

This summary includes research currently underway or near completion at the PFC, MOF, the University of British Columbia, and Simon Fraser University and is based on information from the "Research Information Bank" (MOF) and individual researchers.

1 Current Research Conducted on Forest Pathogens

1.1 Root/Butt Diseases:

Armillaria root disease (Armillaria ostoyae)

- o Evaluate host resistance the root diseases and investigate biological control of root diseases (JS/PFC - FCFP37)
 - Determine biological effects of dsRNA or virus-like particles on growth, morphology and infectivity of Armillaria ostoyae isolates.
- o Evaluating the resistance of western larch to Armillaria (BJK/UBC+DM/PFC - FCFP09)
 - To determine the mechanisms of resistance of western larch to Armillaria and to describe the variation in resistance with tree age.
- o Rate of spread of Armillaria centers (BJK/UBC)
 - Protocol developed for spread rate (aprox. 0.25 m/yr).
- o Management of root disease via inoculum removal and alternate species (BJK/UBC+DM/PFC - FCFP24)
 - To test efficacy of stump removal.
 - To test the relative susceptibility of four conifer (Douglas-fir, lodgepole pine, interior spruce, and western larch), and three hardwoods (birch, aspen, and cottonwood).
- o Determination of MAI reductions due to root disease of a stand in the ICH zone within the Kamloops Forest Region (BJK/UBC + DM/PFC - FCFP26)
 - 1. Determine the MAI of hardwoods and conifers within infected areas.
 - 2. Determine how the MAI of healthy stands compare with that of diseased stands at various levels of infection.
 - 3. To elucidate the role of Armillaria as a natural component of ICH forests and to determine the conditions under which the pathogen enters the quiescent stage, and to recommend appropriate silvicultural techniques to deal with the pathogen following harvesting.
- o Understand critical aspects of the biology of root diseases (PFC)
 - Monitor (Armillaria) epidemiology plots at Sugar Lake and Nakusp.
 - Develop computer graphics and modeling techniques for the display and analysis of root disease epidemiology.
 - Determine variation in virulence of A. ostoyae isolates.
- o Determine the effects and impacts of silvicultural practices on disease epidemiology and recommend changes to practices that will reduce losses (PFC)
 - Effects of precommercial thinning (spacing) on crop tree infection and mortality by root diseases in the Southern and Central Interior.
 - Monitor destumping trials at Skimikin, Phoenix, Duncan, Hillcrest and North Arm.
 - Measure background levels of A. ostoyae in southern Interior biozones.

- o Pure and mixed paper birch stand management studies in the ICH zone in the southern interior of British Columbia: Root disease study (MOF/KAM - B33)
 - 1. Examine the root morphology and infection patterns of paper birch and Douglas-fir in mixed stands.
 - 2. Compare *Armillaria* groups that occur on paper birch and Douglas-fir by isolating and culturing mycelia from each species.
- o Paper birch and *Armillaria* root disease interaction studies in the ICH zone in the southern interior of British Columbia (MOF/KAM - BCFP04)
 - 1. Remeasure three permanent plots established in 1991 to follow annual mortality.
 - 2. Examine older stands of paper birch to observe age related susceptibility and pathogenicity to *Armillaria ostoyae*.
- o Effects of precommercial thinning on crop tree infection and mortality by root diseases in the southern and central interior (DM/PFC - FCFP03)
 - Determine the effects of precommercial thinning on infection and mortality by root diseases.
- o *Armillaria* root disease in the IDF and ICH zones of southern Interior: Effects of partial cutting on disease incidence (DM/PFC - FCFP33/SS008)
 - Determine which factors are responsible for the greatest variation in *Armillaria* root disease.
 - Determine the relationship between a given level of root disease severity in standing timber and the corresponding root disease severity following timber harvest.
 - Determine the relationship between *Armillaria* root disease severity and standing timber basal area and volume in the ICH zone.
 - Develop a root disease severity prediction model which will determine which areas of the ICH zone are most prone to severe *Armillaria* infections both prior to and following timber harvest.

Tomentosus root disease (*Inonotus tomentosus*)

- o Understand critical aspects of the biology of root diseases (RH/PFC - FCFP40)
 - Determine the relative frequency of *Inonotus tomentosus* and *Phellinus pini* in stumps.
 - Examine the protein patterns of *I. tomentosus* vs *P. pini*.
- o Evaluate host resistance the root diseases and investigate biological control of root diseases (RH/PFC - FCFP40)
 - Determine the relative susceptibility of various species to *I. tomentosus* by establishing test plantations.
 - Determine the relationship between infection risk and stump to tree distances for spruce and pine.
- o The effect of *Inonotus tomentosus* on growth of spruce (RH/PFC - FCFP40)
 - 1. Determine the effect of *Inonotus tomentosus* on tree growth, and relate crown symptoms and/or root condition to reduction in volume increment.
 - 2. Determine losses to butt cull and provide estimates of gross to net volume, and estimates of net volume by firewood rule.
- o Development of survey procedures for *Inonotus tomentosus* (RH/PFC - FCFP40)
 - 1. Develop survey procedures that fulfill different survey objectives.
 - 2. Examine and recommend stratification procedures which will increase survey efficiency and accuracy.
 - 3. Relate above ground symptoms to fungal infection of the root and compare the actual size of root disease centers with the size indicated by above ground symptoms.

- 4. Determine the efficiency of push-over logging as a disease control measure.
- o Construction of managed stand yield tables for root disease infected stands of coastal Douglas-fir, and interior white spruce and lodgepole pine (MOF/BC - BCGY01)
 - Develop managed stand yield tables designed to assess the impacts of laminated root disease (Phellinus weirii) and tomentosus root disease (Inonotus tomentosus) on the timber productivity of coastal Douglas-fir, white spruce and lodgepole pine, when combined with a range of silvicultural regimes.

Laminated root disease (Phellinus weirii)

- o Inactivation of Phellinus weirii root disease centers (BJVK/UBC - GREAT)
 - A search for mechanisms that may explain the phenomenon. dsRNA particles have been eliminated. Current work focuses on soil factors.
- o Validation of the TASS-ROTSIM Model for the prediction of laminated root disease in second growth coastal Douglas-fir (MOF/BC - BCFP03)
 - Validate the performance of the TASS-ROTSIM laminated root disease model for Douglas-fir using a large set of Permanent Sample Plot (PSP) data from a variety of stand and treatment conditions.
- o Efficacy of Telone IIB for the control of Phellinus root disease in second growth Douglas-fir stumps (MOF/BC - BCFP05)
 - Evaluate the efficacy of Telone IIB (applied at two doses) in killing the ectotrophic Phellinus weirii inoculum.
- o Construction of managed stand yield tables for root disease infected stands of coastal Douglas-fir, and interior white spruce and lodgepole pine (MOF/BC - BCGY01)
 - Develop managed stand yield tables designed to assess the impacts of laminated root disease (Phellinus weirii) and tomentosus root disease (Inonotus tomentosus) on the timber productivity of coastal Douglas-fir, white spruce and lodgepole pine, when combined with a range of silvicultural regimes.
- o Evaluate host resistance to root diseases and investigate biological control of root diseases (RS/PFC)
 - Screen coastal Douglas-fir for genetic resistance to P. weirii.
 - Investigate incidence of crown recovery from P. weirii and factors involved.
- o Determine the effects and impacts of silvicultural practices on disease epidemiology and recommend changes to practices that will reduce losses (RS/PFC)
 - Evaluate and monitor push-felling as a disease control technique for coastal, Phellinus infested sites (FCFP19).
 - Determine effects of bridge tree removal and spacing on spread of P. weirii.
 - Determine effect of planting distance from inoculum sources (stumps) on incidence of P. weirii.
 - Determine effect of commercial thinning on spread of P. weirii (FCGY -06).
 - Evaluate alternate species (white pine, alder, yellow cedar) on survival and spread of P. weirii.
- o Understand Critical Aspects of the Biology of Root Diseases (RS/PFC)
 - Refine and test inoculation technique for P. weirii.
 - Determine colonization pattern, infectivity and longevity of P. weirii inoculum, particularly with respect to spacing stumps.
 - Determine epidemiology and effect of P. weirii on western hemlock.

- o Use of red alder in managing Phellinus weirii root disease (RS/PFC - FCFP36)
 - Investigate the effect of mixed alder/Douglas-fir cropping regimes on laminated root disease.

Annosus root disease (Heterobasidion annosum)

Blackstain root disease (Leptographium wageneri)

Brown cubical disease (Phaeolus schweinitzii)

Other root diseases

- o Determine the cause of laminated and honey-comb patterns of decay in spruce stumps (PFC).
- o Acceptability of western red cedar regeneration in the Interior Hemlock Zone: Kamloops Forest Region (MOF - SS043)
 - 1. Examine rooting patterns of western red cedar.
 - 2. Determine the events leading to the colonization of decay organisms.
 - 3. Assess the heartwood decay in western red cedar over its range.
- o Decay in advanced hemlock and cedar regeneration in the northern extent of the ICH zone (MOF - SS044)
 - 1. Determine which fungi are responsible for internal stem defect in advanced cedar and hemlock regeneration.
 - 2. Determine how extensive the distribution of such stem defect is within the northern subzones of the ICH.

1.2 Stem Rusts & Cankers:

White pine blister rust (Cronartium ribicola)

- o Develop biochemical markers for host resistance to white pine blister rust (PFC)
 - Analyze bark proteins, pathogenically induced proteins, and complete immunocytochemical analysis of the host-pathogen interaction.
 - Produce and characterize monoclonal antibodies to the blister rust fungus.
 - Develop cell-image-reconstruction techniques.
 - Isolate putative disease-response genes, and determine whether polymorphisms in these genes correlate with resistant genotypes.
- o Develop and use new methods to determine genetic variation in the white pine blister rust pathogen (PFC)
 - Determine distribution of dsRNA in foreign aeciospore collections.
 - Develop methods for southern blot DNA analysis and random amplified polymorphic DNA analysis (RAPD's), and determine whether either detect polymorphisms.
- o Demonstrate blister rust resistance in selected white pine stocks (PFC)
 - Cross selected candidates, graft selected stocks and establish demonstration plantations of selected stocks.
- o To develop silvicultural practices that encourage the regeneration and growth of rust resistant trees in British Columbia and determine the transferability of white pine among bioclimatic zones in British Columbia (PFC)
 - Evaluate provenances for susceptibility to root disease in plantations established for this purpose.

- Correlate a recently identified protein as a potential marker for frost-hardiness and evaluate field tests established for this purpose.
- Establish and monitor plantations of wide vs. narrow crosses of white pine.
- o Demonstrate blister rust resistance in selected white pine stocks (PFC)
 - Field select, evaluate and gather cones of candidate trees and screen selected families via rust inoculation.
 - Rank parents and select seedlings with specific defenses.
 - Evaluate selected stocks for susceptibility to major pests.
 - Recommend selected parents and seedlings to MOF for seed orchards.
 - Monitor and evaluate seed-orchard practices re design and yield recommendations.
 - Develop practices such as pruning to manage wpbr in already established white pine plantations.
 - Evaluate the gains of pruning.

Western gall rust (Endocronartium harknessii)

- o Population structure of western gall rust using molecular techniques.(BJK/UBC+EW/PFC - NSERC)
 - Describe within and between population variation.
 - Is there an effective sexual stage in the life cycle?
 - Are there host specific races in natural populations of the pathogen?
- o Effect of juvenile spacing on stem rusts and cankers of lodgepole pine. (BJK/UBC - FCFP23)
 - Quantify the effect of juvenile spacing on the incidence and damage caused by the common stem rust and cankers of lodgepole pine.
- o Relative susceptibility of lodgepole and Scots pine to North American stem rusts and other pathogens.(BJK/UBC - Bo Rydin Foundation)
 - In cooperation with the Swedish University of Agricultural Sciences, Umeo, Sweden.
- o Models of effects of hyperparasites on western gall rust.(BJK/UBC)
 - Develop a conceptual model of the mode of action of hyperparasites.

Commandra blister rust (Cronartium comandrae)

- o Effect of juvenile spacing on stem rusts and cankers of lodgepole pine. (BJK/UBC - FCFP23)
 - Quantify the effect of juvenile spacing on the incidence and damage caused by the common stem rust and cankers of lodgepole pine.
- o Relative susceptibility of lodgepole and Scots pine to North American stem rusts and other pathogens.(BJK/UBC - Bo Rydin Foundation)
 - In cooperation with the Swedish University of Agricultural Sciences, Umeo, Sweden.

Stalactiform blister rust (Cronartium coleosporioides)

- o Effect of juvenile spacing on stem rusts and cankers of lodgepole pine. (BJK/UBC - FCFP23)
 - Quantify the effect of juvenile spacing on the incidence and damage caused by the common stem rust and cankers of lodgepole pine.
- o Relative susceptibility of lodgepole and Scots pine to North American stem rusts and other pathogens.(BJK/UBC - Bo Rydin Foundation)
 - In cooperation with the Swedish University of Agricultural Sciences, Umeo, Sweden.
- o Uredospore production on alternate hosts of Cronartium coleosporioides in B.C. (BJK/UBC)

Atropellis canker (Atropellis piniphilla)

- o Effect of juvenile spacing on stem rusts and cankers of lodgepole pine. (BJK/UBC - FCFP23)
 - Quantify the effect of juvenile spacing on the incidence and damage caused by the common stem rust and cankers of lodgepole pine.
- o Relative susceptibility of lodgepole and Scots pine to North American stem rusts and other pathogens.(BJK/UBC - Bo Rydin Foundation)
 - In cooperation with the Swedish University of Agricultural Sciences, Umeo, Sweden.

1.3 Dwarf Mistletoes:

Lodgepole pine dwarf mistletoe (Arceuthobium americanum)

- o intensification of lodgepole pine dwarf mistletoe following clear-cutting and 'knockdown' of small residuals (bjk/ubc - fcfp25)
 - preliminary study.

Hemlock dwarf mistletoe (Arceuthobium tsugense)

- o impact of hemlock dwarf mistletoe (bjk/ubc fcfp16)
 - estimate volume losses due to dwarf mistletoe via pruning and stem analysis. analysis in progress.

Larch dwarf mistletoe (Arceuthobium laricis)

1.4 Hardwood Diseases:

Aspen cankers and root diseases (various species)

- o Develop and provide diagnostic services and tools for diseases of native and hybrid poplars (PFC/FIDS)

Other Hardwood diseases

- o Understand critical aspects of the biology of root diseases (PFC)
 - Determine pathological problems associated with management of hardwoods, including alder, birch and cottonwood in both pure and mixed stands
- o Survival, Growth and Yield of Four Hardwood Species on Five Sites in the Cariboo Forest Region (MOF - EP1136.01)
 - 1. Compare the survival and growth of three hardwoods: aspen, paper birch and black cottonwood with that of fast growing hybrid poplar (P. deltoides x P. Trichocarpa) on five sites in the Caribou Forest Region.
 - 2. Determine the susceptibility of these species to insect, disease (especially root disease), small mammal damage, frost, and decay throughout the rotation.
 - 3. Determine if these species improve long-term site productivity.
 - 4. Establish growth and yield plots for hardwood species in the Caribou Forest Region.
- o Assessment of decay and waste factors and decay organisms for red alder (Alnus rubra) (MOF - EP1137.01)
 - 1. Produce decay and waste factors for red alder by diameter class, risk group, and biogeoclimatic units within Forest Inventory Zone (FIZ) of the Vancouver Forest Region.
 - 2. Assess the reliability of external pathological indicators as predictors of alder decay.
 - 3. Isolate and identify species of decay fungi present in alder samples collected above.
 - 4. Determine the decay and/or staining potential of these fungi in vitro (wood block tests), and in vivo (field inoculations).

- o The significance of site variables in predicting decay in aspen trees in the BWBS biogeoclimatic zone (MOF - 1139)
 - 1. Identify variables which will provide reliable predictions of decay and stain on a stand by stand basis.
 - 2. Review and assess post-research feasibility and practical utility of collecting, compiling and applying data on variables found to be significantly correlated to aspen decay and stain.
 - 3. Examine and develop options for harvesting and silvicultural treatment regimes.

2 Current Research Conducted on Forest Insects

2.1 Bark Beetles:

Mountain pine beetle (*Dendroctonus ponderosae*)

- o Refinement of aggregation and antiaggregation pheromones of the mountain pine beetle (JHB/SFU - FCFP13)
 - The search continues for a long-hypothesized missing aggregation pheromone.
 - Research on ipsdienol and other antiaggregants continues.
 - A potential alternative to MSMA (a bark applied paste formulation of an organophosphate) was tested, but not found to be any more effective.
- o Develop a novel biological control method for the mountain pine beetle based on the manipulation of competing bark beetle species using natural chemical attractants (LS/PFC - FCFP31)
 - Assessment of biological potential: In the laboratory, test the effects of combinations of attack densities by the mountain pine beetle and competing species on the survival of mountain pine beetle broods.
 - In small infestations of the mountain pine beetle, manipulate attack densities in individual trees of this insect and its main bark beetle competitors using pheromone baits.
 - Measure effects of the timing of bait placement, and release rates of the pheromone baits, on attack success and brood survival of the mountain pine beetle and competing species.
 - Assess feasibility of the method for suppressing small infestations of the mountain pine beetle.
- o Develop silvicultural control methods through investigation of the relationship between stand density, tree vigor, stand climate and mountain pine beetle damage (LS/JS/PFC - Green plan)
 - Set up experimental installations in mature lodgepole pine consisting of levels of spacing and fertilization.
 - Measure host vigor, key variables of stand climate, beetle dispersal and population size, and tree mortality from the mountain pine beetle.
 - Test effects of the spacing/fertilization treatments on host vigor, stand climate, tree mortality, beetle dispersal and population size.
 - Establish and document demonstration areas re the effectiveness of thinning and fertilization for mountain pine beetle management.
- o Develop decision support systems to integrate the knowledge of the mountain pine beetle and its interaction with lodgepole pine stands and provide computer-based tools for improved decision-making (JS/PFC - FCFP05)
 - Develop a mountain pine beetle population dynamics model to predict population trends and tree mortality in lodgepole pine stands.
 - Develop a spread model to predict the spread of mountain pine beetle epidemics within and among stands.
 - Develop a risk rating system to provide a means of prioritizing stands for treatment based on their likelihood of being damaged by the mountain pine beetle.

- Develop an expert system which will integrate forest and mountain pine beetle management guidelines and provide assistance and consistency to the decision making process.
- Develop a user-friendly interface which will bring together maps and databases, GIS, models, and expert systems to facilitate the forest health decision making process.
- o Mountain pine beetle hazard reduction through two different partial cutting methods (MOF - SS040)
 - 1. Establish replicates of hazard reduction thinning of mature lodgepole pine (i.e. "Beetle proofing") in the Morice Forest District.
 - 2. Establish a Simulated Group Selection trial to examine the long-term implication of removing patches of high hazard trees and its affect on the rate of mountain pine beetle infestations.
- o Group selection system for even-aged lodgepole pine stands in the SBPSxc and MSxv subzones (MOF - SS067)
 - 1. Demonstrate group selection systems for even-aged lodgepole pine stands in the Chilcotin Forest District
 - 2. Maintain the regeneration success, Caribou habitat and the incidence of mountain pine beetle.

Spruce bark beetle (Dendroctonus rufipennis)

- o Semiochemical ecology of the spruce bark beetle (JHB/SFU - FCFP13)
 - Ongoing research to develop better pheromone traps for the spruce beetle.
 - Indications of site specific research is required for better pheromones for use in mass-trapping or tree-baiting programs.
- o Competitive displacement of the spruce beetle by secondary species using semiochemical based techniques (JHB/SFU - FCFP13)
- o Assess the impact of harvesting, competing bark beetle species and natural enemies on spruce beetle populations in down host materials (LS/PFC - FCFP31)
 - Analyse spruce beetle population data base; relate spruce beetle survival to harvesting activities, windfall, densities of competitors, parasites and predators.

Balsam bark beetle (Dryocetes confusus)

- o Development of semiochemicals for the management of the balsam bark beetle (JHB/SFU - FCFP13)
 - Development of pheromones and host volatiles for use in mass-trapping or tree-baiting programs.

Douglas fir bark beetle (Dendroctonus pseudotsugae)

Fir engraver (Scolytus ventralis)*

- o Semiochemical ecology of the fir engraver (JHB/SFU - FCFP13)
 - Investigation of pheromones produced by this insect are underway.
- o Competitive displacement of the fir engraver by secondary species using semiochemicals

Pine Engraver (Ips pini)*

- o Competitive displacement of the pine engraver by secondary species using semiochemicals

Ambrosia beetle (Trypodendron lineatum)*

- o Development of a day-degree model to evaluate the development of the ambrosia beetle, Trypodendron lineatum (JM/UBC)

2.2 WEEVILS:

Spruce weevil (Pissodes strobi)

- o Climate based hazard rating system for the spruce weevil (Pissodes strobi) in the Prince George Region under present climate conditions (JM/UBC)
- o Genetic variation of Pissodes strobi (Coleoptera:Curculionidae) in British Columbia (JM/UBC)
 - Using RAPD (DNA) analytical techniques to determine the genetic variability of weevils reared from Sitka spruce, Englemann spruce, white spruce, and eastern white pine.
- o Aspects of host selection, host resistance and chemical ecology of the spruce weevil (JHB/SFU - FCFP13+PFC+MOF - FCFP13)
 - Investigate morphology of leaders and branches of resistant spruce.
 - Investigate weevil produced volatiles
- o Control of spruce weevil damage in Interior spruce plantations by introduction of alternative species (RA/PFC - FCFP28)
 - Develop a means of providing side shade in spruce plantations which are already established.
 - Show that lodgepole pine and cottonwood can be introduced into spruce plantations and that once overtopping the spruce trees, the and cottonwood can effect a reduction in damage caused by the spruce terminal weevil.
- o Devise and evaluate silvicultural systems for reducing damage by P. strobi in Sitka spruce plantations (RA/PFC)
 - Monitor plots set up to test the effect of various silvicultural practices on damage by P. strobi.
 - Set up new experimental installations to test the effect of combinations of control methods and alternative silvicultural practices on damage by P. strobi.
- o Development of an integrated pest management system for spruce weevil in B.C. (RA/PFC - FCFP06)
 - 1. Identify mechanisms involved in weevil resistance.
 - 2. Determine chemical factors associated with weevil attack on resistant and susceptible interior spruce clone trees.
 - 3. Develop a quick method for identification of weevil resistant trees.
 - 4. Assess the impacts of weevil attack on tree growth and form.
 - 5. Determine the genetic variability among regional spruce weevil populations.
 - 6. Elucidate weevil population dynamics and weevil/host interactions.
- o Field testing of spruce emblings for resistance to spruce weevil (RA/PFC - FCFP29)
 - Exploit tree resistance to damage by P. strobi for use in the provincial tree-breeding program.
 - Monitor biological development in plots set up to compare the resistance to P. strobi damage among provenances and clones of spruce.
 - Construct chemical profiles for vascular and foliage chemicals extracted from families of spruce that differ in the amount of damage sustained from P. strobi attack; isolate, separate and supply extracted components for physiological activity testing in insects.
 - Devise experiments to test theories on why certain isolates of spruce sustain less damage from P. strobi that have been developed from our comparative observations on the development of damage.
- o Investigate methods of regulating populations of P. strobi that exploit the natural complex of insects which attack P. strobi (RA/PFC)
 - Devise tests to estimate the impact of insect natural enemies on brood mortality.
 - Investigate methods by which intervention may improve the impact of these natural enemies.

- Search for natural enemies abroad from related *Pissodes* species that may have more impact than the native natural enemies in *P. strobi* without detriment to other environmental components.
- o Develop computerized decision support systems to forecast stand and forest level impacts of the weevil in spruce plantations (RA/PFC)
 - Refine a spruce weevil attack model designed to predict the impact of different levels of spruce weevil attack on a given stand of spruce.
 - Incorporate the spruce weevil attack model into a provincial model designed to simulate the growth and yield of trees throughout the province.
- o Development of a Spruce weevil infestation hazard rating for B.C. (MOF - BCFP002).
 - Develop a hazard rating potential for spruce weevil development using air temperature and biogeoclimatic subzone information.
- o Modeling the impacts of weevil attack on Sitka spruce productivity (MOF - BCFP06)
- o Acephate and Oxydemeton-methyl implants for Sitka spruce weevil (EP1090)
 - Test both acephate and oxydemeton-methyl stem implants to prevent Sitka spruce weevil (*Pissodes strobi*) infestation of Sitka spruce.

Pine terminal weevil (*Pissodes terminalis*)

Warren's root collar weevil (*Hyllobius warreni*)

- o Survey of Warren's root collar weevil in Prince Rupert Region (JM/UBC)
 - Incidence survey in young lodgepole pine plantations (weevils were widespread). Trees over 6 cm dia were able to withstand larval activity at the ground line.

2.3 DEFOLIATORS:

Western spruce budworm (*Choristoneura occidentalis*)

- o Development of a bioirritant/feeding deterrent to the western spruce budworm (JHB/SFU - FCFP13)
- o Understand and quantify the impacts of defoliators on forest productivity (PFC)
 - Monitor and analyze joint FORCAN/MOF permanent plots in areas defoliated by the western and eastern spruce budworm.
 - Develop methods for assessing defoliation impacts on growth and yield.
 - Develop a model of eastern spruce budworm impacts on the Fort Nelson Timber supply, jointly, with members of the Budworm Impacts Green Plan Network.
- o Develop a decision support system that integrates pest-host tree interaction and various control options, and provides forest managers with a computer-based tool to make rational control decisions to enhance forest productivity.
 - Turn this into a computer based and user-friendly pest management system.
 - Calibrate this decision support system.
 - Transfer the calibrated decision support system the MOF and other pest managers.
- o Reduction of Spruce budworm losses in Douglas-fir through silvicultural treatments (RA/PFC - FCFP07)
 - Determine if fertilizing and thinning infested stands can compensate for defoliation by western spruce budworm.

Douglas-fir tussock moth (Orgyia pseudotsugae)

- o Control of the Douglas-fir tussock moth using pheromone-based disruption (JHB/SFU - FCFP13)
- o Development of a pheromone control system for Douglas-fir tussock moth (MH/PFC - FCFP11)
 - Demonstrate efficacy of male disruption through the dissemination of sex pheromones for reducing Douglas-fir tussock moth populations of less damaging densities
- o Use, and develop, new, ecologically based control methods, including silvicultural ones, for defoliating pests (MH/PFC - FCFP11)
 - Assess control of pest damage by application of naturally-occurring insect pathogens.
 - Demonstrate the effectiveness of the control method(s) (both pheromone and virus application for Douglas-fir tussock moth).

Western hemlock looper (Lambdina fiscellaria lugubrosa)

- o Identification of semiochemicals of the western hemlock looper (JHB/SFU - FCFP13)
- o Development and calibration of a semiochemical based monitoring system for the western hemlock looper (JHB/SFU - FCFP13+GVS/PFC+FIDS/PFC)
- o Understand critical aspects of population and outbreak dynamics of the major forest defoliators (PFC)
 - Identify stands susceptible to Western Hemlock Looper outbreaks by comparing overlays of maps of past outbreaks, forest types, plant communities and bioclimatic zones.
 - Establish and maintain monitoring sites within susceptible stands to determine the year to year trends in number of male moth caught in pheromone traps, with the cooperation of FIDS and MOF.
- o Development of an economically acceptable control method for the Western hemlock looper (IO/PFC - FCFP12)
 - Develop an economically acceptable control method for the western hemlock looper.
 - Identify the biological control agents (predators, parasitoids and pathogens) affecting the population of the pest western hemlock looper.
 - Investigate the effectiveness of these biological control agents.

Two-year cycle budworm (Choristoneura biennis)

Western blackheaded budworm (Acleris gloverana)

Gypsy moth (Lymantria dispar)

- o Identification of new semiochemicals of the Gypsy moth (JHB/SFU - FCFP13+LH/PFC)

Western false hemlock looper (Nepytia freemani)*

- o Identification of semiochemicals of the western false hemlock looper (JHB/SFU - FCFP13)

Larch looper (Semiothisa sexmaculata)*

- o Identification of semiochemicals of the larch looper (JHB/SFU - FCFP13)

Grey Spruce looper (Caripeta divisata)*

- o Identification of semiochemicals of the grey spruce looper (JHB/SFU - FCFP13)

2.4 Aphids:

Balsam woolly adelgid (Adelges piceae)

2.5 Hardwood Pests

- o Survival, Growth and Yield of Four Hardwood Species on Five Sites in the Cariboo Forest Region (MOF/CAR)
 - 1. Compare the survival and growth of three hardwoods: aspen, paper birch and black cottonwood with that of fast growing hybrid poplar (P. deltoides x P. Trichocarpa) on five sites in the Cariboo Forest Region.
 - 2. Determine the susceptibility of these species to insect, disease (especially root disease), small mammal damage, frost, and decay throughout the rotation.
 - 3. Determine if these species improve long-term site productivity.
 - 4. Establish growth and yield plots for hardwood species in the Cariboo Forest Region.

3 Current Research Conducted on Mammal Pests

3.1 Deer

- o The effect of deer browsing in the early growth of three conifer species in the Queen Charlotte Islands (MOF - EP814)
 - 1. Determine the extent of deer browsing on the juvenile growth of western red cedar, western hemlock, and Sitka spruce.
 - 2. Compare the growth rates of managed plantations of these species and their mixtures.

3.2 Other Mammal Pests

- o Survival, Growth and Yield of Four Hardwood Species on Five Sites in the Cariboo Forest Region (MOF - EP1136.01)
 - 1. Compare the survival and growth of three hardwoods: aspen, paper birch and black cottonwood with that of fast growing hybrid poplar (P. deltoides x P. Trichocarpa) on five sites in the Cariboo Forest Region.
 - 2. Determine the susceptibility of these species to insect, disease (especially root disease), small mammal damage, frost, and decay throughout the rotation.
 - 3. Determine if these species improve long-term site productivity.
 - 4. Establish growth and yield plots for hardwood species in the Cariboo Forest Region.