecdotal evidence will be evaluated quantitatively in this project.

Fifty controlled test burns of natural fuels will be conducted to simulate small full-scale fires well beyond conventional ground-based fire suppression capabilities. The relative performances of various Class A foams and foam solutions will be statistically compared to those of plain water using Critical Flow Rate knock-down and rekindle curves.

Expected Benefits
This study will develop a scientific method for evaluating suppression systems, as well as for generating quantitatively based comparisons of Class A suppression systems. Application of these results will likely lead to reduced fire losses and improved ground-based suppression and mop-up technologies.

Project FC-FP19  Push-over logging of second-growth Douglas-fir infected with Phellinus root disease

Project Leader:  Rona Sturrock, Forestry Canada

Objectives:
To determine if the push-over logging technique can be used successfully under coastal conditions to sanitize sites infected with Phellinus weirii.

Proposed Approach
Laminated root rot (Phellinus weirii) survives saprophytically in old forests, subsequently infecting young stands. This makes it necessary to sanitize an infected site before replanting it with a susceptible species such as Douglas-fir. This project provides an opportunity to investigate an alternative to the present costly sanitation methods of post-harvest de-stumping or root-raking. Using machinery that would remove the root systems from the soil at the same time as felling the trees could potentially reduce the overall cost of preparing a site for replanting.

The treatment area is an infected stand located along the South Shawnigan Lake Road on Vancouver Island. The logging will be done by a large backhoe equipped with a hydraulic grapple to shake trees and dig for roots, a bucketman, and two grapple skidders. Trees will be pushed over with the backhoe, then picked up and shaken over the hole left by the uprooted stump to free roots of attached soil. Operational planting will be done in the spring of 1993. Follow-up will include productivity and cost studies, data collection on the status of roots remaining in the soil, and monitoring of seedling mortality 2 years after planting and at regular 5-year intervals after that.

Expected Benefits
The development of a cost-effective logging technique for diseased second growth will remove the need for costly post-harvest treatments and allow immediate replanting of Douglas-fir on diseased sites.

Project FC-FP18  Development of an interface for the PROGNOSIS-Pest Subroutines Model

Project Leader:  Jeff Beale, Ministry of Forests

Objectives:
1. To provide a compatible interface for the root rot subroutine-PROGNOSIS model; and
2. To evaluate the productivity impacts of root rots on various silvicultural treatments and systems by conducting different stand condition/stand treatment simulations on the root rot model.

Proposed Approach
Armillaria and other laminated root rots cause extensive damage to forest crop value and productivity in southern B.C. Forest managers need quantitative information about the impact of root rot on productivity so that they can evaluate the efficacy of silvicultural treatments and systems.

PROGNOSIS, with its pest subroutines, is the only stand-level computer model that can be used for modelling in southern interior forest conditions at this time. The Ministry of Forests Inventory and Silviculture branches are working co-operatively to bring the PROGNOSIS model and pest subroutines to a common functional level in order to model various stand and treatment scenarios.

Prospective client requirements for model-subroutine interfaces will be solicited and reviewed. From that feedback, interface computer software will be developed and tested. Field testing the PROGNOSIS-root rot model will require some special root rot sampling in key test areas so that input variables can be collected and model projections validated.

Products
The development of PROGNOSIS-root rot model interfaces will simplify scenario testing and the evaluation of silvicultural treatments, and aid in yield forecasting.
Project FC-FP20  

Development of a spruce weevil infestation hazard rating for B.C.

Project Leader:  Dave Spittlehouse, Ministry of Forests

Objectives:
To develop a spruce weevil hazard rating system based on air temperature and bioclimatic subzone information.

Proposed Approach

The spruce weevil (Pissodes strobi Peck) occurs over a large area of B.C. and results in significant reductions in growth and timber quality. The development of a hazard rating system for forest subzones in B.C. would help foresters in targeting areas for field surveys and site treatment.

Guidelines have been produced on the temperature requirements for the development of the weevil (L.H. McMullen 1976, "Effect of temperatures on oviposition and brood development of Pissodes strobi." Can. Ent. 108:1167–1172). Temperature data from climate stations in B.C. have been correlated with bioclimatic subzones and will be used to determine infestation hazard.

A preliminary hazard assessment of the subzones in the Prince George and Cariboo regions was done using this methodology (Sieben 1991, unpublished contract report to Ministry of Forests). Sieben's study showed the potential of the methodology and the improvements required.

This project will compare the predictions in Sieben's report with field survey results in the regions in order to refine the methodology. Other sources of data, such as the Ministry of Environment fire weather network and B.C. Hydro network, will be investigated to improve climate station coverage in some subzones. Field measurements will be made to compare the temperature of spruce leaders with climate station temperature. An energy balance model of a leader will be developed.

Products
This research will produce a temperature-based hazard rating system for spruce weevil infestations, which will be applicable throughout B.C. The data will be entered into a geographic information system to produce maps, and will also be available for addressing other pest and management concerns.

Project FC-FP21  

Gray mould of container-grown Douglas-fir seedlings: physiological studies relating needle senescence to disease severity

Project Leader:  Jack Sutherland, Forestry Canada

Objectives:
1. To continue a project investigating the relationship between needle senescence characteristics of Douglas-fir and the severity of gray mould infection in container-grown fir seedlings; and
2. To identify future research goals in this area.

Proposed Approach

Gray mould is a common disease of container-grown conifer seedlings in B.C. to which Douglas-fir is particularly susceptible. Although cultural practices are used against the disease, nurseries still rely largely on fungicides to control the mould. More knowledge is needed on how cultural practices affect host susceptibility. It is well known that one of the most important factors in disease susceptibility is the time during the growing season when needle senescence (dropping needles) begins. Dropped needles serve as infection sources from which the pathogen spreads. There is evidence that senescence relates to the density at which seedlings are grown and to the abundance of suppressed seedlings present in the crop. Suppressed seedlings tend to be the slower germinants, and these usually become small, weak seedlings that serve as disease epicentres.

This project will determine the effects of seedling density (seedlings grown per unit area), and the germination speed of seeds, on the onset and abundance of senescent needles (which are in turn related to grey mould severity). Needle senescence will be determined by chemical analyses of such characteristics as needle chlorophyll content, abundance and nature of needle waxes, and needle sugar content.

Products
This research will result in new knowledge on the physiology of the most serious nursery disease in B.C. and Canada. The analyses will provide data on the chemical characteristics of senescent needles of Douglas-fir seedlings and relate senescence to seedling density and germination rate within seedlots. New knowledge may lead to improved cultural practices and less reliance on fungicides.

Project FC-FP22  

Impact of site environment and seed source on pest-related damage of plantation lodgepole pine.

Project Leader:  Cheng Ying, Ministry of Forests

Objectives:
1. To assess damage caused by rodents, insects, and disease at all pine provenance trials in the Interior;
2. To develop models to predict pest infestation based on site environments, seed sources, and their interaction; and
3. To make preliminary recommendations on pest management and further research needs.

Proposed Approach

Plantation lodgepole pine tends to be vulnerable to damage caused by pests, including rodents, insects, and disease. Success in the intensive management of lodgepole pine is largely dependent on the effective management of these pest problems.

A network of 17-year-old pine provenance tests exists at 70 locations throughout interior B.C. With 140 seed sources represented, this network offers a perfect opportunity to assess pest problems in plantation lodgepole pine, with the objective of developing measures to alleviate their impact.
A preliminary survey of some of the provenance tests suggests that pest damage is related to both site environment and seed sources.

In this project we will conduct systematic, quantitative assessments of pest impacts and use high quality data to evaluate the effects of site environments, seed sources, and their interactions on the level of pest damage. Models will be developed to predict pest hazards related to particular environments or seed sources, and a report will be produced to summarize findings, identify major potential pest problems, and define further research needs.

Products

This research will help us produce preliminary guidelines to direct the selection of seed sources and planting sites that will best reduce the impacts of major pests on lodgepole pine plantations.

Project FC-FP23 Development of short- and long-term use of genetic resistance to the white pine weevil in Sitka spruce

Project Leader: Cheng Ying, Ministry of Forests

Objectives:

1. To assess an existing test comparing Sitka spruce rooted cuttings and seedlings;
2. To establish a rooted cutting vs. seedling test and to establish a demonstration plantation, using weevil-resistant clones;
3. To gather information on the relationship between the traits of weevil resistance, growth, and wood quality (density) to establish between-trait correlation; and
4. To publish a brochure illustrating weevil resistance.

Proposed Approach

The long-term success of plantation Sitka spruce depends on three traits: weevil resistance, volume production, and wood quality (density). Information on the relationship among these traits is lacking and a study is needed to identify any phenotypic or genotypic correlation that may exist. Several Sitka spruce provenances have shown high resistance to the weevil in existing provenance plantations. This resistance has been reproduced in a clonal trial, suggesting that provenance resistance to weevil attack is genetic.

An effective way to capitalize on genetic resistance in the short term is to vegetatively propagate the resistant trees. In Sitka spruce, techniques exist for rooting cuttings on a large scale, and propagation of resistant trees is in progress. However, information on field performance of rooted cuttings vs. seedlings is still lacking.

This project will focus on establishing a field trial to compare rooted cuttings of resistant clones vs. seedlings. In addition, data on weevil resistance, growth, and wood density will be collected and analyzed so that between-trait correlations can be identified.

Products

The information generated in this study will allow managers to make better decisions on how to manage Sitka spruce plantations most effectively and productively. A better understanding of the genetic resistance of some spruce provenances to weevils will help in the development of management strategies to minimize damage from this pest.
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