



Province of
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Ministry of Forests

FOREST HEALTH PROGRESS

A summary of forest health activities in the British
Columbia Ministry of Forests.

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THE NEW FOREST PRACTICES CODE ACT

With the advent of the new Forest Practices Code Act, explicit measures for forest health will be instituted in forest management legislation and regulations: a first for British Columbia, if not for all of North America.

Forest practices or treatments will be prescribed, planned, and implemented to ensure the health of trees and forests. Surveys of occurrence and incidence of damaging agents, including insects, diseases, animals and abiotic factors will be required. The risk of future damage by these agents must be assessed in forest development planning, and in the preparation of silvicultural and stand management prescriptions.

All of us in forest health can be very proud of our contribution to the code, a major accomplishment, resulting from many hours of hard work by branch, regional and district staff, and enthusiastic support of forest health by our co-workers and colleagues.

As we implement the new code requirements to ensure the health of British Columbia forest resources, we will encounter several current or new challenges, such as: to more clearly define standards and measurable thresholds for treatments; to recognize new investment opportunities; and to make recommendations for improved forest practices. A major challenge will be to determine amounts or extent of damage to forest resources that we will either tolerate or decide to prevent.

With the numerous recent initiatives and issues in forest management, meeting these challenges will not be easy or comfortable. We must pursue new directions, and undertake new duties or tasks. Judging from our past successes, and the new affirmation of forest health as a major resource management issue, we can be confident that our efforts will help to sustain and enhance forest health.

- J. Muir, Silviculture Branch, Victoria.

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FOREST HEALTH PROGRESS

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EDITOR'S NOTE

Forest Health Progress is a report to the Forest Health Committee of British Columbia on issues, projects and proposals by Ministry staff. Brief, informal and informative articles are welcome from all staff.

Contributions labeled with an appropriate subject heading should be submitted to the regional forest health forester, or advisor, who will edit and forward them to Silviculture Branch. Forest Health Progress is submitted to the spring (May) and winter (December) meetings of the Forest Health Committee.

Authors should be contacted for any clarification, as the contents of this report do not necessarily constitute official statements of the Ministry of Forests.

EXECUTIVE SUMMARY

Items of general interest include: changes in forest health personnel and activities due to re-organization of the Forest Service (p. 4); an outline of why determining damage for current and future activities is important (p. 4); definition of forest health (p. 5-6); using global positioning to produce maps for reconnaissance and aerial surveys (p. 6); using compact aerial spectrographic imagery (CASI) to detect Douglas-fir beetle-attacked trees (p. 7); assessing lodgepole pine provenance trials for pest damage (p. 7); seed orchard and natural stand cone and seed pest monitoring activities (p. 8-9); forest health impacts in timber supply analyses (p. 10-12); forest health field guides for the Forest Practices Code Act of British Columbia (p. 12); including forest health surveys (p. 12-14); modelling the effects of insects and diseases (p. 14-16); and assessing spacing trials in young, lodgepole pine stands (p. 16).

For insects, a survey of spruce aphid (p. 17); 1994 aerial surveys in the Cariboo Forest Region (p. 17-18); a bark beetle probe course for first nations workers (p. 18); balsam woolly adelgid (p. 19); a risk rating system for Douglas-fir beetle (p. 20); spruce beetle current (1994) attack (p. 20); monosodium methanearsonate (MSMA) used for western balsam bark beetle (p. 21); a risk rating system for white pine weevil (*Pissodes strobi*) in the Nelson Forest Region (p. 21); collapse of an eight-year outbreak of western spruce budworm at Pemberton (p. 22); bucking windthrown Douglas-fir to control bark beetles (p. 23); a study of mountain pine beetle displacement by pine engraver beetle (*Ips pini*) (p. 23); insect displays (p. 23); Lindgren funnel traps and Theyson intercept traps to monitor mountain pine beetle (p. 24); weevil (*Pissodes spp.*) pheromones (p. 24-26); prescribed fire to manage western spruce budworm (p. 26-27); aerial spray program results and other activities for the Kamloops Forest Region (p. 27); sampling techniques to predict western spruce budworm defoliation (p. 28); mountain pine beetle populations (p. 28); and Douglas-fir tussock moth populations in the Kamloops Forest Region (p. 29); a plan to evaluate the effects of mountain pine beetle in south Okanagan (p. 29); and a decision-support system for managing spruce beetle in the Prince George Forest Region (p. 30).

For diseases, a new root disease survey method (p. 32-33) is being tested for use in Vancouver Forest Region (p. 31); a stump-top survey for tomentosus root rot is being assessed (p. 31); and long-term sample plots were established to determine effects in young spruce stands (p. 32).

For animal damage, use of lodgepole pine to reduce elk damage (p. 34); girdling by grizzly bear (p. 34); vole monitoring (p. 35); and a trial of plastic collars to protect young seedlings from damage by voles (p. 35) were reported.

For pesticides, *Bacillus thuringiensis* var. *kurstaki* had no effects on stream invertebrates and insects (p. 36); an extract from neem seed had promising results for control of mountain pine beetle (p. 36) but not for Douglas-fir beetle (p. 38) nor white pine weevil on spruce (p. 39-40); and a trial of three systemic insecticides to control Douglas-fir beetle was established (p. 37-38).

FOREST HEALTH - GENERAL

Reorganization Issues and Forest Health. Recent changes in organization structure and functions throughout the Forest Service will dramatically affect how we do business at branches, regions and districts.

Silviculture Branch will become Silviculture Practices Branch, and the forest health section will be incorporated into the expanded forest renewal section managed by Robin Brown. The noxious weed biological control group under Allan Sturko will also be incorporated into the forest renewal section, but continue to be situated at the Agriculture Canada station at Kamloops.

In the forest renewal section, Patricia Humphreys will become a forest surveys technician reporting to Michael Pedersen, but will continue to provide some coordination for forest health training. Kathy Hopkins, who devoted considerable time to developing forest health training modules, has accepted a training position with Resources Planning Branch (incorporated into the new Range, Recreation and Forest Practices Branch).

Development of business information systems has been transferred to the new Business Design Branch. This branch will undertake projects identified as high priorities by districts and regions. Val Fletcher will assume new duties in designing sampling methods for forest health surveys.

Regions have identified positions for a forest entomologist and forest pathologist. Prince George Forest Region has established a forest health operations forester position. Incumbents of the previous forest health forester positions at Kamloops, Nelson and Cariboo Forest Regions are expected to be re-assigned to new duties within the Forest Service.

Organizations at districts are expected to follow either a zone management model or an organizational structure based on functions before or after a cutting permit is awarded. At the time of writing, details for all districts are not known, and the functional or designated responsibilities for forest health issues have not been established.

- J. Muir, Silviculture Branch, Victoria.

Forest Damage: A Crucial Issue. As we plan forest development or design prescriptions for silviculture renewal or stand management under the new Forest Practices Code, a recurrent, crucial question is how much damage is present or will result from an insect or disease?

Monitoring forest health or condition requires methods and measurements to determine damage. We currently spend almost 60 per cent of our provincial forest health operations budget of \$11 million on surveys. Most of the ten forest health field guides being developed include a large section on surveys, and a forest health surveys field guide is also being prepared.

Implementing the new code will necessitate development of more effective management plans and better forest practices to prevent or reduce harmful effects of insects and diseases. These requirements, and particularly the application of specific treatment strategies or control methods, will require measures of damage—both current condition and future status—especially for young stands.

A critical step is to determine how much damage can be tolerated, and where and when certain actions will be required to prevent or control damage. We will have to discuss and debate the amount of disturbance or damage that will be required to maintain certain ecosystems, or that can be accepted under various resource management objectives. In instances where "treatable" or preventable levels of damage are accepted, for example to maintain visual quality objectives, we will have to measure and account for the damage in analyzing the overall productivity or sustainability of the forest resource.

These examples illustrate the need for on-going work to determine forest damage, and indicate that determining damage will remain a primary issue for forest health.

- J. Muir, Silviculture Branch, Victoria.

What Is Forest Health? A recent article in the July issue of the Journal of Forestry contains the best discussion on the concepts of forest health that I have come across (*Concepts of Forest Health* by Kolb, Wagner and Covington, 1994). I recommend that everyone interested in forest health read this paper. In lieu of that, a brief summary may be worthwhile.

The authors start by reviewing some of the current definitions of 'forest health'. They do this by distinguishing between the "utilitarian perspective" and the "ecosystem perspective." The utilitarian perspective defines forest health in terms of human use and relates it to management objectives, e.g. "a condition where biotic and abiotic influences on forests do not threaten management objectives now or in the future," and, "a condition of forest ecosystems that sustains their complexity while providing for human needs." This perspective suggests that forests are healthy if management objectives are achieved and unhealthy if not. According to the authors it suffers from circular logic, i.e. a desired state of forest health depends on the occurrence of a healthy forest; or, forest health is a management objective, yet the management objective is a healthy forest.

The ecological perspective emphasizes the basic ecological processes that create and maintain forest conditions that potentially satisfy a range of diverse objectives, e.g. "A forest in good health is a fully functioning community of plants and animals and their physical environment"; "A healthy forest is one that is resilient to change"; "The term forest health denotes the productivity of forest ecosystems and their ability to recover from stress"; and, "Forest health can be defined as the ability of a forest to recover from natural and human-caused stressors". The criticism of this perspective is that it is difficult to quantify or even know if you have a healthy forest.

The authors then suggest that a more useful definition of forest health "must at least contain a qualitative statement of the types of processes, structures and resources to support forests in the sense of satisfying at least some of society's objectives." The definition envisioned also implies that a useful ecosystem concept of forest health must consider patterns and rates of change in forest composition and structure, or successional processes. The concept then starts getting rather complex. They go on to list characteristics of a healthy forest ecosystem, as follows:

- a physical environment, biotic resources and trophic networks to support productive forests during at least some seral stages;
- resistance to catastrophic change and/or the ability to recover from catastrophic change at the landscape level;
- a functional equilibrium between supply and demand of essential resources (e.g. water, nutrients, light, growing space) for major portions of the vegetation;
- a diversity of seral stages and stand structures that provide habitat for many native species and all essential ecosystem processes.

Given this, the authors recognize that attempts to define forest health in rigorous scientific terms will likely diminish its present value as an intuitive, general concept. Regardless of improved precision, incorporating all the above elements into one definition would make it long and much too complex. Another point is that the concept of health was developed for individual organisms. Applying it to a landscape is difficult and is probably not a valid ecological concept.

I would be happy with something more simple such as the Society of American Foresters' definition, "the ability to maintain forest ecosystems functioning well over long periods of time in order to provide resilience to short-term stress and adaptation to long-term change", and leave it as a general, intuitive concept without all the rigorous scientific jargon. However, I believe the pursuit of a scientific understanding of forest health is still required.

One final point from the paper, with which I agree, is the authors' criticism of pest management specialists who think of themselves as forest health specialists. True forest health specialists would require broad training in plant physiology, ecology, and ecosystem science. Pest management is "a subdiscipline emphasizing the role of biotic and abiotic agents in the production of commodity outputs."

- D. Heppner, Vancouver Forest Region, Vancouver.

Global Positioning System (GPS)/MicroStation® Sketch Mapping System. A sketch-mapping system using digital map files presented on a colour laptop computer, linked with a GPS receiver, is being developed. The application would be appropriate for aerial overview surveys and for low-level reconnaissance surveys and mapping. The products of the software will include a digital map, a summary report of pest damage, and a project-tracking spreadsheet. Cariboo Forest Region has contracted Global Mapping Services of Williams Lake to produce this by March 31, 1995.

- M. Hamm, Cariboo Forest Region, Williams Lake.

Testing Compact Aerial Spectrographic Imagery (CASI) to Detect Douglas-fir Beetle. Current methods for bark beetle detection rely on the human eye during aerial sketch mapping in fixed-wing aircraft. Remote sensing techniques have previously been examined for bark beetle detection, with mixed results. However, advanced remote sensing technology that is accurate and precise may provide a more effective method for bark beetle detection. Compact Aerial Spectrographic Imagery (CASI) is a remote sensing device which has high resolution and records imagery at low altitude, thus, decreasing the distortion from the earth's atmosphere. The CASI imager is mounted on a fixed-wing aircraft, and records pixel elements down to 3m² which is roughly equivalent to the area of a tree crown. The CASI provides visual and non-visual spectral bands which cover the spectral range from 428 to 946 nanometres. The imager has the ability to differentiate between 256 colours and can distinguish differences in foliage colour which the human eye cannot detect. The CASI imager may be able to identify red tree crowns with greater accuracy than human vision. It may also be able to locate previously undetectable, green infested trees.

A CASI study site is located at Upper Loon Lake in 100 Mile Forest District. Both CASI and ground survey data for Douglas-fir beetle activity were collected during August and September, 1993. The next step is to enhance the CASI imagery using two remote sensing packages, Photostyler and PCI. The objective is to compare the computer enhanced images to ground survey data and check for accuracy. The analysis is being completed by Integrated Wood Services Ltd. of Kamloops. If successful, this method of detection could locate all trees attacked by bark beetles with an accuracy similar to a ground survey. Results should be available early in 1995.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Pest Assessment of Lodgepole Pine Provenance Trials (EP657). We have completed the assessment of 56 test plantations in the central and southern interior of British Columbia. Data are being analyzed. A summary report will be available next spring.

Provenances from the jack-lodgepole pine hybridization zone showed a high level of pest tolerance, in particular to western gall rust. Jack pine introgression may have played a significant evolutionary role in the pest-host relationship in lodgepole pine.

We will continue the assessment of the test plantations in northern British Columbia and the Yukon, and complete the field assessments in 1995.

- C. Ying and H. Wu, Research Branch, Victoria.

Seed Pest Management Report, Fall 1994. For information on seed orchard and natural stand cone and seed pest monitoring services, 1994 results, or detailed information on any of the projects briefly summarized below, please telephone the Seed Pest Management Group at (604) 652-5600.

Summary of current research:

Spruce cone rust, *Chrysomyxa pirolata*. Spruce cones were scarce at our cone rust trial site this year and this project was put on hold. We expect to continue testing metiram as an alternative to ferbam for control of spruce cone rust in 1995.

Fir coneworm, *Dioryctria abietivorella*. Pheromone traps at a coastal seed orchard and an interior Douglas-fir site successfully attracted male moths and indicated that *D. abietivorella* has an extended flight period occurring from May to October. This may explain why larvae at all stages of development can be found in Douglas-fir cones at any time. Larvae and pupae from orchard and natural stand cones are currently being held in diapause for rearing to adults in the late winter of 1995. These moths will be used for further pheromone analysis at Simon Fraser University to refine the pheromone blends tested this year. Green Plan funds continue to support this project.

Hemlock woolly aphid, *Adelges tsugae*. Three compounds were tested for control of the hemlock woolly aphid at a heavily infested, unmanaged seed orchard. Diazinon, Safer's® Insecticidal Soap and Enstar® (kinoprene, an insect growth regulator) all provided effective control. Both Safer's® and diazinon rapidly eliminated woolly aphid populations. Enstar® was equally effective, but, due to its mode of action, was slow to take effect. We continue to recommend Safer's® for control of this insect. We also advocate avoidance of nitrogen fertilizers on infested hemlock as this increases the fecundity of this woolly aphid and neutralizes control measures taken against it. Drought stress and other factors are contributing to the death of large numbers of the hemlock trees at this site. This trial may be discontinued in 1995.

Larch cone woolly aphid, *Adelges lariciatus*. Diazinon and Safer's® Insecticidal Soap were successful in knocking down populations of overwintering adult woolly aphids in a larch seed orchard. Populations rebounded quickly though, and there was no difference in cone infestation levels early in the summer. Seeds from trial cones will be tested this winter for effects on filled seed counts and germination. This trial will be modified and continued through 1995.

Redcedar cone midge, *Mayetiola thujae*. Metasystox-R® applied at one half the label recommended rate was as effective as the label rate in controlling populations of the redcedar cone midge. A poor pollen crop caused very poor seed set in the trial orchard. We were not able to obtain good data on effects of the trial control measures on filled seed counts or germination.

Yellow-cedar eriophyid mite, *Trisetacus chamaecyparis*. Sevin XLR+® produced excellent control of this mite following a late summer trial application in a yellow-cedar seed orchard. We have monitored yellow-cedar eriophyid mite on a regular basis for several years and now have a reasonable understanding of its life history.

Neem trials against spruce and larch insects. In conjunction with Phero Tech, a series of trials were conducted to test the effects of neem (azadirachtin) on green spruce aphid (*Elatobium abietinum*) in Engelmann spruce, larch cone woolly aphid (*Adelges lariciatus*) in western larch, and woolly aphids and spiral spruce cone borer (*Strobilomyia neanthracina*) in interior spruce. Data are currently being analyzed. Based on the results of this year's work, these trials will be modified and continued in 1995.

Vegetation management. Due to problems with obtaining trial samples from the manufacturer, our tests of Spectrum®, a new Dow-Elanco soap based herbicide have been shelved for the time being.

Cone and seed entomofauna inventory. With the help of the Tree Seed Centre and forest district staff and in spite of a low cone crop year, we were able to supply the Canadian Forest Service with cones of *Abies lasiocarpa*, *A. amabilis*, and western hemlock from a number of sites in Vancouver, Prince Rupert, Prince George, and Kamloops Forest Regions. Cones are currently being treated in Sault Ste. Marie to extract and record insects associated with them.

New Projects:

Sequoia pitch moth, *Synanthedon sequoiae*. Damage to stems of lodgepole pine caused by the feeding activity of sequoia pitch moth caterpillars has become significant at one seed orchard site. In 1995, we will begin a cooperative moth monitoring and damage assessment project geared towards developing a management plan for this moth.

Spiral spruce cone borer, *Strobilomyia neanthracina*. A cooperative study involving researchers in eastern Canada is being planned to study various aspects of cone borer behaviour including the role of conelet volatiles in the attraction of adult flies, alternative monitoring schemes, and pheromones. The project is tentatively scheduled to start in the spring of 1995.

Douglas-fir cone gall midge, *Contarinia oregonensis*. Infested cones have been collected and are in storage for pheromone analysis in late winter. New technology developed at Simon Fraser University is expected to overcome problems encountered during earlier pheromone work with this tiny insect.

Western conifer seed bug, *Leptoglossus occidentalis*. Destruction of lodgepole pine, western white pine, and hemlock seed crops at three seed orchard sites in 1994 has been attributed to the feeding activity of relatively large numbers of seed bugs. After a couple of years of relative peace on this front, a renewed interest has developed in creating a workable management plan for this insect.

Forest Health Impacts in Timber Supply Analysis. As some of you may be aware, I have just returned from a one year secondment with the Timber Supply Section, Resource Planning Branch, where I completed a timber supply analysis for the Queen Charlotte Timber Supply Area. The report was released in August, 1994. In March, 1994, I presented a talk to the Southern Interior Silviculture Committee (SISCO) winter meeting on the incorporation of forest health impacts in timber supply analysis. An overview of my talk follows.

Timber Supply Modelling Process. The Timber Supply Area (TSA) land base is divided into *Zones* based on current management practices such as wildlife, visual quality, and integrated resource management. Each *Zone* is then further divided into *Analysis Units* (*AU's*) of similar forest cover and site quality attributes (e.g. Douglas-fir, good/medium sites, Hemlock, poor sites). Aggregate yield curves are then developed for each *Zone/AU* combination using the forest inventory information.

A 'Forest Estate' timber supply model (FSSIM) is used to model timber supply flow from the present to 400 years into the future. The model 'grows' and 'harvests' timber, subject to constraints determined by management practices. For example, biodiversity constraints may require a minimum of 6% of a zone at any one time be maintained in old growth timber. A wildlife zone could have special forest cover constraints to provide thermal cover for wildlife. Likewise, a visual quality zone might have special requirements for a maximum area that may be below green-up age.

Forest Health Impacts on the Timber Supply Impacts may take the following forms (MacLean, D., 1990):

- non-lethal growth losses, such as those caused by western spruce budworm, white pine (spruce) weevils and root rots,
- top kill and stem defects (forks and crooks), caused by spruce weevil, as well as defoliating insects,
- mortality of individual trees and stands caused by such damage agents as the Douglas-fir tussock moth, western hemlock looper, mountain pine beetle, and root rots.

Forest health damage agents can affect the timber supply in several ways. They can reduce yields at harvest, lengthen rotation ages, or change harvest schedules for salvaging damaged timber (Alfaro, R.I. 1988).

Current Methodology. For epidemic or catastrophic damage agents such as bark beetles, defoliators and windfall, unsalvaged losses are deducted from the harvest forecast. Note, in some areas (e.g. Okanagan and Williams Lake TSAs) an uplift in the allowable annual cut has occurred in order to salvage beetle killed timber. In cases where endemic damage agents, such as root rots, occur in natural stands, it is assumed that the Variable Density Yield Prediction (VDYP) tables incorporate such losses based on the fact that they are derived from empirical temporary sample plot (TSP) data without bias for forest health conditions. In managed stands, operational adjustment factors (OAFs) are applied to the 'potential' yields based on damage agent-free permanent sample plots (PSPs), spacing trials and thinning projects.

Managed Stand Yield Tables and Operational Adjustment Factors (OAFs) are volume reduction factors (percentages) that are applied to 'potential' managed stand yields to account for the following:

OAF 1

- a reduction on the productive land base due to 'holes' such as rock outcrops, swamps, etc. It reduces the magnitude of the yield curve by a specified constant percentage over time (shifts curve down);

OAF 2

- a reduction in the productivity of the land base due to the presence of damage agents;. The reduction increases with time, such that the indicated percentage is reached at reference age 100 and continues to increase indefinitely (e.g. a 10% OAF 2, increases $100\%/10 = 0.1\%$ per year until at 100 years it would be 10%, at 150 years 15%, etc.).

NOTE:

- 'standard' OAF's are: OAF 1 = 15% and OAF 2 = 5%
- 15% is recommended if no site specific information is available
- 5% recommendation is based on judgement and field experience

Improvements to the Current Methodology

The following are examples of the ways in which OAFs and yield impact estimates are being or may be improved:

- In the Okanagan TSA, the extent and severity of root rots were determined to develop a managed stand yield curve for ICHw Analysis Units. We began with a VDYP curve and modified OAF's for a managed stand yield curve so that yields were 10% higher at 100 years and 10% lower at 200 years.
- A Forest-Level Multipest Survey (FLMPS) pilot project was conducted in the Arrow TSA ICHdw during 1992/93. Sampling methodology consisted of fixed and variable radius 9-plot clusters. Both inventory and forest health information were recorded in order to estimate mortality and yield impacts (OAF adjustments).
- The following forest health impact 'modules' are being developed for Tree and Stand Simulator (TASS) to generate managed stand yield tables directly:
 - TASS-ROTSIM links two single tree distant dependent models, TASS and ROTSIM (a root rot spread/yield reduction and mortality model) and can simulate planting densities, spacing regimes, inoculum densities, disease resistance/tolerances, de-stumping treatments, etc. Phellinus affected yield curves will be developed in the near future.
 - TASS-SWAT is a Spruce Weevil Attack (SWAT) model incorporated in TASS, and is presently operational for Sitka Spruce.
- The inclusion of a sensitivity analysis (e.g., + 10%, 20%) in timber supply analyses on managed stand yields. While the long-term harvest level is usually affected, typically, there is no impact in the first five to six decades.

Long-Term Requirements:

Timber supply analysis process must reflect timely, geographically located knowledge of pest incidence and severity as part of the standard forest inventory, and damaged stand yield tables need to be developed based on damage agent affected PSP's.

We need to understand and be able to predict the long-term dynamics of damage agents, including the frequency, duration and severity of infestations, and associated impacts. As well, the effects of stand management on damage agent dynamics (silviculture) and other forestry activities, such as harvest scheduling, need to be understood (Reed, W.J. and Errico, D., 1987).

We also need to develop stand hazard and damage risk ratings for damage agent effects on forest productivity.

The concepts expressed were formulated as the result of discussions with the following colleagues to whom I wish to express my appreciation: Rene Alfaro, Canadian Forest Service, Jeff Beale, Silviculture Branch, Darrell Errico and Ian Cameron, Research Branch, Gerrard Olivotto, Chris Fletcher, Cassandra Mann, Doug Beckett, Timber Supply Section, B.C. Ministry of Forests.

- V. Fletcher, Silviculture Branch, Victoria.

Forest Practices Code: Forest Health Field Guides. Members of the forest health community have been diligently wearing down their pencils this summer and fall to meet our deadline for completion of the first rush of forest health field guides. The field guides that will be completed and sent out for review this winter are, *Management of Dwarf Mistletoe*; *Management of Root Diseases*; *Management of Bark Beetles*; *Management of Defoliators*; *Forest Health Surveys*; and an additional one, thanks to the hard work of Dave Calder, entitled, *Management of Foliar Diseases*.

The field guides that will be written and ready for review in the coming year will include the following topics: rusts, terminal weevils, tree wounding and decays, pests of young stands, and surveys, part II.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Forest Health Surveys Field Guide. It's difficult to compose an informative article on field guides. They have consumed almost every hour of work for staff in branch and regions for the last six months. I cannot tell you anything specific about the forest health surveys guide, because they are all still confidential. So my report, for those of you who have not already had enough of the subject, will be general.

As you are probably aware, under the Forest Practices Code, field guides are designed to assist field staff and licensees in carrying out legislated forest practices. They are intended to summarize all technical directions and recommendations in a comprehensive set of cross-referenced guides. I expect that within the next few months some of the guides will be completed and published for public review. Completion of all the guides is targeted for the end of 1995.

This undertaking, though causing chronic headaches for many forest service employees, is an extremely valuable one for forest health. As a result of these guides, forest health is now clearly a basic component of silviculture, and is intimately linked with all other facets of forest management in the province. In order to create the forest health field guides, staff, for the first time, had to agree on provincial standard damage thresholds, treatment methods, and consistent ways of working with the rest of the forest program.

Forest health surveys are a primary topic of the three field guides entitled, *Forest Health Surveys*, *Silviculture Surveys* and *Species Selection*, and *Stocking Standards*. Other field guides which also contain important forest health survey information include *Five-Year Silviculture Plans*, *Silvicultural Systems*, *Silviculture Prescriptions*, and *Stand Management Prescriptions*.

There are two types of forest health surveys. One is used to determine the extent of pest attack on the landscape employing either aerial or ground survey methods. The results of this type of survey will contribute to Forest Development Plans. The other involves assessment of forest sites or stands, and will contribute to the creation of silviculture prescriptions, silviculture survey treatment recommendations, and stand management prescriptions.

Landscape level surveys will, over a period of time, give us a much more detailed inventory of pest occurrences than we have at present. Our current knowledge about pest occurrence is being addressed in the Forest Health Charts. These revamped charts will be published in *Species Selection and Stocking Standards*. They summarize what is known of the occurrence of important pests in all biogeoclimatic subzones of the province. Forestry staff will be able to use the charts when they make silviculture prescriptions or other treatment recommendations to determine what pest damage to expect in particular biogeoclimatic zones and when they are most likely to be present in the rotation of a stand. Once the charts are published, field staff using the information will be able to offer recommendations for future improvements.

At the stand level, all forest health survey information will be collected in a quantitative manner during silviculture surveys. Thus, the information will be fully compatible with the rest of the forest information recorded, and will be stored in the Integrated Silviculture Information System (ISIS). Most forest health information will be gathered this way. However special, though compatible surveys, may be used to collect more detailed information, for example on root diseases.

We anticipate that the post free-growing (usually called pre-stand tending) silviculture surveys procedures will be adapted in a similar fashion to collect forest health information. This will bring greater continuity to the silviculture program, and will have tremendous benefit to forest health. For example, root disease infections, originally mapped in the silviculture prescription surveys, may be periodically re-surveyed, using the same methods throughout the rotation period of the next crop of trees.

As the field guides make their way into the hands of forestry staff, and the dust settles, the result should be healthier forests in British Columbia.

- J. Henigman, Silviculture Branch, Victoria.

Approaches to Modelling the Effects of Insects and Diseases. In March, 1994, I attended the Western International Forest Insect and Disease Work Conference, in Albuquerque, New Mexico. The following is the paper I presented on *Modelling the Effects of Insects and Diseases*.

Setting the Modelling Objectives: Modelling the effects of forest insects and diseases can be done for many different objectives, ranging from estimating the impact on site and stand productivity, timber quality and yield, tree species successional shifts, insect and disease population behaviour, visual quality and risks to management. These objectives must then be filtered by evaluating:

- the *resolution required*, e.g., forest-level versus stand-level;
- the *management questions* (e.g., damage impacts, or opportunities for treatment response); and,
- the *accuracy required*.

In order to evaluate the wide variety of modelling approaches, I've narrowed the scope of the information required from them to the estimation of timber quality and yield, and the assessment of risks to management at the stand-level. I've taken this approach, since these objectives are generally the reason forest managers attempt to manage insects and diseases. This is not to say that forest managers don't desire to manage for other objectives, we do! But, this approach helps us to focus, and narrows the range of modelling-approaches into something more manageable.

Evaluating the Approaches. Over the years, four major approaches to modelling forest growth and yield have emerged:

- mechanistic;
- ecosystem;
- succession;
- mensurational (whole stand and individual tree).

Very little modelling of insect and disease effects has been done using the first three approaches, although there are many useful factors in them that can aid modelling. Most insect and disease modelling efforts to date have been mensurational. Apart from the legacy of growth-and-yield models, the mensurational approach has the advantage of being able to incorporate some form of stochastic growth and mortality functions (e.g., SPS-Stand Projection System), or after-prediction operational yield adjustments (e.g., in TASS-TIPSY-Tree and Stand Simulator-a Table Interpolation Program for Stand Yields). Other models estimate insect and disease effects "interactively", for example, PROGNOSIS plus Western Root Disease model, or TASS-ROTSIM (laminated root rot simulator). Mensurational models also have an advantage over other approaches, because many of them are widely used and the users can interpret the output reasonably well.

However, the mensurational modelling approach is not without flaw. For example, mensurational models depend on being able to predict the future based on availability of historical data (permanent sample plots, etc.), which is very expensive to capture. And, historical data, by its nature, means we will not necessarily be able to change prediction responses quickly enough to adequately represent new sets of insect/disease-stand-treatment conditions because mensurational modelling approaches tend to focus on stochastic functions compared to biological process functions. Models based on biological process functions may be more adaptable to the changing sets of insect/disease-stand and management conditions.

Also, most mensurational models are not very accurate in portraying insect and disease conditions spatially, although this would not always be a concern for stand-level modelling. Distance-dependent host-pathogen relationships (e.g., dwarf mistletoes and root diseases) might be better addressed through single-tree distance dependent modelling.

A notable quote on mensurational modelling fits well at this point, "...growth and yield models comfort is justifiably low regarding predictive accuracy, but, comfort levels will never again be as high, given the rates of change in forest practices" (Ian Cameron British Columbia Forest Service, Research Branch, 1994).

Where to go next? Given that modelling objectives are complex, and getting more so, and that modelling approaches are already complex *but*, are beginning to converge, I propose that modelling the effects of insects and diseases include more biological-ecological-successional processes through the merging of mechanistic, ecosystem, successional and mensurational modelling approaches. Although this proposal may be sound in itself, there are outstanding issues that hinder it. The issues are as follows: (i) forest practices are changing rapidly, (ii) historical data for model prediction purposes likely cannot be obtained fast enough, and, (iii) forest managers urgently need answers for tomorrow's management, not for the year 2005! The complexity and urgency of needed forest management decisions, necessitates flexible support systems that integrate with our existing modelling tools.

In conclusion, the most fruitful approach to modelling the effects of forest insects and diseases, lie in strengthening the biological reality of our models through a convergence of mechanistic, ecosystem, successional and mensurational modelling approaches. Linkages to Decision Support Systems that diagnose problems and select best management options, given other resource management factors, are also needed. Graphical displays, and confidence and risk values for management options should also be available.

- J. Beale, Silviculture Branch, Victoria.

Assessment of Spacing Trials in Lodgepole Pine. Five spacing trials, funded by FRDA I, were established in 1987-88 to evaluate the effect of stand density on attack dynamics of *Pissodes terminalis* (and other pests) and subsequent tree defect severity. Four trials were located in the Kamloops Forest Region and one in the Cariboo Forest Region. The density of natural stands of lodgepole pine was brought down to near and below the operationally targeted goal of 1,600 stems per ha which is equivalent to 2.7 m target spacing. In each trial, areas were left at the natural stem density to compare the activity of forest health factors (insects, diseases, mammals and others) in the natural density to that in the artificially manipulated densities. All the spacing trials are presently being reassessed. I hope that results of these spacing trials will clear up many questions regarding pest levels and their bearing on the optimal spacing and density of young lodgepole pine.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

FOREST INSECTS

***Pineus spp* in Planted Englemann Spruce in Cahility Creek.** A reconnaissance and damage appraisal survey was conducted on a number of spruce plantations in the Cahility Creek drainage northeast of Kamloops. The plantations were being attacked by an unknown aphid later identified by Dr. Lee Humble as a member of the genus *Pineus* of the family Adelgidae.

Twenty-three 0.05 ha plots were established to determine the frequency of occurrence of the adelgid. On average, 10.9% of the sampled trees were under various levels of attack. On one of the plantations, over 30% of the sampled trees were infested.

An additive stress index to predict the relative frequency of occurrence of the adelgid was developed. The index relates the level of infestation to a combination of variables including topography, aspect, planting micro site selection and planting quality ($r^2 = 0.875$). There appears to be a strong relationship between the incidence of *Pineus spp* and the stress index. However the index needs to be tested further before its merits can be fully determined.

A more detailed survey involving 0.25 ha permanent sample plots will be conducted in the spring of 1995. This survey will track the ongoing evolution of the adelgid infestation, and further test the merits of the additive stress index.

- D. Piggin, Kamloops Forest District, Kamloops.

Cariboo Aerial Survey. The annual aerial pest survey in the Cariboo Forest Region was completed on September 30, 1994. Heath Krevesky, University of Victoria Geography Cooperative Education student, coordinated the survey, which was carried out by regional and district Forest Service staff with help from contractors in areas of anticipated low damage (low-priority areas).

A 1:40 000 forest cover base map was used. Fixed-wing aircraft flew on a north-south grid at two-kilometre (high-priority areas) and four-kilometre (low-priority areas) spacing.

Mountain pine beetle populations inside Ts'yl-os Park have collapsed after six years of direct control work to keep them inside this area. In other areas around Ts'yl-os Park and the Taseko special management zone, populations remain at a manageable level.

Other infestations in Cariboo are estimated to have once again doubled in number. Most of the increase occurred in Quesnel and Williams Lake Forest Districts.

No action (beyond pheromone baiting in the spring of 1993 and 1994) has been taken to control mountain pine beetle on the military training area west of Williams Lake. Administrative responsibility for the area remains under discussion by federal and provincial governments and the Toosey Indian band.

Douglas-fir beetle damage is declining over the region, except in the military training area, where damage is estimated to be similar to that reported in 1993. No action has been taken in this area since the outbreak began in 1988.

No significant spruce beetle damage was found.

Western balsam bark beetle damage remained significant over the region this year, including previous severe outbreaks in Franklyn Arm and Edmonds Creek in the Chilcotin Forest District.

Populations of western hemlock looper in the Quesnel Lake area of the Horsefly Forest District have collapsed. Mortality of hemlock and western redcedar is expected to be as high as 40 per cent in stands which were defoliated three years in succession.

Defoliation by two-year cycle spruce budworm occurred over 110 000 hectares of spruce and subalpine fir.

Forest tent caterpillar defoliation in the eastern part of the region increased slightly to 52 000 hectares in 1994 from 47 000 hectares in 1993.

No significant defoliation by Douglas-fir tussock moth was detected from the air.

Defoliation by western spruce budworm was observed in the area around Clinton. Egg mass surveys indicate that moderate to heavy defoliation can be expected in several sites next year.

A pine needle cast, *Lophodermella concolor*, infected lodgepole pine foliage over 500 000 hectares of Williams Lake, Horsefly, 100 Mile House and Chilcotin Forest Districts.

Survey results (area and volume damage figures) are not yet compiled. A report will be available in December, 1994.

- M. Hamm, Cariboo Forest Region, Williams Lake.

Bark Beetle Surveys for First Nations People and Forest Workers. A bark beetle probe course for workers is under development by The Alexandra Projects of Vancouver, and Phero Tech of Langley. The five-day course is to be held mostly in the field, and will include such topics as compass use, forest measurements, survey tools and techniques, bark beetle biology and probe methodology. A pilot is scheduled for November, 1994 at Dog Creek.

- M. Hamm, Cariboo Forest Region, Williams Lake.

Balsam Woolly Adelgid in the Kamloops Forest Region? Well-established populations of balsam woolly adelgid have recently been discovered close to the boundary of the Kamloops Forest Region, in the Birkenhead Lake area. This suggests that this introduced insect pest may already be established within the Cadwallader Creek/Anderson Lake area of the Lillooet Forest District. It has also been found at Lizzie Creek east of Lillooet Lake and just west of Spuzzum in the Fraser Canyon. In addition, the adelgid has been on the east side of the Cascade Mountains in Washington since 1961 and is now well established in northern Idaho.

Since its initial detection in British Columbia in 1958, the balsam woolly adelgid has been slowly spreading northward up the coast and westward toward the interior. When first detected, there was great concern that this pest was going to severely impact all *Abies spp.* on the coast and eventually in the interior as well. Large survey and research programs were initiated. The initial spread of the insect caused widespread mortality in what were probably the most susceptible trees within the *Abies* population. After the death of the most susceptible individuals, it seems that the rate of adelgid-caused mortality declined. With this reduction in tree death, the concern about the insect also declined. Survey efforts were reduced and research on this insect all but disappeared after the early 1970s.

Recent finds of balsam woolly adelgid well outside the bounds of the previously known zone of infestation, and the recent detection of this insect in young stands, has led to the perception that the distribution of this insect has dramatically expanded and that it has suddenly adapted to young stands. This impression is more likely the result of our limited survey efforts than any sudden change in adelgid behaviour. Surveys for balsam woolly adelgid are not straightforward. Severely infested stands are relatively easy to find, but, detection on the edge of the adelgid's distribution is akin to searching for a "needle in a haystack". A major survey effort is expensive and time consuming.

Although more surveys are needed, it now appears that balsam woolly adelgid is well established throughout the Squamish Forest District, a district that relies heavily on the natural regeneration of *Abies amabilis* for reforestation. A number of young stands (there may be many) are now heavily infested — a significant portion of which will probably not reach maturity. The use of *Abies spp.* here is now in question.

There is some good news. Even within heavily infested stands, there appears to be individuals that either are not fed upon or are not affected by the adelgid - that is, there appears to be natural resistance. Although the use of resistant trees would require planting instead of relying on natural regeneration, I think it is an area of research worth pursuing.

- D. Heppner, Vancouver Forest Region, Vancouver.

Susceptibility Rating for Douglas-fir Beetle in the Cariboo Forest Region. Douglas-fir beetle, a major damaging agent of interior Douglas-fir forests, may be treated more effectively if it can be determined which stands are most susceptible to the bark beetle. Terry Shore and Les Safranyik, Forestry Canada, have developed a draft susceptibility and risk rating system for Douglas-fir beetle. Their system uses forest cover attributes to determine the relative susceptibility of any stand. Although their rating system is based on criteria gathered from ground surveys, an adapted version of this system, using inventory data base information, provides a general estimation of the susceptibility of each stand to bark beetle. A computerized susceptibility index based on Shore and Safranyik's proposed index is being developed in the Cariboo Forest Region, primarily to evaluate the susceptibility of Douglas-fir in mule deer winter ranges. Inventory data base files are used to generate susceptibility ratings based on an adapted version of Shore and Safranyik's model in SAS®. Once the data is manipulated to provide a ranking system, a computer mapping system will produce detailed colour maps which display five categories of susceptibility ratings, as follows:

0 (no risk)	no Douglas-fir is present in the stand;
LOW	Douglas-fir is present in the stand, but there is very little likelihood of bark beetle attack;
MODERATE	Douglas-fir is present in the stand, with a moderate risk of bark beetle attack;
HIGH	several characteristics of the stand make it a likely target for bark beetle attack;
VERY HIGH	stand is most likely to become heavily infested with Douglas-fir beetle.

After testing and refinement, we believe it will be practical to create susceptibility rankings and colour-thematic maps for Douglas-fir beetle using this susceptibility rating system.

- K. Howse; Cariboo Forest Region, Williams Lake.

Weak 1994 Spruce Beetle Flight in the Northern Prince George Forest District. The spruce beetle flight in several locations of the northern Prince George Forest District was weak in 1994. Stands assessed near Summit Lake and Kerry Lake revealed low level attacks on otherwise healthy spruce resulting in many "pitchouts" (or repelled attacks); or light, largely unsuccessful attacks on spruce that had already been attacked in 1993.

However, the fairly successful 1993 attack, the brood of which is now mainly on a 2-year life cycle, is expected to yield mature flying adults in May and June of 1995. Further assessments of the various *Dendroctonus* beetle populations will continue in other locations and forest districts.

- R. Hodgkinson, Prince George Forest Region, Prince George.

Western Balsam Bark Beetle and MSMA. An experimental post-attack application of monosodium methanearsonate (MSMA) against western balsam bark beetle, *Dryocoetes confusus* Sw., was carried out in cooperation with Riverside Forest Products in the Vernon area. Trees were baited in the spring of 1993, and monitored for beetle attack. Full strength MSMA was applied to selected trees approximately one week after attack. Initial assessment took place in September, 1993, but the unusually cold, wet summer delayed bark beetle development by at least six weeks, so data collection was deferred until September, 1994. Results of the study are still being analyzed, but it appears that post-attack MSMA treatment resulted in virtually complete control of attacking western balsam bark beetles. It was not possible to directly assess any potential repellent effect of MSMA, since trees treated with MSMA were apparently dead, with red foliage, by the fall of 1993, whereas, baited, untreated trees were available for beetle attack for two flight periods (1993 and 1994). However, there does not appear to be a significant difference between attack densities on MSMA treated trees and untreated trees.

Interestingly, live and apparently healthy populations of other secondary bark beetles, notably a small scolytid, possibly *Pityokteines* spp., which is a common associate of the western balsam bark beetle, were found in the inner bark of MSMA-treated trees.

Further work is required to assess the possibility of using diluted strengths of MSMA, any possible repellent effect of MSMA, and the potential for MSMA use in felled "lethal" trap trees.

- A. Stock, Nelson Forest District, Nelson.

Hazard Rating for White Pine (Spruce) Weevil, *Pissodes strobi*, in the Nelson Forest Region. Spruce accounts for approximately 50% of planting effort in the Nelson Forest Region, but there has been little systematic assessment of current or potential problems with white pine (spruce) weevil. Such an assessment is now considered to be a priority in the Nelson Forest Region, in view of the problems encountered in other forest regions of the province. Also, the Canadian Forest Service, Forest Insect and Disease Survey Unit has recently detected sharp increases in weevil populations.

A contract to assess weevil hazard and activity in the Nelson Forest Region is being carried out this fall. Components of the work are developing a climate-based hazard rating; assessing the extent and intensity of current weevil activity in the region; and, recommending strategies and options for minimizing weevil problems in the future. The general results to date indicate that many spruce plantations are just beginning to enter ages and sizes which may be susceptible to the weevil, and that much of the region has a climate that will support weevil populations. Observations suggest that weevils generally occur throughout the region, and may be a problem even in higher elevation plantations in the Engelmann Spruce-Subalpine Fir biogeoclimatic subzone in the southern part of the region. It is expected that the full report will be available by January, 1995.

- A. Stock, Nelson Forest District, Nelson.

Collapse of Western Spruce Budworm Outbreak in the Pemberton/D'Arcy Area. After eight years of defoliation, the western spruce budworm outbreak in the Pemberton/D'Arcy area of the Squamish Forest District has collapsed. No defoliation was detected this year during aerial surveys. This area has traditionally received defoliation from periodic outbreaks of western spruce budworm over the past century—four have now been recorded. Outbreaks have probably been occurring here since budworm followed the migration of Douglas-fir into the area after the last ice-age. The previous and most serious of the recorded outbreaks in this area occurred from 1970 to 1977.

The most current outbreak was first detected in 1986 when over 1 255 ha were defoliated in the D'Arcy and Blackwater Creek drainages. At the peak of the outbreak in 1992, the area of defoliation reached 20 760 ha. Defoliation severity generally remained at light to moderate levels, only reaching severe levels in 1992 on 1 450 ha located, primarily in amabilis fir, above the Lillooet River northwest of Pemberton.

Some stands were defoliated for seven consecutive years (Blackwater and Phelix Creek), while other areas received only one year of defoliation. It appears that the budworm population in any one stand peaks after about two to four years of active defoliation. This is probably a function of increasing parasitism and a reduction of foliage within the stand. Although budworm numbers within a stand decline after this period, in some stands they still seem to be able to maintain themselves at defoliating levels for many more years.

So far, little tree mortality has occurred, however, topkill is common, especially in stands that have had five or more years of defoliation. Most trees have now refoliated, except for dead tops. A number of young stands were also impacted, receiving defoliation severe enough to cause topkill. Dead tops in immature trees lead to deformities in the main stem of the tree at harvest, and may be the most serious loss caused by budworm. These stands will be monitored to learn how they recover.

Branch beating collections prior to defoliation did not detect building budworm populations (samples were not collected close enough to the area of defoliation). Experimental pheromone trapping, however, did detect increasing budworm populations in 1985. During the outbreak period, egg mass sampling worked fairly well in predicting the next year's defoliation level within the sampling area.

Predictions can possibly be extrapolated somewhat, maybe to the drainage level, but, beyond that they are unreliable. Egg mass sampling did not seem to be as accurate for declining populations. Although it forecast population declines, the forecasted declines were usually less than what actually occurred. There must be poor survival of eggs and/or young larva during the decline phase of the budworm population. This is consistent with most theories of budworm population dynamics.

The budworm outbreak in the Fraser Canyon is still active with light to moderate levels of defoliation predicted for 1995. The current outbreak was first detected here in 1989. Budworm activity in the Fraser Canyon consistently seems to lag a few years behind the Pemberton/D'Arcy area.

- D. Heppner, Vancouver Forest Region, Nanaimo.

Bucking-Desiccation Experiment for Douglas-fir Beetle Control. Windthrown Douglas-fir often attract Douglas-fir beetle, therefore, creating infestation centres. Destroying or harvesting single or scattered windthrown trees is often not possible due to economic or access restrictions. Questions have been raised as to whether bucking windthrown trees before or shortly after beetle attack may prevent successful beetle progeny production due to desiccation or fungal contamination. To address this question, trap trees were felled and bucked at eight sites in the Williams Lake Forest District. One third of the trap trees were bucked pre-attack, one third were bucked post-attack, and one third were left unbucked as controls. Sections of the trap trees were cut into three length categories, 50 cm, 25 cm and 12 cm. Bark samples were collected in October and dissection and analysis is underway. Final results will be available January, 1995.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Competitive Displacement of Mountain Pine Beetle by Pine Engraver Beetle. Competition for food and space, both within and among species, is a major mortality factor for bark beetle broods. Competitive interactions between mountain pine beetle and pine engraver beetle, *Ips pini*, are currently being studied in the Cariboo Forest Region. A cooperative project between Les Safranyik, Forestry Canada, and the B.C. Forest Service is in its third year. Previous work suggests that mountain pine beetle brood failure was significantly greater for trees baited with *Ips pini* tree baits. Treatments this summer were similar to previous trials, apart from the fact that half the trees in the treatment were felled. This will test the hypothesis that mountain pine beetle may be at a competitive disadvantage to pine engraver beetle when trees are on the ground. *Ips pini* prefers dead or down trees as hosts. Bark samples collected this fall will be analyzed over the winter and additional bark samples will be collected in early summer, 1995, to evaluate population interactions due to spring attack by pine engraver beetle.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Insect Displays. Due to the high use of the insect display made for the Kamloops Forest Region Office by the Forest Insect and Disease Survey Unit of the Canadian Forest Service, and numerous requests from the districts for similar displays of their own, two of my cooperative education students spent some of their time this summer collecting and preserving specimens. In addition to the insect collection, Mark Gardiner (Agriculture Canada, Summerland) did some photography of insect life stages, symptoms and parts of our spray operations. This winter I am putting the photos and collections together in a mobile display for some of the districts.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Comparison of Lindgren Funnel Traps and Theyson Bark Beetle Traps for Catching and Monitoring Mountain Pine Beetle Flight. Five Theyson intercept traps were purchased for the Penticton Forest District to monitor the mountain pine beetle flight. Three intercept and three Lindgren funnel traps were placed at 100 meter intervals in one stand (sites 1-3) and one of each trap type was placed at two other sites in the district. We attempted to make weekly collections, but this was not always the case.

Three of the trapping locations, sites 1, 3 and 4, showed no significant difference in total number of mountain pine beetle caught by the two trap types. Two trapping locations, sites 2 and 5, had significantly higher trap catches in the Theyson intercept trap. Both of these sites had generally lower numbers of mountain pine beetle than the other three trapping locations, which may indicate that the Theyson trap catches more beetles than the Lindgren trap at lower population densities. Overall, both types of traps are useful for monitoring beetle flight periods and for timing treatments such as MSMA application.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Pheromones and *Pissodes strobi*. As a continuation of my work in 1990 and 1993, I wanted to investigate whether *P. strobi* produces a pheromone which attracts conspecific weevil species while active in the duff rather than on the leaders, and exclusive of the period when oviposition occurs on the leaders. Another objective was to determine if *P. strobi* produces a pheromone which blocks the pheromone response of conspecifics to the pheromone produced by *P. schwarzi* males or inhibits the production and release of pheromone by *P. schwarzi*. The presence and identification of such a pheromone could lead to a better understanding of pheromone communication in the genus *Pissodes*, and thus to better management of the weevils. The last objective was to determine if the presence of females with male *P. schwarzi* would enhance the response, thus acting as an aggregation pheromone.

I set up two experiments, one in a lodgepole pine stand (age 17 years) in the Penticton Forest District (Ellis Creek) in the Montane Spruce biogeoclimatic zone, and the other in a spruce stand (age 17 years) in the Clearwater Forest District (Gollen Creek) in the Interior Cedar Hemlock Zone. The treatments were as follows:

- 1) one male *P. strobi* with spruce;
- 2) one male *P. schwarzi* with pine;
- 3) one male *P. strobi* and one male *P. schwarzi* with pine and spruce;
- 4) one male and one female *P. schwarzi* with pine; and
- 5) control with only pine.

The Clearwater experiment had only four treatments (number 4 was excluded) and each treatment consisted of 15 pitfall traps. Traps were checked on a weekly basis from May through August, using the same procedure as outlined in Maclauchlan *et al.* (1993).

The total number of weevils caught at Ellis Creek was 106 (71 females and 35 males) over an 11 week time period (May 26 to August 8, 1994). Over an eight week period (May 30 to July 17, 1994) a total of 15 weevils were caught in the Gollen Creek experiment, of which 11 were females and 4 were males.

Temperature seemed to influence trap catch numbers. More weevils caught when average weekly temperatures were in the 9-13.5° C range at Ellis Creek and the 7-13° C range at Gollen Creek. Lower trap catch numbers and increased bait mortality occurred when average weekly temperatures increased to above 16-17° C.

A Poisson distribution at both sites showed the attraction of weevils to the traps was not due to random chance ($P < 0.05$). This indicated that there was some sort of attraction between the weevils and the baits. An ANOVA showed that, at both sites, there was a significant difference between the number of weevils caught by the different treatments ($P < 0.05$).

There were significant differences in the number of weevils caught between the control treatment and the male *P. schwarzi* treatment; between the control treatment and the male *P. strobi* with male *P. schwarzi* treatment; between the male *P. schwarzi* treatment and the female/male *P. schwarzi* treatment; and, between the control treatment and the female/male *P. schwarzi* treatment (Tukey's test; $P < 0.05$). These results support the presence of a male sex pheromone (MacLauchlan *et al.* 1993).

There was a significant difference in trap catch numbers between the male *P. schwarzi* and the female/male *P. schwarzi* treatment ($P < 0.05$) which supports the hypothesis that this is a male produced sex pheromone rather than an aggregation pheromone. Further evidence that the pheromone produced by male *P. schwarzi* is a sex pheromone and not an aggregation pheromone is supported by a G-test (Zar, 1984) which showed that significantly more females were attracted to the traps than males at Ellis Creek ($P < 0.05$).

There was a significant difference in number of weevils caught between the control treatment and the male *P. strobi* with male *P. schwarzi* treatment and between the male *P. strobi* treatment and the male *P. strobi* with male *P. schwarzi* treatment at the Gollen Creek site (Tukey's test; $p < 0.05$). There was no significant difference between the number of males and females caught at Gollen Creek (Tukey's test; $p < 0.05$). There was no significant difference in number of weevils caught between the control treatment and male *P. strobi* treatment, and between the male *P. schwarzi* treatment and the male *P. strobi* with male *P. schwarzi* treatment at either site ($P < 0.05$). However, the traps were set up at the end of the oviposition period (May 26, 1994) at Gollen Creek and we may have missed the early season activity of *P. strobi* (Please refer to Figure 1, Seasonal response of *Pissodes* to *P. strobi* baited traps, *P. strobi/schwarzi* baited traps, and *P. schwarzi* baited traps on Page 47 of the Graphics and Tabulation Section of this issue of Forest Health Progress).

The results indicate that the presence of *P. strobi* with *P. schwarzi* produces no blocking or inhibition of conspecifics to *P. schwarzi*. *P. strobi* has been shown to interfere with the pheromone of *P. nemorensis* (Phillips and Lanier 1986). However, the apparent inability of *P. strobi* to block the production, release or perception of the *P. schwarzi* pheromone to conspecifics may be due to the fact that, unlike *P. strobi* and *P. nemorensis*, *P. schwarzi* and *P. strobi* are not considered sibling species.

- L. MacIaughlan, Kamloops Forest Region, Kamloops.

Long-Term Management of Western Spruce Budworm: Underburning Project.

Three major factors have done much to shape the character of coniferous forests in the Pacific northwest - fire, insects and disease, and timber harvesting. Fire suppression and our practice of selective harvesting in the Interior Douglas-fir forest have resulted in increased proportions of seral species and decreases in climax species. Fire suppression and selective harvesting have not only affected species composition, but also the structure of forests. A continuous vertical and lateral crown canopy of shade-tolerant species increases the number of favourable landing sites for dispersing western spruce budworm larvae; creates favourable microsites for insect feeding and development; and, presents a "catchment" so that few larvae fall to the forest floor where they can be destroyed by various biological and physical factors. Thus, from a relatively insignificant insect of the northwestern forest, budworm has become a major concern in the management of our Interior Douglas-fir stands.

Current forest management practices must begin to reverse the successional trends toward climax species if losses to the budworm are to be addressed. Silvicultural systems, using seed-tree, shelterwood, and clearcutting, as well as thinning in multi-storied stands will help this process. Stands with greater species diversity and a higher composition of seral species should be promoted. The reintroduction of light ground fires to these Douglas-fir dominated stands will also promote a more species-diverse stand, with a higher proportion of seral species, and a higher tolerance for budworm.

The Swakum Mountain underburn project is located in the Interior Douglas-fir biogeoclimatic zone, with three main stratum recognized in the underburn area, as follows:

Stratum A (IDFxh2 04): an open Py(Fd) type with sparse understory vegetation and low level budworm.

Stratum B (IDFxh2 05): a Fd(Py) type with more advanced regeneration and pinegrass occupying 80% of the understory vegetation. Budworm incidence is high.

Stratum C (IDFxh2 01): a multi-layer Fd type with very few scattered Py, and is much more heavily treed. Budworm incidence is high.

The objectives of the project were to introduce light-moderate intensity ground fires into these stratum in order to remove understory vegetation and thickets of Douglas-fir; to create gaps in the stand; and to create stand openings to promote natural regeneration of ponderosa pine and/or underplant ponderosa pine. Plots were established in each of the strata, inside and outside the designated burn area, prior to burning, to monitor annual budworm defoliation, number of trees removed by the burn, and ingrowth. In one plot in stratum B, 22% and 57% of total overstory and understory trees, respectively, were killed by the fire. Gaps averaging 0.13 ha in size were created throughout this stratum. The 1994 defoliation assessments indicated budworm feeding was less intense in the burned plots than outside the burn. A second underburn project is being planned for the Kamloops Forest District in the spring of 1995.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

1994 Spray Program for Western Spruce Budworm and Other Activities in the Kamloops Forest Region. We are just approaching the end of the most current outbreak, which at its peak in 1987, covered over 80 000 ha. This outbreak has been ongoing for approximately nine years, although 20-30 thousand ha of forest are still being defoliated annually. Annual monitoring of 32 plots located in multi-layered Douglas-fir stands in the Kamloops Forest District, indicates significantly less tree mortality in overstory than understory trees; particularly in plots with a recent harvesting history. In plots which had no history of budworm control, 57.1% mortality of trees less than 5 cm diameter occurred. Analysis of information gathered on an annual basis from these growth and yield plots is giving us new direction for managing ecosystems with a high budworm hazard. A report on the findings from these plots was presented at the Entomological Society of Canada Conference in Winnipeg, and a report summarizing the results and recommendations is being prepared.

The 1994 spray program went off without a hitch again this year. We are approaching the end (hopefully) of this outbreak. However, we still anticipate having a spray program in 1995. The budworm population has increased in the south Okanagan (Penticton Forest District) and we will be assisting the Cariboo Forest Region with a spray program near Clinton. Lillooet, Kamloops, Penticton and Merritt Forest Districts anticipate small spray programs in 1995.

In cooperation with the Kamloops Forest District, we have laid out areas in the Interior Douglas-fir biogeoclimatic zone for large scale spacing trials. The treatments include a variety of spacing regimes in the understory and intermediate layers of stands, incorporating different inter-tree spacing as well as different spatial distributions of stems. The spacing is scheduled to commence late November and we hope to get about 300 ha treated this winter. Aerial photography of the treated areas will be done next summer, and permanent sample plots will be established.

Please refer to Figure 2, on page 47 of this issue of Forest Health Progress for the annual record of hectares defoliated by the western spruce budworm in the Kamloops Forest Region from 1982 to 1994.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Assessment of Sampling Techniques to Predict Western Spruce Budworm Defoliation. One of our University of Victoria cooperative education students, Cheryl Horvath, tested the field-ease and reliability of three different bud mining assessment methodologies. The objective of this study was to determine the accuracy of the three sampling techniques at predicting budworm defoliation; and to determine the most operationally efficient method for use in forestry. The techniques tested were sequential bud count, three-tree cluster, and five-tree cluster.

In June, four sites were selected in the Interior Douglas-fir biogeoclimatic zone and each of the three sampling techniques was performed in each of four selected sites. Mid-crown branches were cut and the percent of budworm infested buds was recorded. Five samples for each sample method were taken at each site. An average percent of buds infested and the total number of buds checked was calculated for each plot and sampling method. Defoliation predictions were made based on the values shown below.

Percent infested buds	Predicted defoliation
0-15%	Light
16-30%	Moderate
>30%	Severe

The four sites were revisited in August, and in each plot, 20 branches, 2 from each of 10 randomly selected trees, were cut and assigned a Fettes (1950) value (based on their remaining current year's needles). Photographs were taken of all samples. Fettes scale was converted to defoliation classes and compared to the predictions made from the 3 sampling techniques. Fettes Value to Defoliation Class conversions were as follows:

Fettes Value	Defoliation class
0-1	Light
2-3	Moderate
4-7	Severe

The sequential sampling technique was out by one defoliation class in three of the four plots. The 3-tree and 5-tree sampling techniques proved accurate for two plots each, and were out by one defoliation class for two plots each.

Each sampling technique proved accurate within, at most, one defoliation class. The 3- and 5-tree sampling techniques were slightly more accurate, which would be expected as more buds were inventoried in these two methods. Based on accuracy and personal recommendations from my crew, we will be adopting the 3-tree sampling method. Copies of Cheryl's work-term report on this project can be obtained from the Kamloops Forest Region.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Mountain Pine Beetle in the Kamloops Forest Region. As predicted last year, the mountain pine beetle population remains static in the south Okanagan. However, we have seen drastic increases in numbers of attacked trees (1994 attack) in the Kamloops, Lillooet, Salmon Arm and Merritt Forest Districts.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Douglas-fir Tussock Moth Decline. It appears that we have seen the end of the tussock moth epidemic for another decade. Mike Hulme and Tom Gray did another mating disruption trial near Walachin. Moths were caught in pheromone traps at some locations, but we are not expecting any noticeable defoliation in 1995. Two traps were placed at each permanent trapping site, using the lure from Phero Tech and from Canadian Forest Service (CFS). Not all the trapping results are in yet, but to date there is a significant difference between the number of moths caught with the two lures. An average ($\pm$ S.D.) of 10.8 ± 13.9 and 1.3 ± 4.1 moths were caught per trap with the Phero Tech and CFS lure, respectively. A final report on the Douglas-fir tussock moth program from 1991 through 1994 is being prepared, and will be completed this winter.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

Consequences of the "Do Nothing Strategy" for Mountain Pine Beetle Management in the South Okanagan. As a result of a two day field trip and planning session this summer in the Penticton Forest District, a joint project between the B.C. Forest Service (Branch, Region and Districts) and the Canadian Forestry Service (T. Shore) was formulated. The objective of the field trip was to formulate a working plan to evaluate the post-outbreak impacts of the mountain pine beetle in the southern interior of the province. This evaluation is the final phase of the Okanagan Task Force recommendations in terms of mountain pine beetle strategies, and also a recommendation of the 1993 audit of the Penticton Forest District mountain pine beetle program.

Moderate to high hazard stands which were left as "no control" areas, for various reasons, are the target of this project. The two phases of the project were: data gathering and stratification, and plot establishment and assessment.

The project will be piloted in the southern portion of the province, including the Boundary, Penticton, Merritt, Vernon and Lillooet Forest Districts. These forest districts are a manageable unit and were, for the most part, following the strategies and tactics recommended by the Okanagan Task Force. Once the protocol has been established, we hope this evaluation will be done for the remainder of the province.

The final report will address impacts on wildlife, riparian areas, watersheds and visual and recreation qualities. The stands will be assessed with regard to the initial desired stand structure and function. Questions to be discussed include, "Would an alternate strategy have been more appropriate in this particular stand?" "Will leaving patches of dead, mountain pine beetle-killed trees provide the same result as single-tree extraction or patch harvesting, in terms of the residual stand, regeneration, silvicultural options and treatment options? etc.

- L. Maclauchlan, Kamloops Forest Region, Kamloops.

A Decision Support System for Managing Bark Beetles in the Prince George Forest Region. A major spruce beetle epidemic in the Prince George Forest Region in 1990 created the need for a substantial sanitation program and an information system to assist management activities. The complexity of the insect's life cycle, a mix of both one and two-years, makes it one of the most difficult bark beetles to manage from a systems perspective.

In 1992, we developed a geographically based operational computer system which couples geographic and treatment priority rating data. The result is a user-friendly application that has received acceptance in four forest districts. The system has been expanded to include three species of beetles. Digitized data is currently available for approximately 230 000 ha of beetle infestation, of which ground data comprises 70 000 ha.

The system is actively used by both the Forest Service and licensees to redeploy 1.2 million m³ of uninfested timber harvest to beetle infested timber and to manage a \$2.7 million beetle program. Graphically generated treatment plan maps are now used as part of the approval process for timber harvest in the four forest districts. The cost of the system represents less than 3% of the Forest Service's direct control budget for the region, or probably less than 1% of the total control budget if industry expenditures could be accurately estimated. The research potential of the system has yet to be utilized, but includes the ability to compare land satellite imagery with the extensive ground survey data.

A report on this project is now available from the author, and will be presented at the upcoming GIS Conference in Vancouver.

- S. Taylor, Prince George Forest Region, Prince George, A. Brackly, Industrial Forestry Service and C. Broster, Mackenzie Forest District, Mackenzie.

FOREST DISEASES

Intensity Measuring Pixel Survey (IMPS) Method Tested in the Vancouver Forest Region. IMPS is undergoing a field test in coastal stands. Mid-Coast Forest District Resource Officer, Silviculture, John McClarnon, volunteered to test the survey in several stands scheduled for stand tending treatments next year. The objective is to see whether the incidence and distribution of *Armillaria* root disease will affect stand management objectives.

Dave Calder, Kamloops Forest Region, inventor of IMPS, was on hand in late October to review the work accomplished to date and provide advice to the contractor and district staff. When completed, those involved will assess the survey method and decide whether to recommend it for use in assessing root disease in pre-stand tending areas on the coast.

- S. Zeglen, Vancouver Forest Region, Nanaimo.

Post-Harvest Survey for Tomentosus Root Rot in the Cariboo Forest Region. A cooperative education student project was initiated to test the feasibility of a post-harvest survey for tomentosus root rot. A post-harvest survey, using a visual check of the stump tops should be more accurate in locating tomentosus root rot and estimating its incidence than pre-harvest surveys. In pre-harvest surveys, standing trees are often inconsistent in expressing infection symptoms, requiring a very experienced surveyor.

The identification of tomentosus root rot was made by noting the presence of the typical honey comb pit pattern on the stump top. The survey method worked well in cutblocks that had cleanly cut stump tops. However, tomentosus root rot is a difficult root disease to positively identify and distinguish from wood decay or diseases caused by other fungi that look similar, such as *Phellinus pini*, *Phellinus weirii*, *Heiracium abietinum*, and *Phellinus nigrolimitatus*. Also, feller bunching, a widely used harvesting method in the Cariboo Forest Region, creates stump tops with chewed and slightly stepped patterns, making tomentosus root rot identification almost impossible except for the most experienced surveyor. The most crucial factor for the success of this survey method is the condition of the stump top. In general, the method works most successfully in areas of clean-cut stump tops.

The survey trial was conducted by Robin Pike and Kerri Howse, University of Victoria cooperative education students.

- D. Doidge, Cariboo Forest Region, Williams Lake.

Permanent Sample Plots for Identification of Tomentosus Root Rot in Spruce Plantations in the Cariboo Forest Region. *Inonotus tomentosus* is a root disease that mainly affects spruce in the Cariboo Forest Region. In order to evaluate the effect of the root disease on young spruce stands, it is important to establish its rate of spread.

In the summer of 1994, four permanent 50m² sample plots were established in spruce plantations in the Horsefly Forest District to evaluate the location and mortality rate of young trees infected with *I. tomentosus*. These sample plots will be maintained and re-evaluated until the stands have reached maturity, or are harvested.

Stem maps, showing the location of all susceptible species of second growth trees and all stumps within the plot boundaries, have been produced using the Microstation® mapping program. Computer mapping technology may also be used to track the size and spread rate of *I. tomentosus* infection centres as research in these plots continues.

The 50x50 metre plots were divided into a 5x5 metre grid system to assist with the stem mapping. The maps include all susceptible trees, seedlings and stumps, infected or not. The plots will be re-visited in five years.

These plots are extremely valuable and will provide important data for years. Thanks are extended to Kerri Howse and Robin Pike for persevering in their establishment.

- D. Doidge, Cariboo Forest Region, Williams Lake.

Intensity Measuring Pixel Survey (IMPS) Spreads like an Insidious Root Disease. As both the awareness of root diseases and its subsequent influence upon the prescription making process grows, it is more and more important for the prescribing silviculturist to be able to accurately assess the extent and intensity of different diseases within forest strata. While not all situations require a detailed survey in order to meet these objectives, one is often required. Initiatives such as the upcoming Forest Practices Code field guides and regional root disease guidelines may include a detailed survey as a formal requirement in many cases. Though several survey methodologies exist for root disease, there was no single method that will accomplish the following:

- be equally effective and accurate in all forest types,
- work for all major root diseases,
- measure the extent and intensity of the disease within the block for the purposes of prescription stratification, and
- be as quick and cost efficient as possible.

IMPS is a new type of root disease survey that was designed to meet these four demands. IMPS is essentially a variable-width hybrid of the Merler/Norris pixel survey and a beetle probe. Given the flexibility and simplicity of the survey, it can easily be integrated into other surveys (such as cruising, reconnaissance, pre-harvest silviculture prescription, mapping, etc.) in order to minimize the additional costs to the operator.

Office compilation and mapping is done with the IMPS desktop computer compilation/mapping program. The program is designed to be compatible with any WINDOWS equipped PC. The program allows the operator to compile the data, stratify survey results, produce unique strata reports, and generate colour-coded grid maps displaying the location and intensity of the disease over the survey area. This program and its user's manual is now available at no charge from the Kamloops Forest Region. We encourage those who obtain the program to feel free to make additional copies and share them with others.

The compilation program will be updated periodically in order to reflect the rapidly changing capabilities of desk-top PC's and printers. It is our intention to continue to supply clients with the best system possible while utilizing desk-top computers. The intent of this exercise is to provide an efficient and cost-effective tool for use in the field and office.

It should be noted that many existing disease survey methods work well under the conditions for which they were designed. Where the currently used survey is fulfilling the requirements of the prescribing forester, it should continue to be used, but where IMPS can provide a superior level of information for the prescriber at a lower cost than surveys currently in use, we suggest it be adopted.

For further details and copies of the IMPS methodology and program package, contact Dave Calder, telephone 371-3707, or Office Vision User ID DACALDER.

- D. Calder, Kamloops Forest Region, Kamloops.

MAMMAL DAMAGE

Elk Damage in Managed Stands. Two herds of Roosevelt Elk have been transferred from Vancouver Island to the Sunshine Coast Forest District. The Sechelt herd has been causing damage in juvenile-spaced and pruned stands by rubbing and pushing trees over. The majority of the damage occurs along the access roads and hydro transmission lines.

A block scheduled for juvenile spacing and bridge tree removal for laminated root rot control has high elk activity and most of the lodgepole pine trees in the block have been extensively damaged by antler rubbing. All lodgepole pine trees will be reserved from cutting, hopefully, to concentrate elk damage onto them and reduce damage to the preferred crop of Douglas fir.

Also, a nearby area scheduled for planting in the spring of 1995 will have lodgepole pine seedlings planted adjacent to access roads and the powerline. These will become future rub trees to help reduce damage in these managed stands.

- R. Diprose, Sunshine Coast Forest District, Powell River.

Grizzly Bear Girdling in Juvenile-Spaced Stands. Mortality in western redcedar in a 1988 juvenile spacing block in Quatam River has been increasing over the past two years. A recent field trip confirmed the damage to be bark stripping by grizzly bears feeding on the cambium layer. Western redcedar comprises 65% of the stand and an estimated 95% of the cedar trees have been girdled. This damage was first noted two years ago and was under 5% of the cedar crop trees.

Two blocks with a total area of 75 hectares are damaged. Ground survey results indicated that 25% of the cedar has died over the past two years. The remaining cedar crop trees that are still green will suffer 90% mortality by next spring. These trees have an average height of 12 metres with a dbh range of 6-40 cm. It is estimated that the stocking in these blocks will become approximately 250 stems/ha. Damage was also noted on some of the Douglas-fir trees in the blocks. However, there was no bear damage to the western hemlock trees. Any future blocks planned for juvenile spacing in this area will have to be reviewed for crop tree selection.

- R. Diprose, Sunshine Coast Forest District, Powell River.

Vole Monitoring. Yet another peak in the vole population cycle has been reported this year throughout the Prince Rupert Forest Region. The vole population was particularly high in the Kalum Forest District, where a provincial monitoring program is being conducted in the Skeena, Kitimat and Nass drainages. Additional trapping is also being done by Buffalo Head Logging, in the north Kalum Forest District. Live traps are employed to estimate the size of the population using the Jolly-Seber and Least Number Alive methods. Vole species abundance is then related to damage using standard B.C. Forest Service survival plots. This project is also being replicated in the Pemberton area to determine if vole population fluctuations are province-wide or regional; if the population cycles can be predicted; and to standardize the monitoring procedure.

Habitat types will be correlated to populations of the various rodent species being monitored.

These studies will enable silviculturalists to avoid damage that can occur during peak vole population years, and to identify high hazard habitats where planting should be delayed. This is the first year of a three to five year project.

- T. Ebata, Prince Rupert Forest Region, Smithers.

Collaring Trees to Prevent Vole Damage - Does it Work? Protective hard plastic collars have been used to prevent seedling mortality in the Kalum Forest District. However, little data have been gathered to determine if these devices actually protect seedlings. Observations of collar efficacy on conifers have revealed that little protection is offered. Voles will either nip off the protruding tops, burrow under the collar and girdle the tree, or chew right through the collar. Often the problem is compounded by wet snow press which bends the collar and seedling and provides an ideal refuge for the offending microtines. Thus, collaring of conifer seedlings is not recommended.

The Kalum Forest District has numerous rich alluvial sites that have been planted with black cottonwood whips in an effort to establish a crop species in brush-prone sites. Voles also damage cottonwood, and collars have again been tried to prevent significant mortality.

This summer, cooperative education students from the Prince Rupert Forest Region established 3.99m radius survival plots in which collars were removed on alternate whips. In addition, a contractor monitored vole populations through the summer, reassessed the survival plots this fall, and will correlate tree damage to vole population levels. The data have not been summarized to date, but some cottonwood mortality has been noted by the contractor. The voles appear to "fall" the protruding portion of the whip in a manner similar to a beaver. Also, more mortality unrelated to voles was noticed on collared trees than on uncollared trees, suggesting that cottonwood may be sensitive to the extra handling from the placement of the collars. More complete results of this trial will be reported in a future issue of the Forest Health Progress.

- T. Ebata, Prince Rupert Forest Region, Smithers.

PESTICIDES

Effects of the Bacterial Insecticide *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) on a Stream Benthic Community. This publication, authored by John S. Richardson and Chris J. Perrin, has been published in the Canadian Journal of Aquatic Sciences (Vol. 51, 1994). The study was funded and directed by Silviculture Branch, Forest Health Section. The abstract of the publication is as follows:

Commercial formulations of the insecticidal bacterium *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) are frequently sprayed over bodies of water. The hypothesis that B.t.k. poses a threat to stream communities was tested using streamside, flow-through mesocosms which received water and invertebrate colonists from a second-order stream in southwestern British Columbia; low (50 BIU/ha) and high (≤ 5000 BIU/ha) treatment levels were contrasted with controls. There were no significant differences in the density or composition of benthos sampled 7 days after B.t.k. application. The densities were highest in the high-dose mesocosms. There were no significant differences in emergence rate of adults due to treatment. During the 2.5 hour treatment, there were marginally elevated drift rates of the mayfly *Baetis* when exposed to the solution, but these differences were negated during the remainder of the 24 hour period. Leaf packs lost significantly more mass in controls than in high-dose mesocosms, but there were no significant differences in the numbers of macro-invertebrates on those leaf packs. There was no evidence that addition of B.t.k. to stream mesocosms created adverse effects for this benthic community, even at >100 times expected exposure rates.

- J. Henigman, Silviculture Branch, Victoria.

Experimental Use of Neem Seed Extract (NSE) for Mountain Pine Beetle Control: Year II. Promising results have been obtained from a cooperative study initiated in 1993 by the British Columbia Forest Service (Cariboo Forest Region), Murrey Isman, University of British Columbia and Ken Naumann, Phero Tech Inc. The study evaluated the effects of NSE on mountain pine beetle (IBM) in lodgepole pine.

Extracts of seeds from the neem tree, *Azadirachta indica*, are useful for the management of insect pests and appear to be safer for natural enemies than most conventional insecticides. A significant reduction in IBM survival was found in NSE treated trees. Field trials involving hack and squirt injection of NSE in baited mass-attacked beetle trees caused decreases in the numbers of surviving larvae per unit area of bark and per unit length of adult gallery. The mortality increased with increased NSE dosage. The effects of the highest NSE dose were not as effective as an application of monosodium methanearsonate (MSMA) at its recommended dose. However, the active ingredient (a.i.) component of NSE at its highest dosage rate was 1.2% whereas the recommended MSMA dosage contains 32% a.i..

The results of the 1993 study were promising enough to warrant continued investigation of this potential control method. The objectives of the 1994 study were to determine, as follows:

- if NSE is effective for IBM control using a pre-attack injection of NSE;
- if a more concentrated formulation of NSE will be effective for IBM control with a post-attack hack and squirt injection (thicker formulation of NSE makes application by hack and squirt easier) and
- if post-attack injection with the new formulation is as effective at 5 to 10m on the bole as at breast height. MSMA will be used again as a comparative control.

The treatment sites were established in July and August, near Lynn Lake in the Williams Lake Forest District. During the pre-attack injection treatments, trees were injected with NSE, and then baited. During post-attack treatments, trees were baited and then injected after IBM mass attack. Bark samples have been collected, but dissection and analysis have not been completed. Analysis of results should be completed in early 1995.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Pre-Attack Injection of Systemic Chemicals to Control Douglas-fir Beetle. Monodosium methanearsonate (MSMA) is registered for use in lodgepole pine and interior spruce for control of mountain pine beetle, and spruce beetle, respectively. In the case of spruce beetle, MSMA is used as a pre-attack treatment. After the chemical is translocated, the spruce tree is felled to create a lethal trap tree. Pre-attack treatment with pesticides can create lethal trap trees which reduce the total number of trap trees required for beetle control. However, MSMA is not effective when injected into Douglas-fir.

In situations where preservation of mature Douglas-fir forests is critical, such as mule deer winter ranges, a lethal trap tree would be a valuable tool for control of Douglas-fir beetle (IBD). No effective lethal trap tree has been developed for IBD. However, acephate, dimethoate, and oxydemeton-methyl translocate in conifers and have been employed to control cone and seed insects, western spruce budworm, *Choristoneura occidentalis*, and white pine (spruce) weevil, *Pissodes strobi*. These systemic chemicals may have potential in a pre-attack hack and squirt program for IBD control.

A project was initiated to test the efficacy of the three systemic insecticides, oxydemeton methyl, acephate and dimethoate, for control of IBD by pre-attack injection to produce lethal trap trees. A trial site was established at four locations along the Mayfield Lake Forest Service road in the Williams Lake Forest District. Ten trees were treated with each chemical by hack and squirt injection. Ten trees were also axe-frilled and not injected to act as controls. Five trees of each treatment were felled one week after injection and five at two weeks after injection, to create trap trees. Bark samples were collected on the upper bole at the time of felling, and analyzed for the presence and amount of chemical. Trees were left until October, 1994 and then bark samples were removed at breast height, 10 m and 15 m to evaluate beetle survival. Analysis has not been completed, but preliminary results suggest that oxydemeton-methyl and dimethoate may be effective for pre-attack injection to control Douglas-fir beetle. Final results will be available by the new year.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Post-Attack Injection of NSE and Acephate for Douglas-fir Beetle Control. Results of a cooperative 1993 study between the B.C. Ministry of Forests, University of British Columbia, and Phero Tech Inc., were promising for mountain pine beetle control with neem seed extract (NSE). NSE was injected through a hack and squirt technique into lodgepole pine to control the mountain pine beetle (IBM). Extracts of seeds of the neem tree, *Azadirachta indica*, can cause mortality, improper moulting, impaired reproductive capacity, repellency and feeding deterrence for insect pests. Acephate is a systemic insecticide which is registered for control of orchard pests and may have potential use for control of Douglas-fir beetle (IBD).

After the good IBM control results, we decided to test the efficacy of NSE for control of IBD. The objective of the project was to determine if post-attack hack and squirt injection of NSE or acephate will control IBD. Fifteen trees were baited with Douglas-fir beetle tree baits to induce beetle attack. After mass attack, five trees each were injected with NSE and acephate. Five trees were also axe-frilled and not injected to act as controls. In September, bark samples were collected at breast height and 10 m. Preliminary analysis suggests that NSE was not effective for controlling IBD. Acephate was significantly effective at breast height but was not significantly effective at 10 m. Bark thickness on Douglas-fir makes hack and squirt injection difficult. Some form of slow injection system may be a more effective method for creating lethal trap trees in Douglas-fir.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Neem (NSE) for *Pissodes strobi* Control in Sitka and White Spruce. The white pine (spruce) weevil, *Pissodes strobi*, is an important pest of young spruce that destroys tree leaders. There are no effective tools to constrain weevil population increases. Neem seed extract contains a compound, azadirachtin, which has demonstrated antifeedant effects against insect larvae. A project was initiated this year to test the efficacy of NSE to protect Sitka and white spruce trees from terminal loss and to control local weevil populations.

Tests were carried out in Sitka spruce plantations on Vancouver Island in the Vancouver Forest Region, and plantations of white spruce east of Williams Lake in the Cariboo Forest Region. At each location, 150 trees were treated at each of two sites containing young, weevil susceptible trees, 3-5 metres in height. Two treatments, applied to randomly distributed trees at each site were neem @ 10 000 ppm azadirachtin, and neem-free solvent as a control. The solutions were applied by drilling small holes in the trunks of the plantation trees and injecting 10 ml of neem or neem-free formulation into the trunk.

Treatments were applied at two different times, with 30 trees/site receiving a treatment immediately prior to adult attack, and 20 attacked trees/site receiving a treatment one to two weeks after attack. Attacked trees were identified by the presence of small, sap-encrusted entry punctures on the previous year's leaders. The early treatment tested whether prophylactic applications can save leaders in attacked trees. The later application provided a larger sample size for studying the effects of systemic azadirachtin on weevil larvae, especially in the event of low attack rates.

In the mid-summer, before larvae had completed development, the leaders were cut from test trees, and any weevil larvae were removed. Numbers of larvae per tree and their weight will be compared between treatments. Results of the treatment have not been completely analyzed but should be available in the New Year.

- L. Rankin, Cariboo Forest Region, Williams Lake.

Neem Trial on *Pissodes strobi*. A trial was established in a young spruce stand, near Gollen Creek in the Clearwater Forest District, to test the efficacy of neem (active ingredient azadirachtin) on the white pine (spruce) weevil, *P. strobi*. To observe the effects of neem on mortality and oviposition by *P. strobi*, 15 healthy spruce leaders were sprayed to drip point with a neem formulation of 7.5 ml neem per litre water on May 11, 1994, and then re-sprayed weekly until August 11, 1994. Six weevils (three male and three female) were caged on the neem-treated leaders, and 6 were caged on healthy leaders which did not receive neem treatment. Treated and check trees were of similar height and in comparable growing conditions, receiving the same amount of incident sunlight and overstory shading. Each week, all trees were checked, and any dead weevils were recorded and replaced with live ones.

Weevils were removed from mesh enclosures on August 11, 1994, and placed in petri dishes with spruce sections to monitor their health and fecundity. This portion of the trial is still in progress.

A second trial, to observe the effects of neem on growth and development of *P. strobi*, was established in the same stand. Ten leaders with new oviposition were treated with neem weekly from May 11, 1994 to August 11, 1994, and ten additional attacked leaders were designated as checks.

All treated and check leaders were clipped on August 11, 1994, and put in rearing cages. The emerging weevils were counted and placed with spruce sections in petri dishes in order to observe weevil health and fecundity. When emergence was complete, the emergence holes were counted. Weevils are still being reared in the lab.

Weevil mortality on neem treated or check trees was low, except during periods of hot weather, and was significantly related to temperature. There was no significant difference in mortality of weevils placed on neem-treated trees versus those placed on untreated trees, (5.7 ± 2.7 dead and 1.2 ± 0.4 dead, respectively). No oviposition was noted on either neem-treated or untreated trees. Therefore, it is not known whether neem inhibits oviposition. However, it does not have much effect on the survival of adult weevils. I am observing the weevils in the lab to see if there is an effect on fecundity.

Significantly fewer weevils emerged from the trees which had evidence of oviposition, and were sprayed with neem on a weekly basis, than from those which were not treated. Although not significantly different, more weevils from neem-treated trees than check trees died subsequent to emergence. The neem had an effect on the number of weevils emerging from attacked leaders, and it remains to be seen whether the weevils which did emerge from these treated trees will survive and produce as many viable offspring as those emerging from check trees.

- L. MacIaughlan, Kamloops Forest Region, Kamloops.

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Guy Newsome	Stand Tending Forester	Williams Lk.	398-4400
Chris Easthope	Range Agrologist	Williams Lk.	398-4396

District Staff

Doug Harris	Resource Officer, Silviculture	Chilcotin	394-4700
Bob Mitchell	Forest Health Officer	Chilcotin	394-4700
Dave Greenley	Resource Officer Silviculture	Horsefly	620-3200
Derek Poole	Forest Health Officer	Horsefly	620-3200
Charles von Hahn	Resource Officer Silviculture	Quesnel	992-4400
Brad Powell	Forest Health Officer	Quesnel	992-4400
Gerry Chapman	Resource Officer Silviculture	Williams Lake	398-4341
Von Vickers	Forest Health Officer	Williams Lake	398-4341
Mark Seilis	Resource Officer Silviculture	100 Mile House	395-7800
Don Wright	Forest Health Officer	100 Mile House	395-7873

KAMLOOPS FOREST REGION**Region Staff**

Lorraine Maclauchlan	Forest Entomologist	Kamloops	828-4177
David Calder	Forest Health Forester	Kamloops	371-3707
Ron Gray	Stand Tending Forester	Kamloops	828-4163
Phil Youwe	Range Resource Agrologist	Kamloops	828-4097
Hadrian Merler	Research Associate	Kamloops	828-4176

District Staff

Dan McDonald	Resource Officer, Silviculture	Clearwater	587-6713
Rob Martin	Forest Health Officer	Clearwater	587-6781
Brent Olsen	Resource Officer-Silviculture	Kamloops	371-6577
Joan Demale	Resource Clerk-Silviculture	Kamloops	371-6529
Dave Piggin	Forest Health Officer	Kamloops	371-6518
Dave Horne	Resource Officer, Silviculture	Lillooet	256-1229
Vacant	Forest Health Technician	Lillooet	256-1227
Ed Nedokas	Resource Officer, Silviculture	Merritt	378-8400
Pat Byrne	Forest Health Officer	Merritt	378-8449
Margot Hollinger	Forest Health Officer	Penticton	490-2242
Savas Koutsantonis	Forest Health Technician	Penticton	490-2250
Bob Johnson	Resource Officer, Silviculture	Salmon Arm	832-1426
Jim Wright	District Silviculturist, Silviculture	Salmon Arm	832-1424
Jerry Wearing	Resource Officer, Silviculture	Vernon	558-1776
Eric Haupt	Forest Health Officer	Vernon	558-1784

NELSON FOREST REGION**Region Staff**

Art Stock	Forest Entomologist	Nelson	354-6633
Rick Stewart	Forest Health Forester	Nelson	354-6144
Don Norris	Forest Pathologist	Nelson	354-6143
Gerald Reichenback	Stand Tending Forester	Nelson	354-6280
Grant Griffin	Range Officer	Nelson	354-6211

District Staff

Tom Johnston	Resource Officer - Silviculture	Arrow	365-8615
Ross Elliott	Forest Health Officer	Boundary	442-5411
Liz Goyette	Forest Health Officer	Cranbrook	426-3391
Kevin Edquist	District Silviculturist	Golden	344-7500
Emile Begin	Forest Health Officer	Invermere	342-4200
Richard Mazzochi	District Silviculturist	Kootenay Lk	825-1142
Bill Beard	Resource Officer - Silviculture	Revelstoke	837-7611

PRINCE GEORGE FOREST REGION**Region Staff**

Robert Hodgkinson	Forest Entomologist	Pr. George	565-6122
Richard Reich	Forest Pathologist	Pr. George	565-6143
Stuart Taylor	Forest Health Forester	Pr. George	565-6123
Heather Dawson	Vegetation Mgmt Forester	Pr. George	565-4113
Les Herring	Stand Tending Forester	Pr. George	565-6191
Ken Long	Range Officer	Pr. George	565-6138
Bruce Johnson	Range Development Coord.	Pr. George	565-6139

District Staff

Bob Richards	Resource Officer - Silviculture	Pr. George	565-7100
Bruce Doerksen	Forest Health Technician	Pr. George	565-7100
Norma Stromberg	Resource Officer - Silviculture	McBride	569-3714
Dave Kraby	Resource Assistant - Silviculture	McBride	569-3748
Greg Rawling	Resource Officer - Silviculture	Vanderhoof	567-6363
Dave Banham	Forest Health Technician	Vanderhoof	567-6363
Keith Gordon	Resource Officer - Silviculture	Ft. St. James	996-5272
Dale Derouche	Forest Health Technician	Ft. St. James	996-5248
Carl Hovey	Resource Assistant - Silviculture	Ft. St. James	996-7131
Andy Pakrastins	Resource Officer - Silviculture	Mackenzie	997-2200
Chris Broster	Forest Health Technician	Mackenzie	997-2200
Steve Bower	Assistant Forest Health Tech.	Mackenzie	997-2200
Sherilyn Smith	Resource Assistant - Silv.	Dawson Creek	784-2350
Brian Wesleyson	Resource Officer - Silviculture	Ft. St. John	787-5628
Gord Haley	Resource Officer - Silviculture	Ft. St. John	787-5634
Steve Lindsay	Resource Officer - Silviculture	Ft. Nelson	774-3936
Neil Edwards	District Silviculturist	Ft. Nelson	774-3936

PRINCE RUPERT FOREST REGION**Region Staff**

Gerry Pinkerton	A/Silviculture Officer	Smithers	847-7512
Tim Ebata	Forest Entomologist	Smithers	847-7479
Alex Woods	Forest Pathologist	Smithers	847-7478
Lou Tromp	Stand Tending Forester	Smithers	847-7514
Don Russell	Range Officer	Smithers	847-7443
Doug Kelly	Vegetation Mgmt. Forester	Smithers	847-7757

District Staff

Gary Lloyd	Resource Officer-Silviculture	Bulkley	847-6307
Bill Camenzind	Audit Forester	Bulkley	847-6310
Henry Hartman	Resource Officer-Silviculture	Cassiar	771-4211
Glen Buhr	District Silviculturist	Cassiar	771-4211
Bob Wilson	Resource Officer-Silviculture	Kalum	638-3290
Doug Davies	Audit Forester	Kalum	638-3290
Janice Bianco	Resource Officer-Silviculture	Kispiox	842-6581
Bob Fedorchuk	Audit Forester	Kispiox	842-6581

PRINCE RUPERT FOREST REGION**District Staff (Con't)**

Bruce Ward	Forest Health Technician	Morice	845-6224
Ruth Edwards	Resource Officer-Silviculture	Morice	845-6200
Mike Grainger	Resource Officer-Silviculture	North Coast	627-0462
Alex Gauld	Silviculture Planner	North Coast	627-0475
Mark Vieweg	Resource Officer-Silviculture	Lakes	692-7515
Terry Thrower	Resource Assistant-Silviculture/Protection	Lakes	692-7515

VANCOUVER FOREST REGION**Region Staff**

Don Heppner	Forest Entomologist	Nanaimo	751-7107
Stefan Zeglen	Forest Pathologist	Nanaimo	751-7108
Mel Scott	Stand Tending Forester	Nanaimo	751-7105

District Staff

John Ingram	Resource Officer - Silviculture	Campbell Rv.	286-9300
Lucy Stad	District Silviculturist	Chilliwack	794-2100
Brenda Cosgrove	Forest Health Technician	Chilliwack	794-2100
Paul Chalifour	Audit Forester	Duncan	746-2700
Allan Powelson	District Silviculturist	Mid Coast	982-2000
Mark Palmer	District Silviculturist	Pt. Alberni	724-9205
Chuck van Hemmen	Resource Officer - Silviculture	Pt. McNeill	956-5034
Carol Reagon	District Silviculture Planner	Pt. McNeill	956-5033
Ron Diprose	Forest Health Technician	Sunshine C.	485-0730
Mark Salzl	District Silviculturist	Qn. Char. Is.	559-8447
Jeff Fournier	District Silviculture Planner	Squamish	898-2100

MEETINGS

Yukon Staff Attend Spruce Beetle Probing Accreditation Course in Prince George. The fourth *Spruce Beetle Probing Accreditation Course* for 1994 was held in Prince George on November 1-2, 1994. The 35 attendees included the following staff from the Forest Resources Department, Northern Affairs Program, Yukon, who chartered an aircraft to Prince George, British Columbia:

Peter Henry	Project Forester	Whitehorse
Don White	Forest Management Technician	Whitehorse
John Jennings	Resource Management Officer	Haines Junction
John Trotter	Assistant Resource Management Officer	Haines Junction
Neale Wortley	Resource Management Officer	Beaver Creek
Mike Sparks	Assistant Resource Management Officer	Watson Lake

The Yukon has several spruce beetle infestations and the situation has created a need for more ground detection expertise in order to delineate and rank stands for possible sanitation logging or other management action.

In 1994, approximately 95 personnel from consulting companies, major licensees, and forest service district offices within the Prince George Forest Region received accreditation via four courses. Target attendees for the course were mainly people who conduct ground probes and classify spruce beetle attacked trees during probes or walkthroughs, or who administer probe contracts and/or check the field work of others. The course has been assigned an estimated 14 education credits by the Association of B.C. Professional Foresters. The next series of courses will start in September, 1995. For information on course content or for a complete list of accredited probers, please contact the undersigned.

- R. Hodgkinson, Prince George Forest Region, Prince George.

GRAPHICS AND TABULATIONS

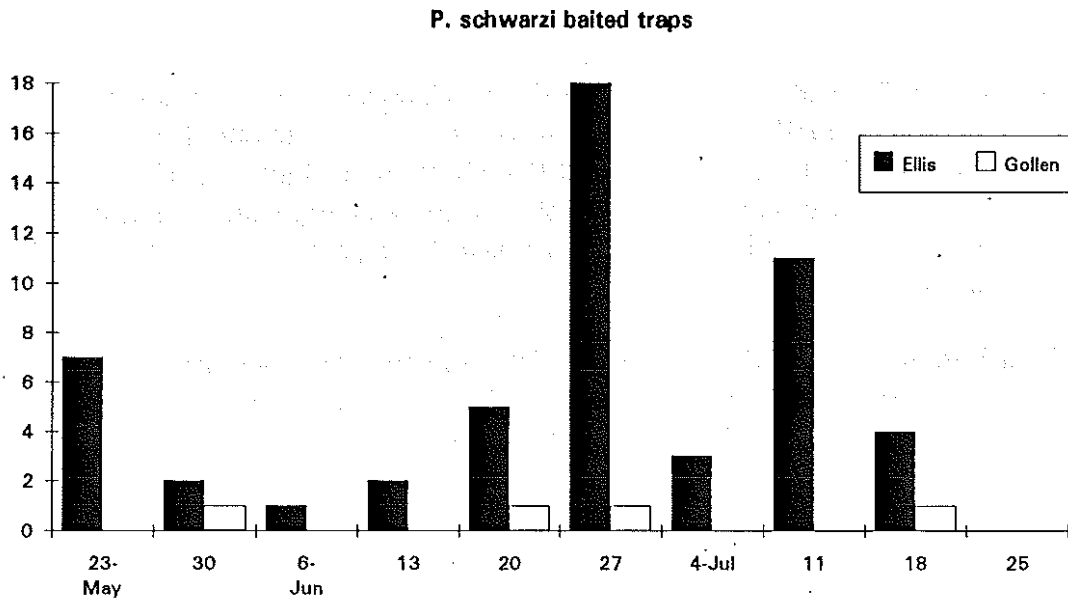


Figure 1. Seasonal response of *Pissodes* to *P. strobi* baited traps, *P. strobi/schwarzi* baited traps, and *P. schwarzi* baited traps.

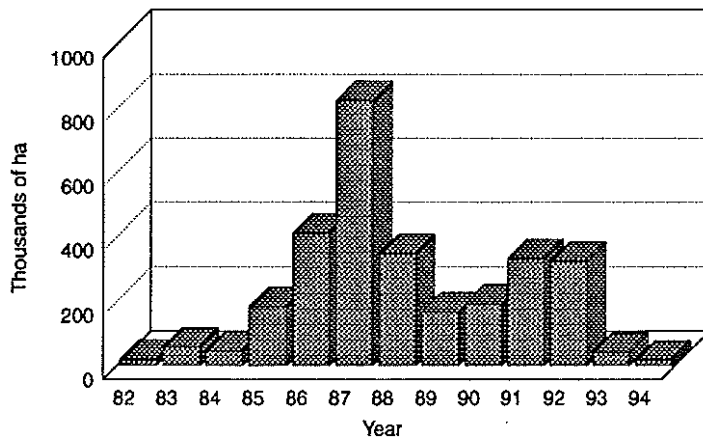


Figure 2. Annual record of hectares defoliated by the western spruce budworm in the Kamloops Forest Region from 1982 to 1994.

PUBLICATIONS AND REPORTS

Dorworth, C.E. and J.A. Muir, 1993. Constraint of transcontinental spread of *Gremmeniella abietina* in Canada. In Proc. of an International Symposium, June 10-15, 1991. (Meeting of IUFRO Working Party S2.06.02—Canker and shoot blight of conifers). Swedish University of Agricultural Sciences, Uppsala, P. Barklund, S. Livsey, M. Karlman and R. Stephan, eds. Grapenberg, Sweden. pp. 111-121.

Richardson, John S. and Chris J. Perrin. 1994. Effects of the bacterial insecticide *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*) on a stream benthic community. Canadian Journal of Aquatic Sciences Vol. 51: 1037-1045.